Bulgarian Academy of Sciences. Space Research and Technology Institute.
Aerospace Research in Bulgaria. 32, 2020, Sofia

DOI: https://doi.org/10.3897/arb.v32.e12

XZ-SERIES OF UNMANNED AERIAL VEHICLES IN 2020

Svetoslav Zabunov

Space Research and Technology Institute – Bulgarian Academy of Sciences
e-mail: SvetoslavZabunov@gmail.com

Key words: *Multi-Rotor Unmanned Aerial Vehicles, XZ-Series of Drones*

Abstract

The XZ-series of unmanned aerial vehicles was initiated in 2014 initially as an endeavour of theoretical development of multirotor unmanned aircraft models. The idea and major work was done by the author of the current article, and now, by the year of 2020, the series is still in constant process of inventing new designs. Most of the models were patented at the Bulgarian Patent Office through patents for inventions or utility models. In the recent years, publications on the XZ-series models have appeared in foreign scientific journals with high scientific impact metric.

The XZ-series of flying machines includes various types of multi-rotor machines such as standard multi-rotors, fixed wing multi-rotors and compound multi-rotors.

This article is a concise guide, as concise as it can be, to the XZ-series of unmanned aerial vehicles as of middle 2020 and, as such, it shall be followed in the future by sequels, published regularly, summarizing the ongoing process of the XZ-series aircraft model development.

Introduction

Found in 2014, the XZ-series of unmanned aerial vehicles is in constant development today. The idea for the series belongs to the author of the current publication. Although started as a theoretical enterprise in originating novel multi-rotor unmanned aircraft models, it evolved into full-featured aircraft design process implementing all the needed on-board avionics, including a developed by the author autopilot (Z-pilot), dynamic reconfiguration battery module [2], motor controllers for brushless direct current electric motors, etc. A few models were brought to prototype stage and laboratory testing [1]. Many of the models were patented at the Bulgarian Patent Office through patents for inventions or utility models.

The XZ-series of aircraft includes multi-rotor aircraft of various types such as standard multi-rotor machines, fixed wing multi-rotor aircraft and compound helicopter multi-rotors. In the current article the XZ-series models are described

systematically in thematic groups related to their technological background and are summarized in an extended table for the sake of ease of reference.

In contrast to previous publications by the author, the current material does not compare the XZ-series models to classical multi-rotors of other inventors, but still does attempt to disclose the major advantages of the XZ-series models. There are other specific publications, aiming at detailed and elaborate presentation of each model to the scientific community and to the general public. These publications do compare the XZ-series models to the known state of the art technological achievements of the present day.

Information found in the table

As already mentioned, the models are divided into three major groups in respect to their construction and paradigm: standard multi-rotors, fixed-wing multi-rotors, and compound multi-rotors (see Fig. 1).

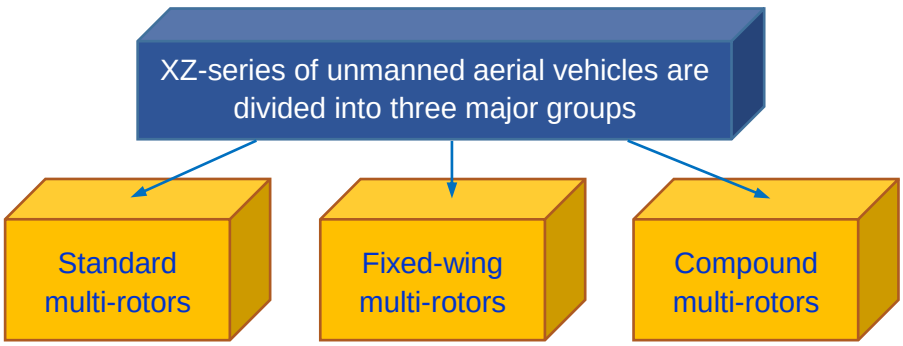


Fig. 1. XZ-series unmanned aerial vehicles are divided into three major groups

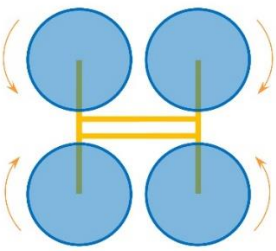
Standard multi-rotor aircraft are based on an airframe, which has no aerodynamic lifting properties but only supporting ones. The lift is generated by horizontal or close to horizontally oriented rotors and attitude control is attained by altering the speed of rotation of each individual rotor. In some cases, this group encompasses models having aerodynamic surfaces employed for attitude control only, but not for creating lift. Vertical or close to vertical rotors are also employed for attitude control.

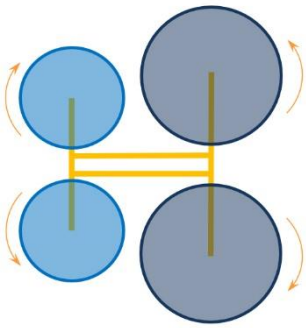
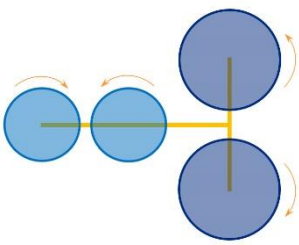
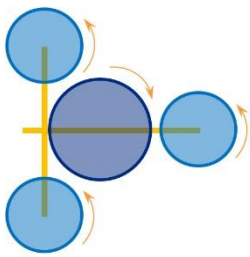
Fixed wing multi-rotors are distinguished from the former group by having a fixed wing that generates lift in flight. These multi-rotors are still taking off and landing vertically not utilizing the fixed wing. The latter is relied on during forward flight only.

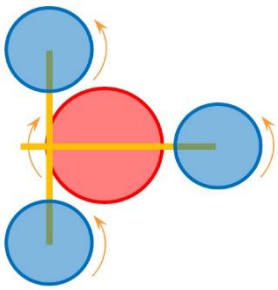
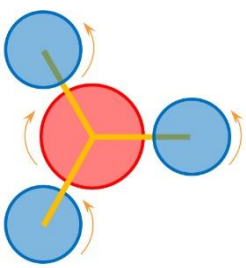
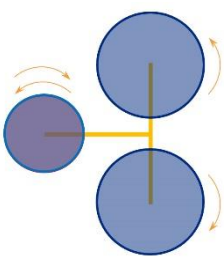
The last group of aircraft includes the so called compound multi-rotors. They employ vertical and horizontal rotors and no fixed wing. The horizontal rotors are used to generate lift, while the vertical rotors are engaged after take-off in order to generate horizontal trust and accelerate the aircraft in a horizontal motion without having the airframe inclined as with the standard multi-rotors to achieve horizontal propulsion.

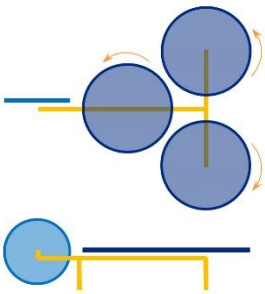
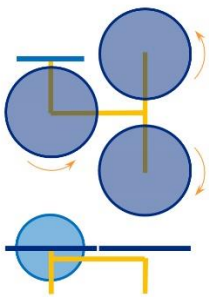
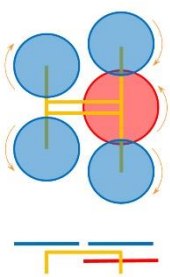
The XZ-series of unmanned aerial vehicles as of 2020

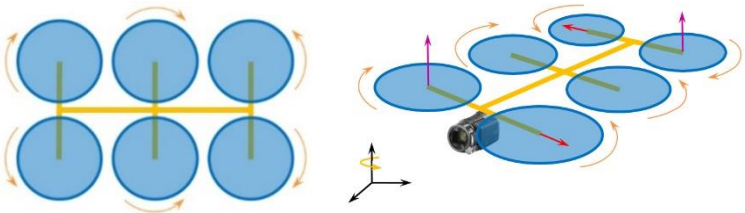
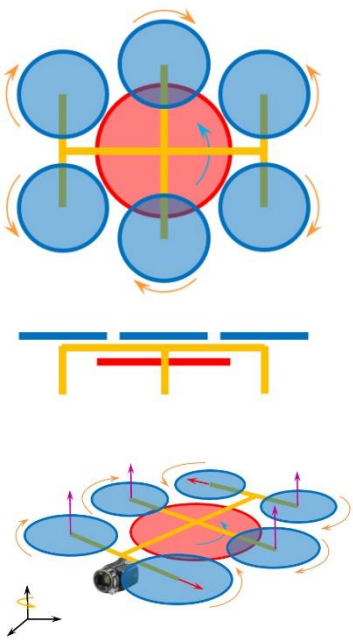
Table 1. XZ-series of unmanned aerial vehicles complete list as of 2020

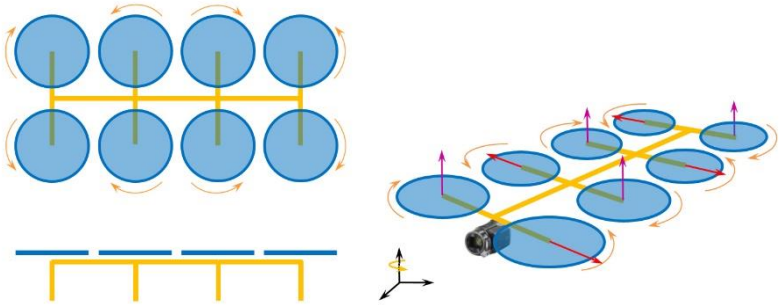
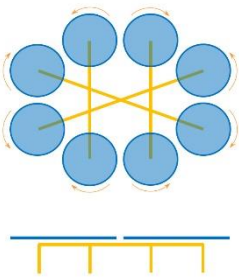
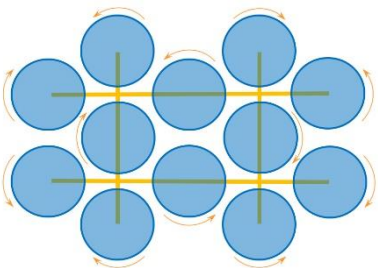
Model	Description and images
Model: **XZ-1** Group: **Standard** Topology: **H-frame** Rotors: **4** Year: **2014**	  XZ-1 is a four rotor multi-copter based on the H-frame paradigm. It is the first model in the series and was used as a testbed for experimenting with the evolving idea of the edge-controller [3]. The model was also a testbed for the first version of Z-Pilot autopilot. The prototype is powered by lithium polymer batteries, 3 cell, 11.1 V nominal voltage. Radio control is established in the standard 2.4 GHz band. The employed brushless direct current electric motors are with KV rating of 1300 and maximum power of 60 W each. The used propellers are 11 inches in diameter.

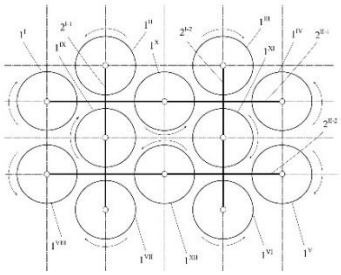
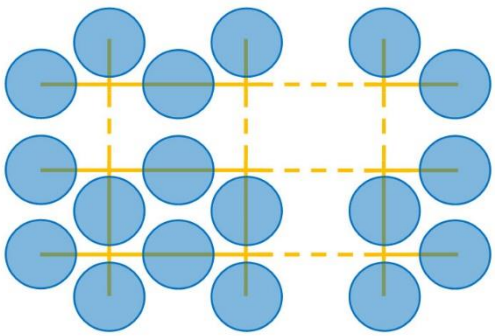
Model	Description and images
Model: **XZ-1B** Group: **Standard** Topology: **H-frame** Rotors: **4** Year: **2014**	 XZ-1B model is a variant of XZ-1 with asymmetric rotor design where two of the rotors on both sides of the main beam are larger and thus responsible for creating the main portion of the lift. The centre of mass in this model does not coincide with the geometric centre of the airframe and the smaller two rotors are used mainly for attitude control. All rotors are mounted above the fuselage.
Model: **XZ-1C** Group: **Standard** Topology: **T-frame** Rotors: **4** Year: **2014**	 While the XZ-series does not include tri-copters, it does rely on T-frame paradigm of designing the airframe for some of its models. Such an example is the XZ-1C quadcopter. It is similar to XZ-1B for having two larger and two smaller rotors mounted above the fuselage, but the airframe is "T"-shaped.
Model: **XZ-1D** Group: **Standard** Topology: **T-frame** Rotors: **4** Year: **2014**	 Another T-frame topology drone of the XZ-series with four rotors. Approximately half of the lift comes from the larger rotor, which is situated in the middle of the airframe while the rest of the rotors are used for the other portion of the lift and for attitude control. The rotors are mounted above the fuselage. The development stage is concept.

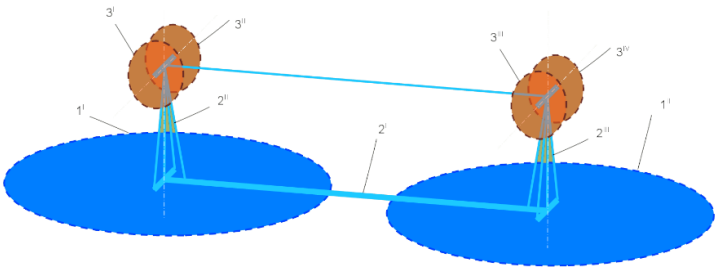
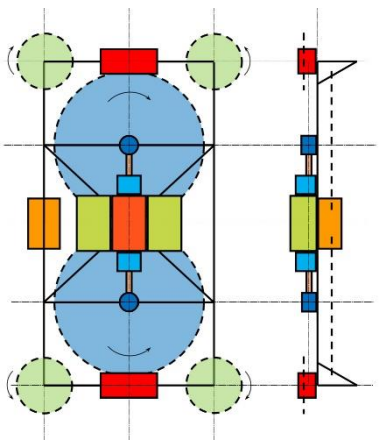
Model	Description and images
Model: **XZ-1E** Group: **Standard** Topology: **T-frame** Rotors: **4** Year: **2014**	 Still another T-frame topology drone and very similar to the previous design, the XZ-1D. The difference is that the larger rotor is mounted under the fuselage. This mounting strategy eliminates the possibility for carrying large payloads under the fuselage at its centre of lift or at its cross point, but reduces the downwash aerodynamic pressure on the airframe this improving flight efficiency. The development stage is concept.
Model: **XZ-1F** Group: **Standard** Topology: **Star** Rotors: **4** Year: **2014**	 The XZ-1F is a Star-topology aircraft. This paradigm of building an airframe is untypical for the XZ-series, but was utilized in this model for the sake of implementing a symmetric construction for a tri-copter like design with the addition of a centre large propeller, responsible for the generating of roughly half of the lifting force. The latter rotor is undermount, thus guaranteeing the same benefits as with the previous model.
Model: **XZ-1G** Group: **Standard** Topology: **T-frame** Rotors: **4** Year: **2014**	 The XZ-1G is still another T-frame multi-rotor following the concept of XZ-1C, but having its two smaller rotors mounted coaxially, one over the other at its tail. The latter two propellers are contra-rotating. The two larger rotors are over-mount. This approach leads to smaller overall dimensions of the aircraft in comparison to XZ-1C.

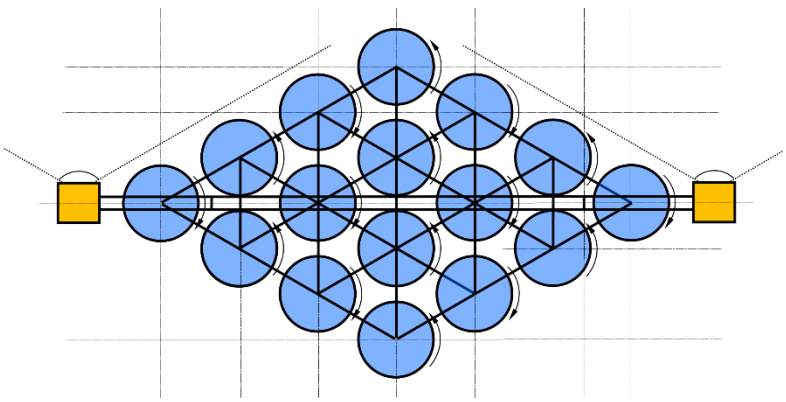
Model	Description and images
Model: **XZ-1H** Group: **Standard** Topology: **T-frame** Rotors: **4** Year: **2014**	 The XZ-1H is a design hybrid taking the approach of the tri-copter paradigm along with the T-frame topology of the fuselage, but also borrowing the idea from classic helicopters of a vertical attitude control rotor mounted at the tail. The major three propellers have same sizes and are horizontally mounted.
Model: **XZ-1J** Group: **Standard** Topology: **T-frame** Rotors: **4** Year: **2014**	 The XZ-1J multi-rotor is a development from the previous design XZ-1H. The new approach minimizes the dimensions of the copter by placing the vertical tail rotor on a supporting beam to one side of the central horizontal rotor, thus saving space. Stage of development is concept.
Model: **XZ-1A** Group: **Standard** Topology: **H-frame** Rotors: **5** Year: **2014**	 XZ-1A is an H-frame model that elaborates on the first representative of the series, the XZ-1 by adding an undermount rotor at one of the cross points of the fuselage. The additional rotor is larger and supports an increased payload of battery load, thus increasing the lifting and carrying capabilities of the aircraft. The dimensions are minimally enlarged, because the undermount rotor disc partially overlaps with the discs of the two neighbouring overmount rotors.

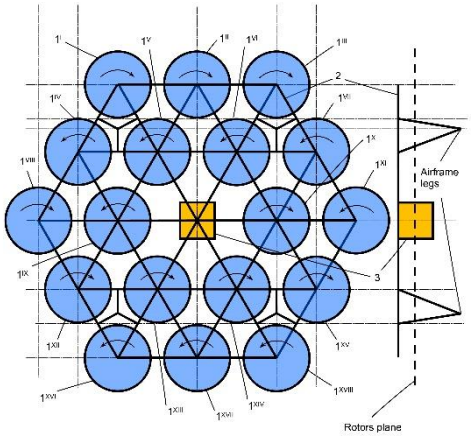
Model	Description and images
Model: **XZ-5** Group: **Standard** Topology: **H-frame** Rotors: **6** Year: **2014**	 The design of XZ-5 multi-rotor is highly conceptual and theoretical. Although it is unpromising for real development for being constructively non-rigid, it serves the purpose of basis for further desings of multicopters with 6 or more rotors based on the H-frame paradigm. The characteristic payload hard-point position is shown in the above figure on the right. H-frame based aircraft are offering this type of hard-point, which is suitable for different types of payloads especially for a camera-based payload requiring large fields of view. All rotors are overmount.
Model: **XZ-5A** Group: **Standard** Topology: **H-frame** Rotors: **7** Year: **2014**	 Evolving from the previous design XZ-5, another H-frame based multi-rotor is constructed – the XZ-5A model. A seventh rotor with larger dimensions is added at the centre of the fuselage and is undermount. This approach, as in previous design of the XZ-series, increases the lifting capabilities of the aircraft with little sacrifice of its dimensions, enlarging them at the centre along the smaller dimension. Such an aircraft is suitable for lifting larger payloads mounted at the centre of the fuselage. Again, certain measures should be followed to guarantee rigidity of the fuselage along its axis of symmetry by establishing a specifically suitable structure of the main beam of the fuselage, should the model be implemented in prototype design.

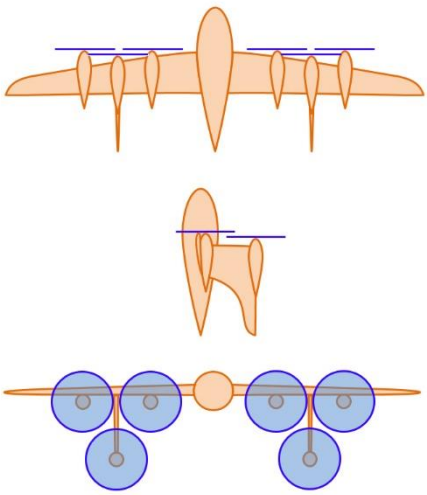
Model	Description and images
Model: **XZ-2** Group: **Standard** Topology: **H-frame** Rotors: **8** Year: **2014**	 The XZ-2 model is development from the XZ-5. It adds another pair of rotors on the same type of H-frame based fuselage elongating it even further. This model is highly conceptual, similar to XZ-5, and serves for further developments of other more practical designs. All rotors are overmount.
Model: **XZ-3** Group: **Standard** Topology: **X-frame** Rotors: **8** Year: **2014**	 XZ-3 is a practical model with crossed beams in the fuselage in triangular structures insuring rigidity of the airframe. It is an eight-rotor aircraft. The ever increasing number of rotors in the consecutive models of the series aims at higher stability, quicker response to external factors, lower noise and vibrations and higher safety of operation. All rotors are overmount. The stage of development is concept.
Model: **XZ-6** Group: **Standard** Topology: **Honey comb** Rotors: **12** Year: **2014**	 XZ-6 is the first model in the XZ-series designed along the honey comb paradigm. The approach guarantees optimal geometric covering of the horizontal plane with rotor discs thus minimizing the size and weight of the airframe structure and consequently improving the lifting capabilities of the aircraft and also its flying time and range. XZ-6 is again a practical design that led to the development of a few multi-rotors along the honey comb paradigm that reached prototype stage. All rotors are overmount. Its own stage of development is concept.

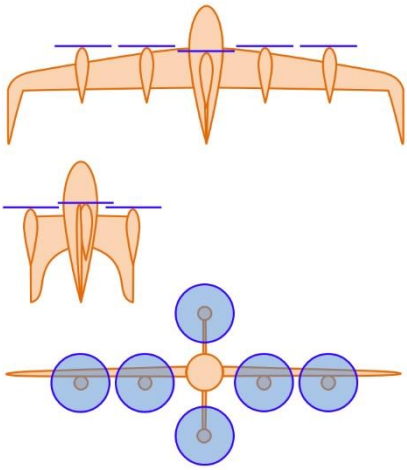
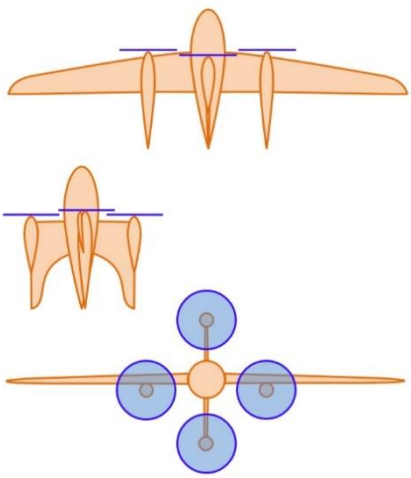
Model	Description and images
Model: **XZ-7** Group: **Standard** Topology: **Honey comb** Rotors: **12** Alias: **Bulgarian Knight** Year: **2015**	  Bulgarian Knight multi-rotor is an award winning design and an article on this model was published in recently [1]. The model won a gold medal at the international inventions exhibition Tesla Fest 2016. Based on the same honey comb paradigm [10], the multi-rotor XZ-7 was the first aircraft to prove in practice the design benefits of the optimal covering approach and also of the undermount rotors scheme. Both ideas were shown to bring adventages of significant merit through the development of the *Bulgarian Knight* prototype and its laboratory tests. The stage of development is prototype. The aircraft was also used as a testbed in the early steps of the Z-Pilot Nano V1.0 development – the first version of a nano-drone variant of the Z-Pilot series of autopilots.
Model: **XZ-7-n-m** Group: **Standard** Topology: **Honey comb** Rotors: **R (see eq. 1.)** Year: **2015**	 The **n** and **m** indices in the model designation denote respectively the number of rows and columns of beams making up the airframe. XZ-7-2-2 is equivalent to XZ-7 Bulgarian Knight multi-rotor. The XZ-7-n-m family of drones has its rotors under the airframe. The number of rotors in a given model variant is calculated after the observation that on each beam there are as many rotors as is the number of parallel beams to it plus one. Hence, the number of rotors R is: (1) $R = n * (m + 1) + m * (n + 1) = 2 * n * m + n + m$

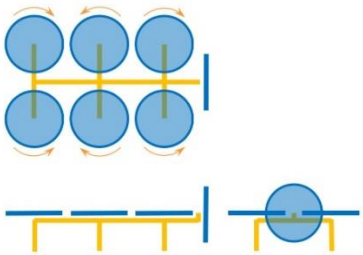
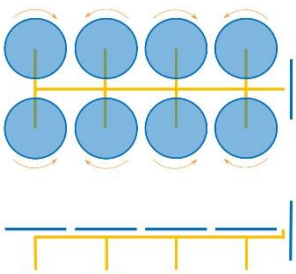
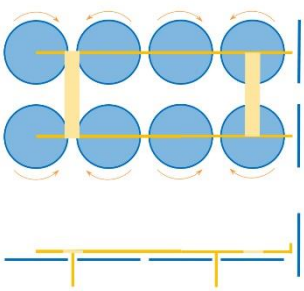
Model	Description and images
Model: **XZ-14** Group: **Standard** Topology: **Tandem helicopter** Rotors: **6** Year: **2015**	 XZ-14 is a model belonging to the well-known tandem rotor helicopters group. This model, as all current XZ-series models, employs only fixed pitch propellers, hence for attitude control it requires 4 additional small vertical rotors, mounted on vertical beams. The large horizontal rotors, creating the lift force, are undermount in respect to the fuselage. XZ-14 is aerodynamically stable [5], in spite of its long vertical beams and the four small rotors mounted at their tops, because the centre of mass coincides with the aerodynamic centre of the aircraft. The model is an award winning invention and has won a gold medal at the international inventions exhibition Tesla Fest 2016, Novi Sad, Serbia.
Model: **XZ-15** Group: **Hybrid** Topology: **Tandem helicopter** Rotors: **6** Year: **2019** Alias: **Storm**	 XZ-15 model is a development from the XZ-14 tandem multi-copter [9]. It is the only hybrid model in the XZ-series having an internal combustion engine as the main source of power. The engine is situated in the centre of the aircraft and is marked with red-orange colour in the figure to the left. The fuel tanks are the two green rectangles surrounding the engine. Along two transmission lines the torque of the engine is transferred to the fixed pitch large undermount horizontal rotors that are driven directly by the engine. On the transmission shafts two electric generators are employed generating electrical power that is buffered using batteries (red rectangles). The four small rotors have horizontal or close to horizontal orientation and are positioned at the edges of the fuselage. These rotors are driven by electric motors powered by the generators and the batteries. The latter rotors are used for attitude control, while the main two large rotors are employed in generating lift.

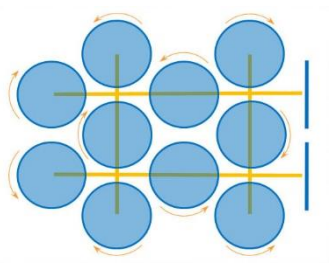
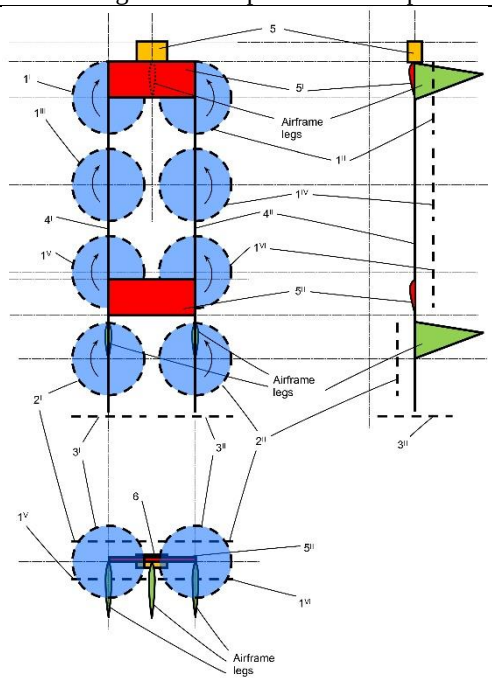
Model	Description and images
Model: **XZ-16** Group: **Standard** Topology: **Honey comb** Rotors: **16** Alias: **Emerald** Year: **2019**	 The XZ-16 multi-rotor is again an example of a honey comb structure drone. The honey comb approach seems very promising in creating new models with superior characteristics and performance. The XZ-16 was named Emerald and a prototype is under active development. The aircraft facilitates 16 rotors, horizontal in disposition and undermount in respect to the fuselage. The airframe has a rhombic shape, meaning the fuselage is elongated along the longer rhombus diagonal. Exactly this feature of XZ-16 led to the specific implementation of the aircraft, among others, as a stereo camera payload platform [6]. In this role the multi-rotor carries two cameras at the ends of its longest beam as shown with orange squares in the figure below.  The developed prototype is of micro-drone dimensions weighing in the proximity of 160 g and employing rotors with propeller diameters of only 55 mm. This very realization of the model is suitable for reconnaissance tasks due to the small visibility footprint of the tiny aircraft and its superior noise characteristics. The aircraft's current prototype is also very safe to operate with, although not completely safe.

Model	Description and images
Model: **XZ-18** Group: **Standard** Topology: **Honey comb** Rotors: **18** Alias: **Diamond** Year: **2019**	 The Diamond model (XZ-18) is the latest model of the series. As it was mentioned above, the honey comb approach proved to be superior to other rotor schemes. As advancement in respect to the Bulgarian Knight drone the newer models that follow the honey comb paradigm do not rely of square beam airframes. Instead they are based on traingular beamed airframes (XZ-16 also) as the latter are considerably more rigid [7]. XZ-18 has 18 rotors, which are undermount. The under-mounting of the rotors increases the efficiency of lift and flight by 5% to 12% with different models and for XZ-18 the efficiency gain is expected to be 9%. Hence this mounting strategy is the preferred way of installing the rotors on multi-rotor aircraft in the recent XZ-series models. Further, the newer models have large numbers of rotors, exceeding 12 and thus allow the mounting of rotors under the fuselage without incurring any consequential problems with the implementation of landing legs and gear and utilizing hard-points for payloads. The hard-point for the payload in the Diamond multi-rotor UAV is in the centre of the fuselage structure. The aircraft relies on four legs for landing, each constructed out of three beams. For these reasons the multi-rotor is suitable mostly for payloads not requiring horizontal field of view, for example cameras photographing the terrain directly below the aircraft or other instrumentation such as ionizing radiation sensors, meteorological data acquisition systems, ground sensing radar or any other devices that are not dependant on the obstructed horizontal visibility. The Diamond multi-copter was conceived as a platform for testing the new micro- and nano-drone ionizing radiation sensors being under development with the purpose of designing drones and robots used for disaster management and ionizing radiation sources control. The first prototype is planned to be developed in the early 2020 and shall be again a nano-drone in the 200–250 g range of total weight.

Model	Description and images
Model: **XZ-4** Group: **Fixed-wing** Topology: **Tail-sitter** Rotors: **6** Year: **2014**	The first model of a series of fixed-wing multi-rotor aircraft having no moving control surfaces and relying only on the rotors rotations per minute to attain attitude control, because, as stated above, currently no model in the XZ-series implements variable pitch propellers.  The XZ-4 [4] is a tail-sitter airplane that takes-off and lands on its tail – vertically as a multi-rotor drone and flies either vertically or horizontally. The horizontal mode is much more efficient and also offers higher speeds than the vertical regime of flight. In horizontal flight mode the aircraft is inherently unstable and relies on the autopilot to be stabilized. The current stage of development is concept, but due to the estimated superiority in comparison to existing vertical take-off and landing aircraft the model is planned for prototype development and laboratory and field testing. Because 6 rotors are employed, the failure of one of the four rotors mounted near the wing will not render the aircraft unconditionally uncontrollable. Nevertheless, the aircraft is not immune to catastrophic failure in case of propeller disintegration or a motor malfunction. The fixed-wing multi-rotors of the XZ-series are award winning inventions from Archimedes 2015, Inventarium Science 2015 and Tesla Fest 2015 international inventions exhibitions.

Model	Description and images
Model: **XZ-4A** Group: **Fixed-wing** Topology: **Tail-sitter** Rotors: **6** Year: **2014**	 This model is similar to the XZ-4 aircraft, but exhibits a larger margin for rotor failure. Due to the mounting of the off-wing propellers not on one side, but on both sides of the wing, the failure of any rotor is in general terms manageable. The design proposes higher rigidity of the off wing rotor nacelles as they are mounted at the fuselage instead of at the wing, thus relieving the wing structure from excessive structural tension and the following structural strength require-ments. Stage of development is concept.
Model: **XZ-4B** Group: **Fixed-wing** Topology: **Tail-sitter** Rotors: **4** Year: **2014**	 The XZ-4B is still another fixed-wing multi-rotor aircraft having only four rotors, instead of 6 as with the previous two models. The airplane is thus lighter, simpler and easier to maintain, but is prone to catastrophic failure if one of the rotors suffers a damage. XZ-4B is nevertheless a valuable testing platform for the vertical take-off and landing approach in the field of fixed pitch propeller multi-rotors. It also does not rely on moving aerodynamic surface for attitude control which makes it one of the simplest and cheapest aircraft in its class. The stage of development is concept.

Model	Description and images
Model: **XZ-5B** Group: **Compound** Topology: **H-frame** Rotors: **7** Year: **2014**	  The XZ-series of drones includes compound helicopters. These are multi-rotors that rely on horizontal rotors for creating lift and at the same time they use vertical rotors for creating horizontal trust and moving the aircraft horizontally like an airplane. The benefits of this approach are numerous and large helicopter companies are evaluating this it such as Sikorski Aircraft and JSC Kamov. In the field of small UAVs such a design is novel and was pioneered by the XS-series through several of its models.
Model: **XZ-2A** Group: **Compound** Topology: **H-frame** Rotors: **9** Year: **2014**	 The XZ-2A model is again a development from XZ-2 which was turned into a compound multi-rotor. The model is again conceptual in its nature and serves only as a basis for the creation of practical compound multi-copters. The aircraft has 9 rotors, one of which is vertical at its tail and is used for horizontal propulsion.
Model: **XZ-2B** Group: **Compound** Topology: **H-frame** Rotors: **10** Year: **2014**	 XZ-2B is the first compound model from the XZ-series that is created with the idea of complete realization and extensive prototype testing. This model is not only following the compound helicopter paradigm, but it is also designed for rigidity and speed. It is aerodynamically sound, has stable fuselage construction and its horizontal rotors are undermount in respect to the airframe.

Model	Description and images
Model: **XZ-6A** Group: **Compound** Topology: **Honey comb** Rotors: **12** Year: **2014**	 The XZ-6A model is a reduction from the XZ-6. Two of the horizontal rotors are removed and two vertical rotors are mounted instead in their places aimed at horizontal propulsion. The model benefits from the honey comb paradigm for optimal geometric covering of the horizontal rotors and also improves its horizontal speed properties by employing vertical rotors at its tail. The stage of development is concept.
Model: **XZ-2C** Group: **Compound** Topology: **H-frame** Rotors: **10** Alias: **Thunder** Year: **2019**	 Still further improvement on the XZ-2B model is one of the latest developments in the XZ-series – the XZ-2C aircraft [8]. This multi-rotor has 10 rotors, 2 of which are used for horizontal propulsion and are mounted at the tail of the fuselage. The 8 horizontal rotors are mounted on two parallel longitudinal beams. The front 6 rotors are undermount while the rears 2 are over mount in respect to the beams, thus minimizing mutual interference among the horizontal rotors during forward flight. The two beams are connected using horizontal flat aerodynamic surfaces exhibiting aerodynamic lift when the aircraft is in fast forward flight. The aircraft lands on three flat streamlined legs. The payload is positioned at the front of the fuselage. This hard-point placement allows wide field of view in case of cameras used as payloads. The horizontal rotors' rotation directions are chosen in such a way that the non-stalled sections of the rotors are in minimal mutual interference. The current stage of development is concept with the aim of prototype development.

Conclusion

The XZ-series is in constant development during the last five years and is an evolving project. It is oriented towards multi-rotor aircraft in different variants and paradigms regarding multi-copters.

Multi-rotors require innovative development because this technology hides a significant potential for modern inventions. The field, although initiated during World War I, is still lacking significant scientific attention and one should be sparked.

The described developments are mostly theoretical, although not exclusively. Nevertheless, the focus on the work has moved towards real experiments with prototypes and flight tests.

The series has covered an astonishing variety of presentations in the scientific media acquiring publications with all kinds of scientific metric such as patents, international medals and awards received from exhibitions, conference reports, and scientific articles published in high impact journals.

References

1. Zabunov, S., and G. Mardirossian, Innovative Dodecacopter Design – Bulgarian Knight. International Journal of Aviation, Aeronautics, and Aerospace, 5, 4. https://doi.org/10.15394/ijaaa.2018.1293.
2. Zabunov, S. and G. Mardirossian, In-flight Reconfiguration of Lithium-ion Cells Aimed at Extending Flight Times and Range of Electrically Powered UAVs, International Journal of Intelligent Unmanned Systems, 7, 3, 98–111. https://doi.org/10.1108/IJIUS-08-2018-0026.
3. Zabunov, S. and Nedkov, R. (2019), "Edge controller – a small UAVs distributed avionics paradigm", Aircraft Engineering and Aerospace Technology, Vol. 92 No. 2, 229–236. https://doi.org/10.1108/AEAT-04-2019-0087.
4. Zabunov, S., P. Getsov, and G. Mardirossian, Vertical Take-off and Landing Airplane, Bulgarian Patent Office Utility model reg. № 2765 / 12.05.2014.
5. Zabunov, S., G. Mardirossian, and P. Getsov, Tandem Helicopter, Bulgarian Patent Office Utility model reg. № 3223 / 05.08.2019.
6. Zabunov, S., G. Mardirossian, and R. Nedkov, Multi-copter for Stereo Observations, Bulgarian Patent Office Utility model reg. № 3170 / 21.01.2019.
7. Zabunov, S., G. Mardirossian, R. Nedkov, 18-rotor Multi-copter, Bulgarian Patent Office Utility model reg. № 3169 / 23.01.2019.
8. Zabunov, S., G. Mardirossian, and R. Nedkov, 10-rotor Compound Multi-copter, Bulgarian Patent Office Utility model reg. № 3200 / 24.06.2019.
9. Zabunov, S., G. Mardirossian, Hybrid Multi-copter, Bulgarian Patent Office Utility model reg. № 3175 / 07.03.2019.
10. Zabunov, S., G. Mardirossian, Twelve-rotor Drone for Remote Sensing Applications, Bulgarian Patent Office, submitted on 11.10.2019.

XZ-СЕРИЯ БЕЗПИЛОТНИ ЛЕТАТЕЛНИ АПАРАТИ ПРЕЗ 2020

С. Забунов

Резюме

Серията XZ безпилотни летателни апарати стартира през 2014 г. първоначално като начинание, целящо теоретични разработки на мулти-роторни безпилотни летателни модели. Идеята и основната работа беше осъществена от автора на настоящата статия и сега, в 2020 г., серията е все още в непрекъснат процес на изобретяване на нови модели. Повечето модели са патентовани в Българското патентно ведомство чрез патенти за изобретения или полезни модели. През последните години се появиха публикации относно серията XZ в чуждестранни научни списания с висок наукометричен статус.

Серията от летящи машини XZ включва различни мулти-роторни летателни апарати като стандартни мулти-ротори, мулти-ротори с фиксирано крило и съставни мулти-роторни летателни машини.

Тази статия е кратко ръководство, толкова кратко, колкото може да бъде, върху състоянието на серията XZ безпилотни летателни апарати към 2020 г. Очаква се тя ще бъде последвана в бъдеще от продължения, публи-кувани редовно, които ще обобщават продължаващия процес на разработка на нови модели в серията XZ.