УДК 656.71.003 (043.2)

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RESTORATION OF THE NETWORK OF LOCAL AIRPORTS OF UKRAINE: APPROACHES, INNOVATIVE MODELS AND ACTION STRATEGIES

The state of aviation of Ukraine in the pre- and post-pandemic period is analyzed. The peculiarities of the development of the existing objects of the aviation infrastructure of Ukraine, including the network of local airports, are determined. Factors influencing the development of state infrastructure in the field of building a network of local airports have been identified. The approach to understanding of networks of local airports as function consisting of such elements as the airport is formed; airline; organization of air traffic and factors of influence: demand for air transportation; geographical resources; technical and technological limitations; economic and organizational requirements; legal requirements; security; ecology; inclusiveness of the territory. A critical and comparative analysis of the strategy of development of the network of local airports of Ukraine on the basis of innovative models: low-cost transportation and organization of hub centers. It was identified that the socio-economic conditions of Ukraine are not favorable for the active development of air transport and the formation of a significant amount of effective demand among the population of Ukraine. The expediency of shifting the vector of aviation infrastructure financing to the development of local airports on the basis of foreign experience in shaping public demand and motivating conditions for the development of air transport on the basis of state financial support, local government financing or attracting investment from private investors. The expediency of financing from the state budget of priority local airports by their classification according to the chosen strategy of aviation infrastructure development in Ukraine, which should be reflected in the mathematical model of decision-making functions.

Keywords: airport, network of local airports, hub, low cost, strategy.

1. INTRODUCTION

The development of the air transport system is becoming not only a necessary condition for the implementation of an innovative model of economic development of Ukraine, but also a factor in improving the quality of life and competitiveness of the national economy. Airports as an element of the transport system are the most important component of local, national and regional infrastructure and are strategically and socially important state facilities in the context of hostilities.

For its successful development it is necessary to introduce qualitatively new infrastructural shifts, in particular their transport component. Due to its advantageous geographical location, Ukraine has access to a large number of countries, as a result of which it is a country with a strong transit potential.

However, factors such as the high cost of air travel, the neglected state of roads, the remoteness of rail transport and low passenger traffic are holding back the development of the network of local airports.

The reliable functioning of international air transport requires the participation of local airports in the global network of airports, which ensures security, regularity of air traffic, the quality of ground handling services. The current state of air transportation in Ukraine does not yet meet the requirements and expectations of passengers and cargo customers. At the same time, the importance of efficient use of capital investments in the aviation industry in terms of technical level, technology, economy and reliability is growing. Currently, there are two key strategies for the development of local airports: the introduction of low-cost

transportation and the development of a hub at the airport. Both strategies require significant funding to implement, which in the case of an unjustified strategic decision can result in multimillion losses both in the construction of new facilities and in the reconstruction of both the state that owns them and the private investor.

2. ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

The theoretical and methodological basis of the study are the fundamental works of domestic and foreign scientists on the problems of development of transport infrastructure of Ukraine in the field of air transportation.

In particular, Marintseva K. [1] researched the scientific foundations and methods of ensuring the effective functioning of air transport systems. Osetrin M., Ryabchenko T. [2] and Sadlovska I. [3] outlined the transport solutions of the airport (on the example of Boryspil Airport, Kyiv and formed strategies for economic development of air transport enterprises. Pereverzeva S. [5] investigated the mechanism of regulating the commercial activity of Ukrainian airlines, and I. Palamarchuk [6] identified the investment needs of Ukraine's transport infrastructure.

Omelyanenko S. [7] predicted the development of airports in Ukraine and assessed the effectiveness of their operation. While Ilyenko O. [8] designed the organization of partnership management of enterprises in the logistics chains of air transport. Batmunkh S. [9] and Akimova T. [10] developed a comprehensive methodology for designing the development of the structure of the air transport system andmethod of determining the competitiveness of the airport. Dumanska I, Vasylkivskyi D, Zhurba I, Matviiets O. and Goncharuk A. [11, 12] are aimed at studying the role of drone and e-logistics in transport infrastructure, giving them an important role in the activities of airports.

3. IDENTIFICATION OF PREVIOUSLY UNFOLVED PARTS OF THE GENERAL PROBLEM TO WHICH THIS ARTICLE IS DEDICATED

So far, the review of scientific works has been in-depth and fundamental research in the field aviation infrastructure and its role in Ukraine. While the issue of local airports remains little studied and sporadic. Accordingly, the establishment of factors influencing the development of state infrastructure in the field of building a network of local airports and the need to form an approach to understand the networks of local airports, and existing concepts today development of the network of local airports of Ukraine on the basis of innovative models: low cost and hub require critical comparative analysis to determine the feasibility of their implementation in the activities of local airports and determine the amount of public funding and private investment for their development.

4. FORMULATION OF GOALS ARTICLES

The aim of the article is to form an approach to understanding the relevance of local airport networks, to critically compare the development strategy of local airports in Ukraine on the basis of such innovative models as low cost and hub, to identify the feasibility of shifting the vector of air infrastructure financing in local airports.

5. PRESENTATION OF THE BASIC MATERIAL RESEARCH WITH FULL JUSTIFICATION OF SCIENTIFIC RESULTS

Today, aviation in Ukraine and the world is going through difficult times. In 2020, passenger traffic through Ukrainian airports decreased by 64.4% compared to the previous year.The world community predicts the resumption of passenger traffic at the level of 2019 no earlier than 2024. In order for us to reach optimistic forecasts - 25 million passengers in 2024 need to invest in the development of regional airports. A pandemic is an ideal time to build resorts. The airport is not only about convenience and tourism, it is first of all the development of the economy of the regions [13].

Due to the impact of the coronavirus pandemic, the number of flights that UkSATSE provided air navigation services in 2020, fell by 57.6%. The largest number of takeoffs and landings during 2020 was made at Boryspil International Airport - 47,524 flights. In second place - the international airport «Kiev» named after Igor Sikorsky («Zhulyany») - 12,805 flights, closes the top 3 - the airport «Lviv» named after Danylo Halytsky (9,850 flights). Next in the top 10: Odessa International Airport - 9,282 flights, Kharkiv International Airport - 7,576 flights, Dnipropetrovsk International Airport - 4,174 flights, Poltava International Airport - 4,119

flights, Zaporizhia International Airport «- 4,087 flights, Kherson International Airport - 1,082 flights, Ivano-Frankivsk International Airport - 808 flights. In 2020, the most flights in the airspace of Ukraineperformed by Turk Hava Yollari AO (Turkey) - 14,623 flights.

At the same time, before the pandemic period, Ukraine showed a high growth rate of air mobility compared to other European countries, in 2018 it was + 25%, compared to 6% of Moldova or 8% of Romania. Thus, Ukraine has the potential for dynamic development of passenger traffic in the medium term, in particular, has the opportunity to reach the level of Poland at + 20-25% per year for 5-7 years. The example of Poland shows the prospects for the development of regional airports - with the right strategy, such resorts can operate successfully. For example, the distance between Katowice and Krakow is 80 km, between Zaporizhia and the Dnieper 85 km - these airports are strategic for Ukraine. The share of regional airports in Poland is 6%, while in Warsaw 40% is a confirmation that in Ukraine it is also possible to diversify passenger traffic.

In recent years, about 30 airlines registered in Ukraine have been operating in the passenger transportation market, but more than 80% of the market belonged to only a few, including two leading carriers: Ukraine International Airlines (UIA) and Aerosvit. According to the World Bank, Ukraine's share in world air cargo traffic in 2013 was approximately 0.0083%. The main air carriers are the companies «Antonov» and «Ukraine International Airlines» [13].

There are more than 40 airports and airfields in Ukraine [15]. There is at least one airport in each region. In 2013, there were 26 airports in Ukraine. Almost 100% of flows (98% of air passengers and 93% of mail and cargo flows) are served at 8 airports of Ukraine, and Boryspil Airport in 2013 served 52% of the total passenger flow (7.9 million passengers), Kyiv Airport - 12.1% (1.8 million pass). For comparison, in Poland, five airports in 2011 served almost 17 million passengers, and eleven airports in Germany in 2010 172 million. The current demand for services of Ukrainian airports is much lower than their capacity.

In total, there are airports in each region, but there are currently 17 resorts. This is how Vinnytsia International Airport has been operating in Vinnytsia since 1983. The last

reconstruction took place in 2008. The runway is now in need of repairs, which are planned for 2021, but the condition of the terminal is still quite good. The pandemic has thwarted plans to renovate the Dnieper airport, which has been operating since 1943, and the new construction of the runway and modern terminals is stalled due to lack of funding. In April 2020, after the sequestration of the budget, the Verkhovna Rada reduced by 10 times the cost of designing and building a new airfield at Dnipro Airport. The initial draft law on changes in expenditures of UAH 1 billion on this item was supposed to be reduced by 100%. Cherkasy Airport, which has been in need of overhaul for a long time, has been closed since 2017. The Berdyansk domestic airport in the Zaporizhia region was closed in 1997. The Khmelnytsky domestic airport, which was built in 1982, has been closed since 2002. Both the runway and the terminal need reconstruction. Back in 1993, the internal airport «Severodonetsk» in the Luhansk region was closed.

The study of a number of scientific papers on the development of transport systems, provided an opportunity to develop an approach to understanding the network of local airports (NLA) as a function consisting of the following elements: airport (AP), airline (AL); air traffic organization (ATO); demand for air transport (Dat); geographical resources (GR); technical and technological constraints (TTL); economic and organizational requirements (EOR); legal requirements (LR); security (S); ecology (E); territorial inclusion (IT).

Formally, the definition of NLA (f) in implicit form can be written as:

NLA $(f) = \langle(Airports, Airlines, ATO),$

$(D_{at}, GR, TTL, EOR, LR, S, E, IT)\rangle$ (1)

Modern foreign and domestic research [1-12] on the effective functioning of the local airport system offers a number of methods to solve this problem based on the resource approach. When describing NLA resources, it is suggested to consider:

- availability and interrelation of physical and non-physical resources in the airline, which allows to make a critical analysis of the effectiveness of airlines in the local and global market and to quantify decisions on the liberalization of air transport;

- distribution of airport resources by its two subsystems: ground and air (controlled) zones, as

well as the classification of automation and mechanization, which simplifies the study of «bottlenecks» in capacity. Currently, the efficiency of the ground area of the airport can provide more than 60% of the revenue of the entire airport;

- the impact of global and national airspace development programs on the resource structure of the NLA subsystem in order to reconcile the input parameters and limitations of this subsystem.

Despite the great variety of factors influencing the formation of demand in the NLA, theoretical studies have confirmed the author's assumptions that the main are: socio-economic development of the country (region) - local aspect, prices (tariffs) for transportation - solvency, development of transport infrastructure - aspect of accessibility and inclusiveness.

Currently, there are two key strategies for the development of local airports: the introduction of low-cost transportation and the development of a hub at the airport. Both strategies require significant funding to implement and require consideration of the aspects of NLA development described above.

The hub is a prototypethe connecting airport through which the base airline carries out transfer transportation of passengers. According to the number of transit passengers in Europe, there are five major ones - Heathrow in London, Charles de Gaulle's Roissy in Paris, Schiphol in Amsterdam, Frankfurt Airport in Germany and the new Istanbul Airport. The so-called medium hubs include the airports in Madrid, Munich, Vienna, Milan (Malpensa), Copenhagen, Moscow (Sheremetyevo) and Lisbon. As for Boryspil, it, together with the airports in Warsaw, Riga, Helsinki and others, is one of the small transit countries.

So, if the UIA and Boryspil abandon the hub model, the airport will lose the 3-4 million passengers brought to it by the base carrier, because there are no examples in the world when the hub airport is developed by a foreign carrier. For example, neither Lufthansa, nor LOT, nor Turkish Airlines have ever concealed that their main goal for Ukraine is to provide access to its own route network to local passengers in transit at their own hub airports.

The advantage of local hub airports within the concept of decomposition of the route network is their unloading and, due to the

reduction of delays, it is possible to return part of the passenger traffic to the feeder routes. Airlines can increase profits by reducing delays and possibly increasing demand from point-to-point routes, and aircraft companies need to work to expand the size range of aircraft to meet the needs of routes with different distances and densities.

At the same time, ordinary Ukrainian passengers, like most local tourism businesses, often do not see any added value from having a transit hub at the airport.Trends in the concentration of airline resources in alliances and the development of hub airports may be limited by available capacity. So, despite the attractive in terms of cost savings of airlines and airports hub model of network development, relevant to the loaded and convenient for the mass consumer of aviation services is a point-to-point model, the development of which is proposed to implement the concept of network decomposition. Hypothetically, the impact of this concept can be measured in the reduction of passenger-kilometers on busy routes, as well as in saving time and increasing comfort. As for low-cost carriers, they do not create hub airports. Airports such as London-Stansted and London-Luton are sometimes called hubs by low-cost carriers, which is a misconception. Indeed, low-cost airlines are based at these airports and operate a significant number of flights from them to various destinations. However, the low-cost business model does not provide for guaranteed transit, so docking at the low-cost carrier's base airport is at the passenger's own risk and is not the responsibility of the airline. In addition, low-cost carriers are developing a network of their own bases, which open fairly quickly, but no less quickly can be closed at the discretion of the airline [17].

All domestic flights in Ukraine are unprofitable. Prior to the annexation of Crimea and the fighting in eastern Ukraine, there were two lucrative domestic routes: Kyiv-Donetsk and Kyiv-Simferopol. Currently, there are no profitable air routes to Ukraine. UIA operates flights from 8 cities exclusively within its network business model, transporting passengers on its own international flights from Boryspil Airport. Transit passengers dominate all UIA domestic flights without exception. If the carrier's network, ie hub, model is terminated, none of the domestic flights will be loaded. A striking example is flights to Ukraine from

SkyUp Airlines, which offers tickets for its flights from Kiev to Lviv, Kharkiv and Zaporozhye from UAH 500, but the planes are half empty. The conclusion is simple - in Ukraine there are not enough passengers who are willing to pay 50-70 euros for a domestic flight. Also because, In contrast to many European countries, Ukraine has rather cheap transportation by state-subsidized rail transport. In the European Union, on the other hand, it is not railways that are subsidized, but domestic air transport.

The UIA route network consists of about 60 destinations [18]. However, only about 15 of them are those that the carrier is able to perform economically only through the local market. That is, in the absence of transit passenger traffic, the number of available direct flights from Boryspil and their frequency will be reduced by 3-4 times. In other words, in order to get to Yerevan or Copenhagen, a Ukrainian passenger will have to fly through Minsk or Riga. From non-hub airports (such as Vilnius), the morning «flight» takes place at 04.30-06.30 in the morning. It is during this time that the airline's planes take passengers to their hubs, from where they will continue their journey to the final destination between 08.30 and 10.30. That is, as long as there is a base carrier and its hub airport, the local passenger has a chance for an additional 2-3 hours of sleep and a more convenient time for his flight.

The presence of additional passengers arriving from other airports allows Boryspil Airport to receive additional income. According to statistics, the country's main airport is not only one of the most profitable state-owned enterprises, but also one of the most successful airports in Eastern Europe. It should be reminded that more than 85% of the airport's profit is received by the state budget. According to the European Commission, the availability of direct flights between cities increases their tourism potential by 5-20 times. In this case, we are talking about the 40-50 routes that the UIA continues to operate due to the transit flow and thus generates hundreds of thousands of additional tourists in the capital. Thus, in case of abandonment of the transit model, there will be no such flights, and in the absence of direct flights - the appropriate number of additional tourists in Kiev [17].

According to an ICAO report, every thousand passengers at the airport creates 1 job in related industries. It is with this data that the Irish Ryanair constantly operates in its presentations. In other words, the lack of 3-4 million transfer passengers in Boryspil will deprive the Kyiv region of 3-4 thousand jobs. Thus, representatives of industries related to the provision of services to foreign citizens will be at risk of losing their permanent jobs. These are primarily travel companies, hotels, taxis, restaurant business and entertainment industry. In all hub airports without exception, the base carrier is the main player. Thus, Air France / KLM generate about 45% of all passenger traffic at Paris's Roissy airport. Charles de Gaulle, and Turkish Airlines generally serves 80% of all passengers traveling through the new Istanbul airport.

Creating a hub is not a cheap pleasure, this requires significant investment not only in the infrastructure of the airport, but also in the opening of new routes and increase the frequency of existing ones. Only large cities such as London, Paris or Madrid can afford to have a hub airport without significant government support. But even here it is not easy. Thus, at the beginning of the year there was a conflict situation between the shareholders of Air France / KLM. The Dutch government has tried to prevent the airline's top management from concentrating its efforts on developing a single hub in Paris. The country of tulips has expressed fears that this will lead to a significant reduction in passenger traffic at Amsterdam Airport. Having a successful hub model at the airport provides additional financial opportunities primarily to its owner, as well as the region where it is located and its residents.

Today, the cost of European airports is estimated at $ 1 billion for every 10 million passengers served, with a factor of 1.5 for the transit hub and 1.7 for transcontinental flights. That is, Boryspil Airport, with a capacity of 14 million passengers, can be estimated at about $ 2.4 billion. In addition, the average profitability of hub airports is at least 20% [17].

Studies of the implementation of hub and low-cost models of local airports show that in general the socio-economic conditions of Ukraine are not favorable for the active development of air transport and the formation of a significant amount of effective demand among the population of Ukraine. Based on foreign experience, it is established that the formation of

population demand and motivating conditions for the development of air transport are based on their state support through funding.

To substantiate the concept of development of the airport network of Ukraine and the feasibility of financing from the state budget of the entire network or individual airports, it is proposed to determine the role of each airport in the development strategy of local airports in Ukraine. Consider three possible ones:

Strategy 1. Development of the main local airports in the conditions of state management of aviation infrastructure.

Strategy 2. Development of a network of local airports for domestic transportation in the context of aviation infrastructure management by local governments.

Strategy 3. Development of all local airports in the conditions of full liberalization of aviation infrastructure and transition to the segment of private business (operation of about 30 airports and airfields).

The mathematical model of the task of deciding on the choice of strategy for the development of the network of local airports in conditions of uncertainty can be given in the form of three objects $\langle U,D,f \rangle$, where U - many acceptable alternatives (strategies), D - the set of possible states of the environment, $f:U\times D \rightarrow W$- objective function [1].

The target function $f(u\phi,da,z\phi)$ is the profit that the network of local airports will receive for the year in a situation when a certain strategy $u\phi$ is chosen, where $\phi = 1$, ϕ is the number of strategies that involve the operation of X airports. As the only parameter that characterizes the state of the environment, in our case we take the average annual demand, which is equal to da, where $a=1,\overline{\overline{A}}$ - the number of states of the environment, and zϕ - estimate the reduction of potential demand depending on the chosen strategy. The set of environmental conditions can be denoted by $D=$ {1, 2, 3, ..., 30}million passengers.

Assume that the revenue of the local airport network is 27.3 million um. penny. from per 1 million passengers, then the target function for this decision-making task will be:

$$f(u\phi,da,z\phi)=27,3(da-daz\phi)-u\phi-80$$
$$f(u\phi,da,z\phi)=3,34da(1-z\phi)-u\phi-80 \qquad (2)$$

Next, we take $f(\phi,a)=w\phi a$ and interpret the number $w\phi a$ as the NLA gain under the condition (ϕ,a). Then the objective function is set in the form of a payoff matrix.

The following environmental conditions for 2022 in terms of the total passenger traffic at the respective local airport were taken into account when constructing the winnings matrix for the selection of the development strategy of the network of regional airports of Ukraine. As criteria for choosing an alternative, it is advisable to use the Laplace test: $L(\phi)=1A\Sigma w\phi aAa=1$ and Wald's test:

$$W(\phi*)=max\phi W(\phi)=max\phi min aw\phi a.$$

As a result, it is advisable to make assumptions about the probability of occurrence of each possible state of the environment ((). Then the expected result from the adoption of the ϕth strategy $ER\phi$ is calculated by the formula:

$$ER\phi = \Sigma w\phi apaAa = 1. \qquad (3)$$

The NLA can choose a strategy that would maximize the expected result $ER\phi*=max\phi ER\phi$.

6. CONCLUSIONS.

Analysis of the development of existing aviation infrastructure in Ukraine showed that the domestic aviation infrastructure is in its infancy and declined during the collapse of the Soviet period, so it needs support from the state and international organizations to improve efficiency. Among the factors influencing the development of state infrastructure in the field of building a network of local airports are:demand for air transportation; geographical resources; technical and technological limitations; economic and organizational requirements; legal requirements; security; ecology; inclusiveness of the territory. These factors are the basis forformation of an approach to the understanding of local airport networks as a function consisting of such elements as the airport; airline; organizations air traffic. Critical and comparative analysis of the strategy of local airports of Ukraine on the basis of such innovative models as low cost and hub identified that the socio-economic conditions of Ukraine are not favorable for the active development of air transport and the formation of significant effective demand among the population of Ukraine. It is expedient to shift the vector of aviation infrastructure financing to the sphere of local airports development on the basis of foreign experience. This requires the implementation of a strategy to generate demand

from the population and provide motivating conditions for the development of air transport on the basis of state financial support.

The expediency of financing from the state budget of priority local airports by their classification according to the chosen strategy of aviation infrastructure development is offered, which should be reflected in the mathematical model $\langle U, D, f \rangle$, where U - many acceptable alternatives (strategies), D - the set of possible states of the environment, $f: U \times D \rightarrow W$ - target function.

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Анотація

ДУМАНСЬКА Ілона Юріївна. Відновлення мережі локальних аеропортів України: підходи, інноваційні моделі та стратегії дій

В роботі проаналізовано стан авіації України у до- та після пандемічний період. Визначено особливості розвитку наявних об'єктів авіаційної інфраструктури України, у тому числі мережі локальних аеропортів. Встановлено фактори впливу на розвиток інфраструктури держави в сфері розбудови мережі локальних аеропортів. Сформовано підхід до розуміння мереж локальних аеропортів як функції,

що складається з таких елементів як аеропорт; авіакомпанія; організації повітряного руху та факторів впливу: попит на авіаційні перевезення; географічні ресурси; техніко-технологічні обмеження; економіко-організаційні вимоги; правові вимоги; безпека; екологія; інклюзивність території. Проведено критично-порівняльний аналіз стратегії розвитку мережі локальних аеропортів України на базі інноваційних моделей: лоукост перевезень та організації хаб-центрів. Ідентифіковано, що соціально-економічні умови України не є сприятливими для активного розвитку авіаційних перевезень та формування значного обсягу платоспроможного попиту серед населення України. Доведено доцільність зміщення вектора фінансування авіаційної інфраструктури в сферу розвитку локальних аеропортів на базі закордонного досвіду щодо формування попиту населення та мотивуючих умов для розвитку авіаперевезень на базі державної фінансової підтримки, фінансування органами місцевого самоврядування чи залучення інвестицій від приватного інвестора. Запропоновано доцільність фінансування з державного бюджету пріоритетних локальних аеропортів шляхом їх класифікації відповідно до обраної стратегії розвитку авіаційної інфраструктури в Україні, яка повинна відображатись математичною моделлю прийняття рішення про вибір стратегії розвитку мережі локальних аеропортів в умовах невизначеності у вигляді множин допустимих альтернатив та можливих станів середовища, цільової функції.

       Ключові слова: *аеропорт, мережа локальних аеропортів, хаб, лоукост, стратегія.*