Volume XXV, 48 – No.1, 2023, DOI: 10.35116/aa.2023.0008

OVERVIEW OF SUITABLE LIGHT SPORT AIRCRAFT FOR SUBURBAN AND URBAN MOBILITY MANUFACTURED IN SLOVAKIA

Juraj VAGNER, Marek Košuda*, Anton KORNIIENKO, Karol SZPARA
Technical University in Kosice, Faculty of Aeronautics, Rampova 7, 040 12 Kosice
**Corresponding author.* E-mail: marek.kosuda@tuke.sk

Abstract. The aim of this article is to describe and explain how they are manufactured and how flying sport aircraft could be used. Partially describe the characteristics of light sport aircraft, parameters, flight characteristics, the material used for their production, and their advantages, which could be used to improve mobility in suburban and urban transport. Currently, materials, procedures, and technologies are developed for the development of such devices to achieve sufficient performance and to be safe for aircrews. The idea of using such air transport for short distances has existed for a long time, and we would like to clarify this issue, as we consider it topical. Some types of light sport aircraft are materially and technologically similar but have different shapes and parameters. Modern technologies are used in production, these flying sports devices have great potential for use not only for sports and recreational purposes but also for transportation between airports, cities, and other countries.

Keywords: urban and intercity mobility, flying sports equipment, rotorcraft, air car

1. INTRODUCTION

Sport aircraft are primarily developed for people's leisure activities. Subsequently, these people began to push the boundaries of technical possibilities, which helped in the development of new modern aircraft, because the technologies used in large aircraft are also used in sports aircraft. They also pushed the boundaries of their knowledge, but also the awareness of the entire general aviation. It is these reasons that make it possible for these flying devices to be used not only for sports and leisure use, but also for transport between municipalities, cities, states, and, in some cases, between continents. Such as, for example, a 19-year-old pilot of Belgian-British origin Zara Rutherford [1], flew around the world in a Slovak-made Shark Aero flying sports equipment. She wanted to inspire young women and girls about aviation with her trip around the Earth.

A light sport aircraft (LSA) is a non-pressurized, fixed-wing, two-seater aircraft no heavier than 600 kg (max. take-off weight), and powered by a single non-turbine engine equipped with a propeller Design is oriented to satisfy three requirements: a high-performance trainer aircraft, a low fuel consumption that permits an extended flight range, competitive cost manufacture processes [2].

Commercial aircraft have well-designed and optimized systems, the result of a huge experience in the field, due to the large fleet of aircraft in operation. For light, utility, or sports aircraft, with a multitude of shapes, tasks, and construction types, there are different solutions that seek to best meet the requirements of the designed aircraft [3]. The purpose of this work is to discuss the possibilities of using such devices and to explain the technical nuances.

2. MATERIALS AND METHODS

The most extensive development of light sport aircraft began around the nineties of the last century when materials such as wood and lattice construction combined with plywood were used to produce fuselages, wings, and tail surfaces, which is essentially the first composite material of flying sports

equipment. Steel ropes were used to control the control surfaces. Dural pipes were not widely used because they were expensive and hard to come by. At that time, composite materials were still not widely believed, because they had not been examined mainly in terms of strength and durability. Two-stroke Trabant and four-stroke Volkswagen engines were used as drive units. The performances of these engines were still insufficient, they had to be adjusted to higher performances and also their rotations had to be reduced because they worked at higher revolutions in order to achieve sufficient performance. The propellers were wooden, two-bladed. They were most often used by the propeller of Křemen manufacturer from the Czech Republic, and trial three-bladed MIHALIDES propellers were also used in Slovakia. At the same time as these two types of engines, a more refined and safer, but considerably more expensive engine of the Austrian brand ROTAX series 447 and 503 was used. The first pioneers include, for example, MiniMax, StratonD-8 Mobydick, and AVD 1 JUNIOR [4].

The methodology is based on summarizing basic information from individual flight manuals, which are processed by individual manufacturers of light sport aircraft. The next step was to assess the flight characteristics of each of the flying devices. Working with literary sources helped to discover different types of flying sports equipment and to expand this article to other types of aircraft in relation to the issue of suburban and urban mobility. Materials are also based on consulting activities with some pilots who have experience flying certain types of light aircraft. In the discussion section, we analyze all the information and discuss the possibilities of using these aircraft in relation to the issue we are dealing with.

3. RESULTS

Newer types of light sport aircraft are designed to be used on a wider scale. Therefore, the constructions of these machines are built on modern materials, which ensure their perfect aerodynamic shape, high strength, and lower weight. Modern composite materials have replaced wood and cotton canvas, which were used in the past for the construction of light sport aircraft. In conjunction with glass carbon laminate composites, the airframes of such machines are much lighter and stronger. The instrumentation is also at a high level. Classic devices, hand analog devices are replaced by new multifunctional screen devices, the so-called glass cockpit. Nowadays, modern navigation systems are used in such machines, which can cooperate with autopilots of various brands and are usually installed in light sports aircraft. At the same time, devices to ensure flight safety are being installed, such as new types of secondary radar transponders and anti-collision systems. In this part of our work, we discuss the characteristics of modern light sports aircraft. Such modern and powerful types of light sports aircraft produced in Slovakia include, for example, WT-9 Dynamic, Viper SD-4, Shark, hybrid AirCar, which is essentially a car, and after transformation an airplane, rotor flying sports rotary device Nisus.

3.1. Light sport aircraft WT-9 Dynamic

It is a light sports aircraft manufactured in Slovakia by Aerospol Prievidza Ltd. Dynamic is a two-seater low-wing aircraft made of glass and carbon composites. They are produced with two types of landing gear. The first is a fixed tricycle landing gear, the second is a retractable tricycle landing gear using an electro-hydraulic system for retraction. The size of the tanks can be determined by the customer before the start of construction. The tail surfaces are in a classic configuration. The cabin has side-by-side seats and is equipped with dual steering.

The Dynamic has a large luggage compartment behind the crew seats. A rescue system is in the front part of the hull. Four-stroke Rotax 912 series engines in the 100-horsepower version with carburetors and Rotax 914 with electronic fuel injection are used for propulsion. The three-blade propellers Woodcomp SR 3000 3WN electrically adjustable in flight are most often used. Instrumentation is via large screens. The classic analog instruments are only the altimeter, speedometer, and variometer, which are only backups in case the main screens fail. This flying sports equipment uses a modern type S or ADS-B transponder and a radio station that can track two

frequencies. Some flying sports equipment may also be equipped with TCAS anti-collision systems. A powerful autopilot also works with such systems [5].

Figure 1: WT-9 Dynamic [5]

Experienced pilot Karol Szpara, who is the co-author of this work, states that: this flying sports aircraft is fast, but not very suitable for training new pilots. Training on this machine is challenging. This machine is not very tolerant of piloting errors, especially during training. Aircraft are designed for traveling over longer, but also shorter distances. Its range is from 800 to 1000 km, depending on the size of the tanks.

Table 1 Basic parameters of WT-9 Dynamic [5]

Span	9,00 m
Length	6,40 m
Bearing surface	10,30 m^2
Empty weight	340 kg
Max. take-off weight	600 kg
Falling speed	60 km/h
Max. unexceed speed	280 km/h
Max. turnover speed	160 km/h
Cruise speed	240 km/h
Ascent	6,5 m/s
Take-off over a 15-meter obstacle in two crews	250m

3.2. Aircraft Shark

Shark is manufactured by the Slovak company SHARK AERO Ltd. in Senica. Shark is a two-seater all-composite low-wing aircraft made of carbon fibres. The Shark uses a retractable type of landing gear. This landing gear is designed primarily for grass take-off and landing areas, but also for concrete and asphalt airports. The control stick is not located like in classic light sports aircraft in the middle but on the sides of the cabin. The control stick is located on the right side of the cabin and the throttle control lever is on the left side. The cabin does not have a large luggage space. The rescue system is in the front part of the fuselage. Shark's instrumentation comes in two versions: a standard analog version and a digital one that uses a large-screen instrument display. In cooperation with these devices, modern S or ADS-B secondary radar transponders, two-frequency tracking radio stations, and TCAS anti-collision systems are installed. Powerful autopilot systems are installed following the customer's request [6]. We use the picture below to illustrate the given type of aircraft.

Figure 2 Aircraft Shark [6]

It is suitable for long journeys, and its range for one refueling is around 1400 km. Its instrumentation makes it possible to fly even in bad weather conditions, but of course with appropriate pilot training.

Table 2 Basic parameters of SHARK [6]

Span	7,90 m
Length	6,80 m
Bearing surface	9,50 m^2
Empty weight	347kg
Max. take-off weight	600 kg
Falling speed	65 km/h
Max. unexceed speed	327 km/h
Max. turnover speed	188 km/h
Cruise speed	249 km/h
Ascent	7,5 m/s
Take-off over a 15-meter obstacle in two crews	225 m

3.3. Aircraft Viper SD-4

Viper SD-4 is an all-metal two-seater ultralight aircraft designed primarily for recreational flying with the possibility of light acrobatics manufactured in Slovakia by the company TOMARK, Prešov. Viper is a two-seater all-metal low-wing aircraft made of duralumin [7]. The tanks are integrated into the wings. The cabin is with side-by-side seats and double steering, luggage compartment behind the crew seats. The tail surfaces are in the classic arrangement but are not part of the fuselage. The Viper is produced with a fixed three-wheel landing gear. The Viper is powered by a single four-stroke Rotax 912 series power unit in the 100-horsepower version with carburetors, and a three-blade NEUFORM CR3-65 ground-adjustable propeller. This configuration gives it sufficient performance. A large-screen digital instrument panel is installed in the Viper, which includes a radio station, an ADS-B type secondary radar transponder, and an anti-collision system. These devices are in a double arrangement for each seat. Viper SD-4 is also produced for night flights according to demand. Also, powerful autopilot systems are installed in this flying sports equipment by request of the customer [8].

Figure 3 Viper SD-4 [7]

Table 3 Basic parameters of Viper SD – 4 [8]

Span	8,34 m
Length	6,40 m
Bearing surface	10,45 m^2
Empty weight	378kg
Max. take-off weight	600 kg
Falling speed	60 km/h
Max. unexceed speed	230 km/h
Max. turnover speed	158 km/h
Cruise speed	180 km/h
Ascent	6 m/s
Take-off over a 15-meter obstacle in two crews	270 m

According to the co-author of this article and experienced pilot and flight school instructor Karol Szpara, this aircraft can forgive minor mistakes in piloting, especially when training new pilots, so it is more suitable for training compared to WT-9 Dynamic and Shark. The claims are based on years of experience flying this type of aircraft. Traveling is comfortable, it has enough space for the crew and a good view out of the cabin. Therefore, the pilot has a good estimate of the actions he must perform during takeoff and landing. The instrumentation allows flying even at night. It is also possible to fly in bad weather conditions with appropriate pilot training. The range for one refueling is 1000 km.

3.4. Rotor light sport aircraft NISUS

It is a rotor light aircraft (gyroplane), manufactured in Slovakia by Jokertrike Ltd., Topolčany. Nisus is a flying sports device that uses the rotation of the rotor blades as a lift generator for flight and needs the power of the engine and propeller in a thrust configuration to move forward. It is a two-seater flying device with side-by-side seats. Instrumentation is located on a single center console between the crew, which is also located in the throttle. Above these elements are one large-screen digital instrument cluster and backup digital-analog instruments. A radio station is located on the instrument panel below the flight instruments, which can monitor two frequencies [9].

Figure 4 Nisus at Bratislava Airport [9]

Nisus uses the rotation of rotor blades for its flight. The rotor blades create lift, but the angle of attack of the blades does not change. The blades are set tight by the rotor manufacturer. To change the lift and to change the tilt, the inclination of the entire rotor disk is changed. This means that during take-off the entire rotor disk tilts to the angle of attack, thereby creating lift at a low forward speed and the rotor rises. The take-off of the rotorcraft is short for this reason. After disengagement, the angle of attack of the entire rotor disk must be quickly reduced, because the large bearing surface of the rotor slows down the forward speed, the rotor speed drops and the rotor falls to the ground. In flight, tilting the rotor disk to the side changes the lateral tilt of the entire rotor. Foot control controls two rudders.

Table 4 Basic parameters of Nisus [9]

Rotor diameter	8,50 m
Length	4,76 m
Area of the rotor disk	56,71 m^2
Empty weight	356 kg
Max. take-off weight	560 kg
Speed in autorotation mode	0-160 km/hod.
Max. unexceeded speed	160 km/hod.
Max. turnover speed	130 km/hod.
Cruise speed	120-130 km/hod.
Ascent	3,5 m/s
Take-off over a 25-meter obstacle in two crews	300m

Flights in strong winds are not a problem, and they also do not feel the turbulence caused by thermals. So, flying in such conditions is not so stressful for the pilot. The range of the gyroplane for one refueling is 390 km. This means that the rotorcraft is not very suitable for long journeys also because of the high fuel consumption. Training on the gyroplane is demanding and requires more coordination, precision, estimation, and fine-sensitive movements. The advantage of such a machine is that it can land on short surfaces and can also take off from short surfaces.

3.5. Flying air car Klein

The AirCar Klein is basically a hybrid machine, it is both a car and an airplane. The aircraft is designed, built, and flown by Stefan Klein. The Aircar Klein prototype is manufactured at the Nitra airport. All ground and flight tests are conducted at this airport. It is a flying device that is still under intensive development. It is currently certified in flight configuration as experimental and similarly in car configuration. Fuel tanks are integrated into the wings with a capacity of 30 liters, and one central tank is located in the fuselage with a capacity of 11 lifters. The controls are combined for both the

airplane configuration and the car configuration. The tail surfaces are handled by two directional stabilizers and rudders, one height stabilizer, and a height rudder located on the direction indicators. The instruments are digital displays for both car and airplane configurations. A rescue firing system is also located in the fuselage [10].

Table 6 Basic parameters of AirCar Klein in airplane mode [11]

Span	8,00 m
Length	7,40 m
Height	1,773 m
Max. unexceeded speed	300 km/h
Maneuvering speed	230 km/h
Cruise speed	230 km/h
Take off over a 15-meter obstacle	550m

Visual inspection is required after transformation. This whole process is shown on the transformation display. In the event of a fault, the exact specification of the fault will appear on the display.

Figure 5 AirCar Klein [11]

This hybrid machine is interesting and has a lot of potential, but it still has to overcome the entire development process to complete perfection, in terms of the safety of flying in the air and driving on land. And also, with regard to approval procedures for flying, training of new pilots, and procedures for driving. So, for use in suburban and urban air and ground transport, it is still too early to say in what time frame it will be able to meet these requirements.

4. CONCLUSION

Based on our simple comparison, the Shark aircraft is the most suitable, easiest-to-control flying device for urban and suburban transportation. Another suitable one is the Nisus rotorcraft, but it is difficult to train and pilot. Since AirCar Klein is still in experimental development, it could not be objectively evaluated in comparison, but it has high prospects for use in urban and suburban transport in the future.

For example, a flight from Partizánské to Košice takes about an hour and a half with a plane flying at a speed of 140 km per hour and uses 15 liters of fuel, but by car, this journey takes four and a half hours and uses 25 liters of fuel.

AirCar has a big advantage in all this. It can cover distances with sufficient speed and, after landing at a suitable airport, it can transform itself from a plane to a car, thus solving the question of the destination. Well, we have to wait a while for that, because it is still in the development phase. A rotorcraft has a similar advantage, although it is not as fast in covering distances and has a higher fuel consumption than airplanes or AirCar Klein, it can take off from a short area, which does not have to

be an airport, basically, a straight road is enough. Such machines are equipped with modern avionics, instrumentation, and cabin comfort, and ergonomics are adapted for longer trips. This flying sports equipment can be used for recreational, holiday, or work trips between cities and towns that have take-off and landing areas.

By expanding the number of cities and towns in which airports or take-off and landing areas would be located, the development of air transport and thus employment in air transport can be significantly increased.

Light sport aircraft can also be used for flights, for example, abroad to the sea, where with such a flight they can significantly shorten their travel time and extend their stay. Such flying machines can be used not only for private and sports activities but also entrepreneurs and business travelers could use them for business trips between cities and towns and also for flying abroad. By flying, they would spend less time traveling and could use this saved time for work matters. Such travel is not so tiring, the stresses of road traffic disappear and there is less likelihood of a traffic accident. Actually, this type of air transport is primarily limited by suitable areas, time of day, and meteorological situations.

References

[1] Ruthenford Z,.Solo flight around the world. Available at: https://flyzolo.com

[2] Piedra S., et al. Computational aerodynamics analysis of a light sport aircraft: Compliance study for stall speed and longitudinal stability certification requirements. In Aerospace Science and Technology Volumes 82–83, November 2018, Pages 234-242, https://doi.org/10.1016/j.ast.2018.09.016

[3] Ghiţescu I.,M et al. New Command Mechanism of Flaps and Wings of a Light Sport Aircraft https://doi.org/10.3390/sym13020221

[4] Gratton G., A UK-centric history of the testing and certification of fuse-tube design microlight aeroplanes, Journal of Aeronautical History, 2012 Available at: https://www.aerosociety.com/media/4850/a-uk-centric-history-of-the-testing-and-certification-of-fuse-tube-design-microlight-aeroplanes.pdf

[5] Aerospol Ltd., Aircraft flight manual WT-9 Dynamic, Available at: https://www.aerospool.sk/downloads/bulletins/LSA/service_bulletins/MBWT9LSA_1A_2011_EN.pdf

[6] SharkAero Ltd., Aircraft flight manual Shark, Available at: https://www.manualslib.com/manual/1505291/Shark-Ul.html

[7] Kužma D., Korba P., Chovanec M., Dulina M., The Use of CAX Systems as a Tool for Modeling Construction Element in the Aviation Industry, Naše more, Vol. 63 No. 3 Special Issue, 2016

[8] Tomark Ltd, Viper SD-4 Flight Manual, Available at: http://www.esme.se/doc/Viper%20SD-4%20UL%20(SN%200042)%20Flight%20Manual%20rev%207a%20upd%20kts.pdf

[9] Jokertrike Ltd, Gyroplane Nisus, Available at: https://www.nisus-aero.com

[10] Aero Affaries, Aircar, the flying car certified by the Slovak transport authority, Available at https://aeroaffaires.com/aircar-the-slovak-flying-car/

[11] Klein Vision, Research and Development of AirCar, Available at: https://www.klein-vision.com/rd

Received 06, 2023, accepted 06, 2023