The conception and development tendencies of the helicourts network design in the world

N H Semyroz¹, S S Kysil², O S Sleptsov¹, O O Safronova⁴ and T V Bulhakova ⁵

¹ Department of Fundamentals of Architecture and Architectural Design, Kyiv National University of Construction and Architecture, Kyiv, Ukraine
² Department of Interior Design and Furniture, Kyiv National University of Technologies and Design, Kyiv, UA

Abstract. The article analyses the origin and development of helicourts [1,2]. This is the new type of constructions which located on top of the roofs of skyscrapers and designed for users of air transport. Historical analysis was performed on the topic of cities design within the vertical plane, including the idea of traffic separation. The modern tendencies of how this issue is resolved were analyzed on the example of São Paulo and Kyiv. It is established, that in modern metropolitan areas there is ongoing new technological revolution, which aims at a radical change of transportation mode in cities, leading to the emergence of the modern aircraft. The main principles of formation of helicourt design decisions within the structure of high-rise buildings in metropolitan areas are: structurality, dominance and form. It has been determined, that the preservation of historical development, natural areas, and improvement of both transport connectivity and the environment where human activity is concentrated in cities can be solved by the introduction of a complex of structures that serves helicopter aviation, and that are located within the structure of multi-storey buildings.

1. Introduction

Growth of urbanization level, automobilization, increase of urban population on the planet, increase of urban development density as well as of buildings height encourage the creation of a transport network with infrastructure located on the roofs of high-rise buildings and skyscrapers. The intensity of population movement within the urban structure is increasing and the use of different modes of transportation is increasing [3,4]. Theoretical methods of research confirm the increasing role of small aircraft such as helicopter transport as a promising type of a passenger transport for major cities [5]. One way to create a convenient, safe, comfortable connection in cities is to introduce infrastructure for helicopter aircraft, such as helicopters (Figure 1).

During the process of research, the scientific and theoretical novelty of the proposed hypothesis was determined. The key element is the vertical stratification of the pedestrian transport system. The practicality of this hypothesis consists in the improvement of the living conditions of society, especially in metropolitan areas. This hypothesis allows for a fundamental change of the urban situation in cities. For the people and their lives, it is advisable to keep the natural environment at the level of pedestrian traffic, and to move all the implementations of transport needs above their heads. In the future, managed and unmanaged transport routes and related infrastructure will be located at the first transport level, and at the higher levels, there will be different types of aviation and space transport [6, 7].
The purpose of this study is to analyze the tendencies and principles of how building complexes for helicopter aviation, that are a part of a larger the structure (high-rise buildings), are organized.

Analysis of the recent research of the XXI century has shown that scientist in their scientific works consider in detail the role of various types of urban transportation in the everyday life of society. Foreign studies, related to the construction of heliports, helipads, and helistops are represented by the work of such American researchers as Michael J. O’Donnell, John Leverton, Leopold A. Goldschmidt, Nicholas H. Ludlow, Alex de Voogt [8-12].

Tendencies of how architecture is integrated in urban environment and how architectural space is designed for helicopters were studied by such famous architects as: Oscar Niemeyer, Henry N. Cobb, Robert Moses, Amnon Niv, Philip Johnson, Toyo Ito, Rem Koolhaas, Zaha Hadid and others [13,14,15,16].

In Ukraine transport situation was the topic of studies by: V. Zahreba, E. A. Reitsen, A. K. Starynkevych, G.I.Filvarov, V. I. Chekmarev [17]; in Russia – S. A. Waksman and others. Studies related to the design of rooftop heliports were made by: Y. V. Verjuzhsky in his work «Design of airports», V. M. Pershakov, A. O. Belyatynsky, T.V. Blyzniuk in the monograph «Vertodroms» [18, 19].

2. Methodological approach
The methodology of the research consists of complex theoretical, empirical, retrospective and factor analyzes. The theoretical method of research is to predict the development of helicopter aviation as a type of urban passenger transport in couple with its infrastructure network. In this article, the theoretical method of developing a metropolitan transport scheme is based on Kyiv as an example. Last time transport mobility of Kyiv’s population was comprehensively investigated in 1986, when the Master Plan was created. Afterwards, the basic indicators have been recalculated using different methodologies, but it should be noted, that during the last decades in Kyiv the traffic flows and conditions of how it is served have changed radically; mobility of the population of the city and its suburbs has considerably increased [20].

The empirical research in this paper was conducted to develop and make integrated decisions on the rational and safe use of various modes of urban transport and their interaction to meet the diverse transportation needs of the population. The empirical methods of the general methodology in this study include compositional aesthetic evaluation, comparison method and modeling. Composite aesthetic evaluation includes selective examination and photo-fixation, visual inspection and architectural and
3. Definition of the term «helicourt»

Growth of the motorization level, insufficient number of parking spaces, low traffic capacity of streets, poor quality of road surface leads to a crisis of transport situation in major cities of the world. There are traffic jams and environmental imbalances in cities [21]. Helicopter transport is still far from being widespread, but the volume of transportation by helicopter is constantly increasing, and there is every reason to believe that it will take one of the leading places in the urban transport system. At the same time, an unmanned aerial vehicle – a drone, which may be used in urban conditions, – will replace the helicopter in the near future.

In turn, the accelerating pace of life both in Ukraine and in the world requires the introduction of new high-speed modes of transport, namely, – air transport. In many countries in the metropolitan areas, there are complexes of structures that are located on the roofs of multi-storey buildings for servicing aircraft. In Ukraine, such complexes just started being born. At the same time, arises the necessity to regulate their location in cities [22].

An analysis of the different interpretations of aviation terms made it possible to propose a new term to further refine the object of study. It makes sense to name the above-described structure a «helicourt». Helicourt is a complex of structures that service air transport passengers, that is located exclusively on the part crowning a high-rise building or is a part of the traffic interchange platform and has a special equipped ground intended for takeoff and landing of air transport [23]. Usually, these are helicopters (Figure 2).

4. Historical analysis of design experience

«The future will free us from our constant commitment to the land» – it was said by modernist architects at the beginning of the 20th century and they were absolutely convinced that the traditional street is outdated. They imagined all sorts of alternatives: intricate multi-level cities with underground tunnels, and all kinds of streets in the sky. The idea of traffic flows separation originated in the 1820s and was widely cited in literature and illustrations, and in the 20s of the 20th century, overpasses and tunnels appeared in major American cities.

In 1904, French architect Tony Garnier showed a plan for the Industrial City with 35,000 inhabitants (Figure 3). His city was organized based on the principle of spatial separation of functions and it is one of the earliest examples of vertical zoning. On the Master Plan of the exemplary industrial city from the Tony Garnier's book, «Une Cité Industrielle», there are residential, recreational and industrial areas [24]. In 1927, Ludwig Hilberseimer designed his high-rise project, High-rise City (Hochhausstadt, Figure 4), where the planar buildings stood side by side, and the transport and pedestrians moved along elevated from the road level sidewalks.
Figure 2. Experience in building helicourts in the structure of residential or public high-rise buildings
Figure 3. Plan of Industrial city, Tony Garnier, 1904 – 1917

Figure 4. High-rise City (Hochhausstadt). Perspective View: North-South Street. View of multi-storey buildings

The key ideas for urban development were the ones from Le Corbusier: zoning principles, the combination of high-rise residential development with landscaping and the differentiation of transport infrastructure. A complete embodiment of the architecture and modernist mid-twentieth-century urban development has been found in the new capital city of Brasilia, built according to the master plan of Lúcio Costa [25, 26].

5. Location of helicourts in the structure of cities
These works formulate the foundations of a modern urban city: transport interchanges, the elimination of the traditional street, reinforced concrete tower buildings, the use of functional zoning. Improvement
of the urban form scoped on the vertical dimension was the idea of many architects, especially considering the fact that air travel was taken as something special. In modern metropolitan areas, the street has ceased to be a place for pedestrians; it became predominantly focused on the intense automotive traffic. There is a new technological revolution happening which aims at a radical change of vehicles in the cities, at the emergence of the newest aircraft: drones, airplanes, airbikes [27].

Increasing traffic congestion and the onset of economic upturn in Brazil have affected the business aviation industry's upswing. Sao Paulo – the largest city in the country has the world's second largest helicopter park, second only to New York today. The rapid development of the helicopter industry in São Paulo is explained by the search for personal safety and convenience. 80% of all flights are business aviation, including police, radios, and television helicopters and a small fleet of «Robinson» helicopters used to search for stolen vehicles.

On June 1, 2012, a record was made in South America's largest city: streets were blocked by 295-km traffic jams. According to the data from the Association of Brazilian Helicopters Pilots ABRAPHE (Associação Brasileira de Pilotos de Helicópteros), by the end of 2011, between 480 and 490 helicopters were registered in the metropolis. The most popular models are: «Eurocopter Astar», «Agusta-109» and «Sikorsky S-76», which are used for both business aviation and oil platform service. There are many «flying» aerotaxis operating in São Paulo, especially on the most important air route Rio de Janeiro – São Paulo. Out of the 260 helipads, about 200 are located on the roofs of houses [22].

The activity of the modern metropolis aims at performing various functions: economic, administrative, scientific, cultural, and wellness-related. The increasing intensity of urban population requires a modern, high-speed transport connection.

The city of Kyiv already ranks 33rd on the European part of the Eurasian continent in terms of population concentration and economic activity. At the same time, 16 helipads are planned to be built in Kyiv [20]. They are necessary, first and foremost, for the prompt transportation of seriously ill patients and the provision of emergency medical care (Figure 5).

Figure 5. Scheme of placement of high-rise buildings and complexes according to the relief map of the city in the long-term development of Kyiv
Besides helicopters and helipads intended for use by public institutions, according to the «Concept of placement of high-rise buildings and structures in Kyiv until 2020», it states that Kyiv will have high-rise buildings built, and they will need helipads for rescuing people in case of fire. Functional purpose of those high-rise complexes – creation of business, financial, hotel, cultural, educational and sports centers serving the whole city – implementing day-to-day functionality of the city as a capital. On the rooftops of high-rise residential buildings, there are platforms provisioned for landing the emergency cabin of fire helicopters [28, 23].

6. Universal principles for the design of helicourts
The overview of foreign and domestic experience shows that in metropolitans today it is necessary to apply universal principles for the design and construction of helicourts. It makes sense to split these principles in three directions, according to the classical triad in architecture – functions, constructions, and forms. Functionality covers the principle of structurality. Constructiveness covers the principle of dominance. In addition, form design covers the principle of form. The principle of technological determinism unites these principles [23].

Conclusions
The activity of the modern largest city is aimed at performing various functions: economic, administrative, scientific, cultural and wellness. The increasing intensity of urban population requires a modern, high-speed transport connection.

In this study it was found, that up to this date the complex of buildings for helicopter aviation, located in the structure of residential and public buildings, has not been sufficiently studied. In Ukraine, as well as in other metropolitan areas of the world, high-rise construction is rapidly being implemented and is growing at a rapid pace; buildings and residential complexes are being constructed, aviation is being developed.

In turn, project activity should outmatch, anticipate and plan the interconnectivity of scientific and technological progress, the economy with the demands and needs of society to ensure a comfortable life. Moreover, it is with the development of aviation transport, especially in the major cities, that it is possible to: resolve urban air transport corridors; deployment, location, parking, refueling and repair of aircraft, including sanitary aviation. Also important is the protection against air pollution from emissions into atmosphere, and noise pollution by the aircraft.

Further research is needed to study the stages of development of a new type of air transport for urban planning, the economy, and the safety of using passenger drone above the city.

References
[1] Semyroz N H 2016 Current state of design and construction of helicorts Inventor's certificate № 66640 (Kyiv: in Ukrainian)
[2] Semyroz N H, Sleptsov O S 2017 Project proposals «Helicort» Inventor's certificate № 70133 (Kyiv: in Ukrainian)
[3] Kysil S S 2013 Construction issues of multi-storey car parks in large cities of Ukraine Mistobuduvannya ta terytorialne planuvannia 50 (Kyiv: KNUBA) pp 275-280 in Ukrainian
[4] Kysil S S 2014 Directions of building design for multi-storey car parks in major cities Arkhitektura i sovremennye informacionnye tekhnologii (AMIT), (Moscow: Moscow Architectural Institute). URL: http://www.marhi.ru/AMIT/2014/3kvart14/kisil/abstract.php in Russian
[5] Semyroz N H 2013 Helicorts in the cities Suchasni problemy arkhitektury ta mistobuduvannia 34 (Kyiv: KNUBA) pp 560-568 in Ukrainian.
[6] Semyroz N H 2014 A study of the historical development of helicopter transport and a retrospective of the development of helicopter industry Arkhitekturnyi visnyk KNUBA 3 (Kyiv: KNUBA) pp 91-97 in Ukrainian
[7] Frost J B 1996. British helipads. (Chester, UK: Appledore Publications)
[8] Michael J O’donnel 2012 Aviation Circular No: 150/5390-2C (initiated by: AAS-110 C. Heliport design) p 188
[9] De Voogt A J 2006 Hospital helipad architecture: ideals of safety and design. InCor Wagenaar (ed.) Hospital Architecture (AZG: Groningen) pp 141–157
[10] De Voogt A J 2007 Heliadrome Architecture. (Rotterdam: 010 Publishers)
[11] ICAO 1995. Heliport manual. (ICAO Publications Montreal, Canada)
[12] Timko T & Ištoka Otković I 2017 Comparison of different heliport solutions for the clinical hospital center in Osijek. Elektronički časopis građevinskog fakulteta Osijek 8 pp 58-67 doi: 10.13167/2017.14.7.
[13] Niemeyer O 1956 Notes on Brazilian Architecture In S. Papadaki, O. Niemeyer: Works in Progress (New York: Reinhold) pp 11–14
[14] Koolhaas R 2002 The Great Leap Forward. Harvard Design School Project on the City. (New York: Taschen)
[15] Urban F 2016, Robert Moses: The master builder of New York City Planning Perspectives 31: 4 659-661 doi: 10.1080/02665433.2016.1203114
[16] Noever P, Haslinger R & Himmelblau C 1991 Architecture in Transition: Between Deconstruction and New Modernism (Munich)
[17] Reitcen E A & Kaddakh Kh 2000 Modelling traffic flows in cities Bezpeka dorozhnoho rukhu Ukrainy 1(6) (Kyiv: NDTsBDR) pp 41-46 in Ukrainian
[18] Veriuzhskyi Yu, Rodchenko O V & Hyrych V Yu 2011 Airport Design (Kyiv; NAU) p 257 in Ukrainian
[19] Semyroz N H, Pershakov V M, Bieliatynskyi A O & Blyzniuk T V 2014 Heliports (Kyiv: NVF «Slavutych-Delfin») p 345 in Ukrainian
[20] The development strategy of the city of Kyiv until 2025. Approved by the decision of the Kyiv city council №824/7060 of December 15, 2011, a new edition of 2016 (in Ukrainian). https://doi.org/10.1787/9789264301436-en
[21] Kysil S S 2016 The principles of the architectural and planning organization of multi-storey car parks (for example, the largest cities of Ukraine): Abstract of the dissertation of the candidate of architecture (Kyiv National University of Construction and Architecture, Kyiv, Ukraine) p 21
[22] De Vasconcellos E A 2005 Urban Change, Mobility and Transport in São Paulo Three Decades, Three Cities, Transport Policy 12 (2) pp 91–104
[23] Semyroz N H 2017 The principles of the architectural and planning organization of helicots: Abstract of the dissertation of the candidate of architecture (Lviv Polytechnic National University, Lviv, Ukraine) p 24
[24] Le Musée Urbain Tony Garnier 2019 (Lyon, France)
[25] Le Corbusier 1929 The City of Tomorrow and its Planning (London: John Rodker)
[26] Le Corbusier 1971 Looking at City Planning (New York: Grossman)
[27] Bulhakova T V 2010 The problem of compositional analysis of the urban environmen. Suchasni problemy arkhitektury ta mistobuduvannia 23 (Kyiv: KNUBA) pp 52-60
[28] Sleptsov O S 2010 The architecture of civil structures: Industrialization (Kyiv, A+S)