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The influence of the development of private air communication on the architecture and urban planning of the 21st century

Wpływ rozwoju prywatnej sieci komunikacji powietrznej na architekturę i urbanistykę XXI wieku

Abstract

In the first part, the article describes the stages of the development of gyroplanes and the influence of wartime policy on the interest in light aircraft. Also presented are links and the possibilities of using gyroplanes in various sectors of the economy. The authors, based on source texts, present the current position of the aviation industry in the Polish economy and attempt to diagnose its development capabilities. As a result, factors responsible for the current condition of the light aviation industry and its links with architecture and urban planning are submitted. The question is posed: what consequences will the development of the aviation industry bring for architecture and urban planning, for the community and the image of 21st century cities?

Keywords: metropolitan transport, urban planning, urban mobility, urban airspace, landing areas, helipads, high-rise buildings, ultra-light aviation, helicopters, gyroplanes, architecture, future of aviation, personal aviation, air traffic control

Streszczenie

Niniejszy artykuł w pierwszej części przybliża etapy rozwoju wiatrakowców oraz ukazuje wpływ polityki czasów wojennych na zainteresowanie lekkimi statkami powietrznymi. Przedstawione zostają również powiązania oraz możliwości wykorzystywania wiatrakowców w różnych sektorach gospodarki. Autorzy, na podstawie tekstów źródłowych, ukazują aktualną pozycję przemysłu lotniczego w polskiej gospodarce i podejmują próbę diagnozy jego możliwości rozwojowych. W efekcie zidentyfikowane zostają czynniki oddziałujące na obecny stan przemysłu lotnictwa lekkiego oraz jego powiązania z architekturą i urbanistyką. Otwarte więc jest pytanie: jakie konsekwencje przyniesie rozwój przemysłu lotniczego dla architektury i urbanistyki, dla społeczności i obrazu miast XXI wieku?

Słowa kluczowe: transport metropolitarny, urbanistyka, miejska przestrzeń powietrzna, lądowiska, wysokościowce, lotnictwo ultralekkie, helikoptery, wiatrakowce, prywatny transport lotniczy

1. Introduction

The progress of civilization significantly affects people's aspirations, which are becoming ever more bold: faster, more precisely, further, higher - these attributes to a large extent define the goals of the 21st century society. Recently there has been seen an increasing interest in light aircraft. Thanks to their small requirements, ultralight aircraft and aerodynes with movable support flaps - gyroplanes and helicopters, have become an attractive alternative to land transport for both emergency and private/business purposes. Many examples of their use can be found in various sectors of the economy. The ease of use light aircraft as well as their small size and small requirements for the landing field have contributed to the increase in interest in above mentioned machines among the uniformed services, engineers and private individuals [37, 38].

In the agricultural economy there are also opportunities to use gyroplanes as is demonstrated by the numerous articles, projects and studies. For instance the GyroScan project proposes to collect data on plants' needs by using a measuring system which can be mounted on a gyroplane's deck. Such method has got many advantages, including non-invasive measurement procedures, as well as the accuracy of the acquired data at low costs [1]. The GyroScan project also raises the issue of positive ecological effects of using gyroplanes in agriculture. D. Ungiert [21] also shows many positive aspects of the use ultralight and electric aircraft, including the ecology – lack of exhaust emissions to the air, as well as the economy – the possibility of obtaining funding for an environmentally friendly object. Thanks to their ease of use, gyroplanes are appreciated among private individuals (the license is easy to obtain), who use them for sports, hobbies and also as the quickest transport option. [19, 38] Ultralight aircraft, gyroplanes and helicopters are growing in popularity and find more and more supporters. Undoubtedly, these machines will be increasingly used in all sectors of the economy, especially because there is work going on to develop the gyroplanes, for instance about the possibility of vertical landing and jump takeoff [8].

The purpose of this article is to gather information and present the current state of the light aviation industry, identify the factors which influenced that state, showing the relationship between the light aviation industry and other fields of the economy, as well as present the predictions of its future development. The text attempts to diagnose how the dissemination of the private, air metropolitan transport system influences the field of architecture and urban planning.

2. Methodology and process of the research

The preparatory phase of the research was to become familiar with classification of aircraft, as well as with the general characteristics of ultralight airplanes and aerodynes with movable support flaps. The next step was to study the history of the development of gyroplanes, which helped to identify the factors responsible for the current state of the light aircraft industry. The preparation covered a wide range of literature.

The next stage of the research was to verify and organize the collected information. Many areas of the economy were found that related to the use of light aviation. The background for the study was to study the experiences and patents in which gyroplanes are being used. The above mentioned actions made it possible to find the answer for the question of whether the aviation industry carries potential. Finding the answer to this question led to forward research. Based on the source materials, it was shown how the development of the aviation industry may impact on architecture and urban planning in the 21st century.

The article was supported by statistical data which are presented in Table 1. The method of logical argumentation was also used in the research. After passing all of above mentioned stages it became possible to identify the factors influencing the current state of the light aircraft industry and its links with various sectors of the economy. In the essay predictions of the future development of the light aviation industry are shown, as well as its influence on the architecture and urban planning of the 21st century. The summary presents the conclusions derived from the research and suggests directions for further work.

3. General classification of aircraft, historical outline of gyroplanes

According to the Regulation of the Minister of Transport, Construction and Maritime Economy on the classification of aircraft [15], the following classes of aircraft are listed: airplanes, gliders, motor gliders, helicopters, gyroplanes, balloons, airships, hybrids, rescue parachutes, heavy unmanned aerial vehicles, flying devices. This article focuses mainly on the gyroplanes, whose general historical outline is presented below.

Juan de la Cierva (1895–1936), a Spanish constructor and pilot, wanted to construct a stall-resistant safe machine. In 1920 the first gyroplane, the autogyro C.1, was created as a result of Cierva's considerable activities. Although this model never rose into the air it confirmed itself the principle of autorotation. Soon after, the unfinished prototype autogyro C.2. and C.3. were constructed. In 1923, Cierva completed the construction of the C.4 model and that year the first, fully controlled flight on the gyroplane also took place. Cierva did not stop at work, several months later he modernized the C.4.. The constructor obtained funding from the Spanish government. Thanks to this he could continue his work. In the short time the following models were created: C.5. and C.6., in the last one constructor made a several-minute flight. The success of Cierva attracted J. Weir, who suggested the Spaniard to set up a gyroplane factory in England. The enterprise was established under the name Cierva Autogiro Company Ltd located in Hanworth.

The C.6 model was implemented for serial production, the United Kingdom became the largest centre for the development of gyroplanes. In 1928 the first gyroplane flight over the English Channel took place, which aroused the interest of Germans and Americans. The success of the experiments prompted Cierva to introduce new refinements to his machines. The models were becoming lighter and more agile. In 1928 Cierva signed a contract with Harold Pitcairn relating to the joint production of gyroplanes in America. The company was founded under the name The Pitcairn Autogiro Company (PCA). In 1930 H. Pitcairn

modified the driving system which was used in the C.11 model. The improved machine was given the name PCA-2. After some slight modifications, this model began to be used in the United States Navy, and several aerodins were bought for private purposes.

In 1931 Burke Wilford of Pennsylvania constructed a machine with a rigid rotor carrying as an alternative to Cierva's models. In the 1930s, Cierva developed a new model: C-30., and in 1933 an improved version of model C-30W. This was a breakthrough in the construction of gyroplanes because it was the first gyroplane in the world equipped with a tilting, rigid rotor. That machine fulfilled all its intended goals such as quicker reaction to the controls as well as easier handling. The Kellett Autogyro Corporation (Philadelphia) was interested in gyroplane production and soon after the model YG-1 was produced, which was modification of C.30W. The license of this gyroplane was also sold to France (where it was produced under the name LeO C.30 in Liore et Olivier), to Germany (where it was produced under the name Focke-Wulf C 30 Heuschrecke in Focke-Wulf factories) and Japan (where the Kayaba Ka-1, based on C.30W. was developed). Poland bought one gyroplane: the Cierva C-30. That machine was intended to be a military aircraft but it did not pass the tests (there was no space for crew parachutes in it. Moreover, it was not possible to arm the machine or maintain the connection with it). For this reason the gyroplane was transferred to the Pomeranian Aeroclub in Torun where it was used until 1939.

In 1935 the first helicopter Breguet-Dorand 314 flew, and subsequently the VS300 helicopter constructed by Igor Sikorski from Russia succeeded. Helicopters became extremely attractive and knocked gyroplanes off their pedestal. The army lost interest in gyroplanes, and therefore the co-financing of experiments conducted on them was stopped. As a result, it led to the stagnation in their production and development. In 1960 Ken Wallis (Great Britain) constructed a gyroplane with a maximally simple construction and very low mass (which evokes associations of current sports aerodins) and in 1961 he opened a workshop in which he started the production of gyroplanes based on his own ideas. Wallis constantly upgraded the produced gyroplanes and in 1974 his WA-116F machine set a new world record for gyroplane flight (670 km). In 1984 The FAA (Federal Aviation Administration) considered a gyrocopter as an aircraft for use in sports. Since then the USA has constituted a major outlet for these machines. The advantages of gyrocopters include their lower construction and operation costs than tourist aircrafts or helicopters. Nevertheless, the gyroplanes did not play significant role in any field and their popularity did not increase more (even in European countries) until the end of the 20th century [10, 16, 40].

4. New possibilities in the use of gyrocopters

The interest in gyroplanes was especially evident the wartime. American engineer, Harold Pitcairn noticed the huge potential of these machines and decided to work with Cierva. Soon after that another American company (The Kellett Autogyro Corporation, Philadelphia) became interested in gyroplanes. The Cierva model was improved and the YG-1 machine became the first gyroplane used by the armed forces of America.

The YG-1 model was used as a scout ship (because it did not have typical combat characteristics) to determine the exact position of the enemy during the Second World War. H. Pitcairn and his staff put a lot of effort into the development of gyroplanes, and they modified the drive system. These improvements were awarded the highest prize in American aviation 'the Collier Trophy' which Pitcairn received in 1930 [34]. In 1939 Eastern Air Lines (the main American airline in 1926-1991) became interested in these aircraft and used them to deliver postal items. Whereas the British army used the capabilities of gyroplanes in calibrating the vital air-defence radar network. The German company Focke-Wolf has started production of gyroplanes on a large scale. However, as quickly as the industry grew it collapsed. Helicopter manufacturers had infringed the rotary wings patents (Pitcairn had brought a lawsuit against them and finally won) consequently the gyroplanes were replaced by a new technical achievement – helicopters. Because of them the gyroplanes disappeared into oblivion for decades. The era of helicopters began. They were used almost in every field. Ultimately, at the end of the 20th century the construction of the first Polish Xenon gyroplane was undertaken. The prototype model called SP-XENA was used by R. Owedykwas. But how does the situation look nowadays? (see:[10, 16, 40])

Recently the interest in the aviation industry has become more widely visible. The number of registered private aircraft is increasing as well as the number of schools offering a piloting course. Increasingly attractive (also in terms of prices) gyroplanes are available to a wider group of recipients including private individuals. They are used for business purposes as well as for recreation or tourism [12, 19]. The potential of the machines is also noticed in many different areas of the economy. In engineering, gyroplanes can be used to scan industrial lines (for instance energy lines) thanks to scanners installed on their base. Scans are used for mapping and three-dimensional city models. It is an extremely attractive solution when taking into account ever more cities aim to create a 3D model of their area [14, 36]. Meanwhile, the possibility of using gyroplanes in the agricultural economy is demonstrated in the GyroScan project [1] which aims at identifying needs in the field of agricultural operations (i.e.: irrigation, fertilization and chemical pest control) through the analysis of hyperspectral images. It is proposed to install a measuring system on a gyroplane deck and use the collected data to create high resolution maps. The use of such methods would have a positive impact on the development of precision agriculture. By understanding the exact requirements of plants it becomes possible to reduce the amount of distributed fertilizers. Gyroplanes can also be used in emergency medical services. The machines are also being used by uniformed services, firefighters: for example for patrols or for searching for missing people. The advantage of using gyroplanes is undoubtedly the lower operating cost than traditional helicopters. What is more, thanks to savings it is possible to train more people to pilot them [11, 24, 25, 35].

5. The impact of the development of the aviation industry on the architecture and urban planning in the 21st century

The insufficient number of scientific publications has been influenced by the delayed implementation of gyroplanes in the Polish economy. Nevertheless, aviation in Poland is gaining more and more popularity and the number of enthusiasts is increasing every year [27, 37]. According to the research, in 2000–2015, it was noticed that the annual average increased about 7% in the number of machines offered by General Aviation, including involvement of rotorcrafts by over 15% and within this the contribution of gyroplanes oscillates around 21%. Therefore, input of the gyroplanes in the market is around 8% (increased by ~4%) [18]. The number of ultralight aircraft registered in Poland is also constantly increasing, as shown in the table below.

Table 1. Number of aircraft in Poland in 2014-2016; based on 2016 the General Aviation Statistic Databook & 2017 Industry Outlook [30]

Date	*Number of ultralight aircraft*	*Number of gyrocopters*	*Total number of all aircraft*
2014	*204*	*21*	*2,871*
2015	*226*	*26*	*2,757*
2016	*239*	*32*	*2,829*

Table 1. shows that the number of ultralight airplanes in Poland increased in the course of two years by ~ 17% while gyroplanes by ~ 52%. The share of gyroplanes in the total number of aircraft in 2014 was 0.73%, in 2015 it amounted to 0.94% while in 2016 already 1.13%. These quotes prove the growing interest of the gyroplane market [26, 31–33, 39].

Based on the above, it can be concluded that the 21st century may be an important time, even a breakthrough moment, in the development of the ultra-light aviation segment. The prototypes of ultralight aircraft and gyroplanes are being tested by the largest manufacturers in the world. It is being talked about refinement gyroplanes in the possibility of vertical landing and jump take off. According to T. Szczepanik and T. Łusiak airplane, gyroplane and helicopter hybrids will soon be observed.

Due to the rotor's limitations in helicopters, further development of possibilities have run out. As a result, prototypes are being created which combine the greatest advantage of helicopters: the possibility of overhang in the air with the lightness and economy of gyroplanes [8, 19]. The development of the aviation industry is also influenced by the popularization of 3D printers. Thanks to the prototyping of machine elements by the 3D printers it has become possible to shorten the preparation time of individual elements, that allows more experiments to be carried out in a much shorter time than before [41, 42]. Nowadays, attention is being paid not only to the mechanical aspects of rotorcraft but also the important role of ergonomics in the cabin. The shape and form of these aircraft has also aroused the interest of architects and designers. Ultralight airplanes and gyroplanes enjoy growing interest in a wider group of recipients including private individuals who use them for recreational and sports purposes as

well as businessmen who regard them as an attractive alternative to land transport. Due to the dynamic development of ultra-light aviation the need to install more helipads in cities is being justified and also the need of taking into account the requirements related to the storage, fuel, maintenance and landing of these aerodins [7, 12, 18].

It is worth drawing architects' and urban planners' attention to the consequences of the advancement of the ultra-light aviation industry. Due to the inseparable connection air transport with metropolitan transport, the development of the private air communication network will results in the growing presence of aerodins in many cities. This may require organization of the urban airspace and designing new air traffic control systems (experiments in this area are being carried out, which are also related to the presence of unmanned air vehicles in the cities [17]). Furthermore, it will be necessary to arrange more landing pads and new infrastructure such as: hangars, fuel stations, places which offers sales, parts and maintenance. All of these might become an issue with which European architects and urban planners will have to face soon. An example of this type of challenge is the private heliport 'Helipark' in Sao Paulo which has encountered resistance from environmentalists and heritage campaigners who were afraid of irreversible effects of vibration of helicopters' rotors on nearly located mud houses [2]. The above mentioned Sao Paulo (the largest city in Brazil and South America) is one of the pioneer cities in bilding a network of rooftop heliports and helipads. Therefore, it is worth drawing on the experience of this and other American cities in the context of the development of the urban air network. Rapid, uncontrolled urbanization in Sao Paulo has induced extreme inequalities in society. As a result of settling on the outskirts, commuting has become more and more longer, which has led to the overloading of the road system. [5] The alternative to road traffic in Sao Paulo was utilization of the airspace, which allowed to set up a new, rapid mobility. In that city in 2004 the world's first air traffic control system for urban helicopter flights was implemented. The case of Sao Paulo allows observing how air communication affects the urban landscape and its transformations, and it is also advisable to examine in more detail the legal regulations referred to air mobility too and how all of these influence on the environment and society. A lot on this topic can be found in B. Cwerner's articles and books [2, 3]. B. Cwerner in his article from 2006 "Vertical Flight and Urban Mobilities: the Promise and Reality of Helicopter Travel" [2] indicates as one of the factors influencing demand for helicopters in Sao Paulo the need for their owners to express. It is precisely this factor that may soon be varied or become obsolete due to the growing popularity of gyroplanes and other ultralight aircraft in recent years (which is associated, among other things, with their increasing availability, lower price and more easiness to fly than helicopters), as was shown at the beginning of the chapter. Therefore having a flying machine will not be such a huge demonstration of social status as was predicted in studies conducted several years ago. A similar conclusion in the matter of the changing perception of the private aviation is shown by Dolf de Roos [4]. The increasing popularity of ultralight vehicles suggests the need to reflect on how the development of private aeromobilty influences on the landscape of metropolitan areas and how the new, air transport system should be designed, because it might be inevitable to broaden the urban 'ground space' to urban airspace in many European cities.

Due to increasing travelling problems, especially in large, densely populated cites, travel by airborne vehicles becomes very attractive. However, it is worth posing the question of what consequences air mobility brings for people who stay on the ground. Regarding the ecological aspects S. Cwerner could be quoted: 'commercial traffic is insignificant in atmospheric pollution in comparison with General Aviation and other forms of transport running on fossil fuels' [2]. But there also remains the matter of noise generated – interestingly, more airstrips can contribute to the reduction of noise (the pilots are able to use a variety approaches due to the fact that the noise generated for one area is limited). This case is explained by the Alex de Voogt in "Elevated City Helipads: Safety And Design" [6].

Although it is shown that there are not many benefits from arranging helipads as a building evacuation tool (an example could be the case of the World Trade Center – helicopters could not land on the roof due to too high temperature on it and smoke), it is worth looking at the research which is shown in the book Commercial Real Estate Investing: A Creative Guide to Successfully Making Money by D. de Roos who considers helipads which are placed on the tall buildings' roof. In this book, the essence of appearance helipads in the cities is being shown through the prism of private users, not just as a fad of rich people. Tenants of commercial buildings are attracted by objects with the possibility of landing on the roof. Based on the example of Asian countries it has been shown that the placement of airstrips on roofs can cause a much greater interest in objects which are offering ability to land on than in those buildings which do not offer it. The situation is similar in New York, where businessmen are increasingly choosing aerial communication because it does not expose them to traffic jams. Despite the higher costs of traveling by aircraft than by land transport the former finds many supporters. Air transport has allowed a lot of time to be saved, so travellers prefer to pay more and land at a local airport rather than risk getting stuck in traffic jams [4, 9, 29].

In many countries, airstrips arranged on roofs are nothing unusual and finds both many supporters and opponents. Opponents use as an argument the fact that the placement landings on the roofs negatively affects the aesthetic values of the buildings and that it causes the repeatability of the architectural form of the newly designed buildings (for instance panorama of Los Angeles). What is more, antagonists indicate that such a location excludes the possibility of a different, more attractive form of roof arrangement (e.g. green roofs). Nevertheless, in opposition to the above, it is worth becoming familiar with the solutions used for instance in the United Arab Emirates or East Asia. The realizations of the Burj Al Arab, the Menara Telekom or the Bitexco Financial Tower show that setting up landing pads in a city does not require designing buildings with flat roofs, because of possibility to design the landing field as a suspended helipad supported by a cantilever, which allows the top of the high rise building to be shaped in an unrestricted way. Thus, it is possible to reconcile attractiveness for a wide range of users with the aesthetics and with the needs resulting from the development of air communication network and thereby with the increasing presence ultralight machines in metropolitan transport. Therefore it is necessary to find a golden mean, acceptable concessions and long-term planning of spatial development. Unfortunately, in Europe the topic of landing sites for ultralight aircraft, whether it is placed on high-rise buildings or on the ground, is still not very widespread. It is important to realize that in connection with the development of ultra-

light aviation helipads will be an inseparable element of metropolitan areas. Although there are many interesting papers which raise equally new problems for instance the development of airport-proximate area, the problem of 'small' airfields still remains marginal. In the Polish literature, this subject is discussed by B. Podhalański in the article "Airstrip system as the element of metropolitan transport". Nevertheless this is one of the few items showing the integrity of development of the ultra-light aviation segment with urbanism of the 21st century. It should be considered that in an era of growing demand for fast communication, the problem of air communication is undoubtedly worth attention [13, 20, 23, 28].

6. Applications and summary

The article was written in order to define the factors responsible for the current state of the light aviation industry, especially gyroplanes. The historical outline and specification, the connection of the development of ultra-light aviation with the possibilities of using it in other areas of the economy, as well as the forecast direction of future gyroplanes' development was presented. The essay also examines the impact of the growing popularization of air communication and using light aircraft as a mean of metropolitan transport on the architecture and urban planning of the 21st century.

In order to distinguish the factors responsible for the current state of the light aviation industry it is necessary to turn to the beginning of the 20th century. This was the time when the first gyroplanes were created therefore the moment from which the research should be started. At the beginning of the twentieth century, people began to be interested in technology and in the turbulent times of war the demand for flying machines increased. The gyroplanes were suited ideally for delivering postal items and for reconnaissance tasks thanks to their advantages such as lightness, economy and ease of piloting. The interest in these machines dropped significantly when the first helicopter was constructed. The great advantage of helicopters was the ability to hover in the air and jump takeoff. The situation turned around at the end of the 20th century. The gyroplanes were again appreciated due to their significantly low maintenance and operating costs compared to the helicopters. What is more, the possibilities of further development of helicopters are becoming more and more limited what also turn interest into the gyrocopter industry.

Factors influencing the development of the light aviation industry are:

- political situation – turbulent times of war have become the cause for searching new ways of observation and communication;
- low maintenance and operation costs of machines;
- ease of obtaining a license;
- a multitude of applications in various fields: uniformed services and rescue, engineering, sports and recreational purposes, private transport;
- the possibility of further development from a mechanical angle;
- ability to use as an alternative to land communication (private air transport).

Aviation is undoubtedly becoming an increasingly attractive sector of the economy. The analysis carried out in the article has made it possible to present the possibility of using gyroplanes in various fields. In the near future, the development of ultra-light aviation industry is expected to grow, contributes to this the possibility of using new technologies during machine construction (elements can be printed by 3D printers). The growing interest in ergonomics (the machine is supposed not only to fly, but also be comfortable) leads to enhancing the comfort of aerodynes. Moreover, the appearance of machines is being improved (the designers are interested in them). All these factors cause the increasing popularity of gyrocopters among uniformed services, rescue services, engineers, as well as among private individuals. The last group uses them for sports, hobbies and as an alternative to land communication. The confirmation of the above is the increasing number of registered gyroplanes.

In recent years, the increasing interest in private air communication has been observed, which is indicated by research conducted in America and Asia. The addition of helipads on commercial buildings affects the increased popularity of these facilities especially among businessmen. Naturally, buildings with a helipad find their supporters and opponents, but in the era of such a dynamic development of technology, it must be taken into consideration that the presence of ultralight machines in metropolitan areas will increase significantly. The questions are posed: how will the image of 21st century cities change? Have architects and planners been already prepared for the popularization and development of a private air communications system? This article shows that metropolitan transport is inseparable connected with air transport, as well as that the urban airspace and flying vehicles are the subject of dynamic changes and ongoing processes, all of which is still a current and relevant topic for the researches. It is worth to turn into long-term planning of spatial development and into legal regulations which regard building landing areas in order to prevent uncontrolled development of aeromobility. The issues related to the increasing presence of ultralight machines in the metropolitan system of transport have been noticed, but this subject is still not sufficiently popularized in the countries of Europe. This paper begins to respond to the lack in the literature in the area of ultralight aviation industry, which is becoming one of the most prospective sector of the metropolitan transport.

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