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ANALYSIS OF AIR TRANSPORT NETWORK OF UKRAINE

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АНАЛІЗ АВІАЦІЙНОЇ ТРАНСПОРТНОЇ МЕРЕЖІ УКРАЇНИ

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АНАЛИЗ АВИАЦИОННОЙ ТРАНСПОРТНОЙ СЕТИ УКРАИНЫ

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Introduction

One of the research stage of air transport system of Ukraine or its subsystems contains usually the study of industrial, technological and financial performance of airlines and airports. The result of the study is mostly containing the representation of the dynamics of such statistics as: traffic volume, the carrying capacity and throughput, the number of aircraft in the fleet, the hourly productivity of aircraft, safety and regularity of flights. Further, the research methodology involves the usage of these data in different regressive models that allow predicting the behavior of the system (subsystem), to describe possible scenarios, and to identify the problems.

For example, in the official report of the State Aviation Service of Ukraine for the 1-st half of the 2013 the state of the aviation industry is estimated by comparing the statistics on the volume of the air traffic of the 1-st half-years during the past 8 years [1]. Omelyanenko [2] makes the assessment of the State Aviation Service of Ukraine by introducing the dynamics of the volume of traffic, passenger turnover and the description of the technical and economic characteristics of the airports' network. It seems strange this author's conclusion that «the real effectiveness of air transport in the time dimension occurs by moving the passenger over a distance of more than 1,500 km» [2, p. 79]. However, the evidence of the statement and references to the studies, unfortunately, are not represented in the thesis.

The analysis of the transport system of Ukraine in the work [3] is also based on the method of the volume indicators comparison of the transport's products and the specific density of the transport types in total volume of the traffic.

Taking into account the active development of the world's hub system the creation of the adequate models of the functioning and the development of the air transport system of Ukraine requires new approaches to analysis and evaluation of the functioning effectiveness. The important factor influencing upon the volume figures of the aviation industry are the structure and the characteristics of the air transport network system. Here the network G will be realized as a set of airports of Ukraine X , connected by regular air routes A with the set of foreign airports Y :

$$G = [N, A], \tag{1}$$

where N is a set of the airports (hubs) containing the air transport network of Ukraine, that is $N = X \cup Y$.

In this paper we propose to consider only regular air transportations, as today the only published source of the information for review of the air transport network of Ukraine is the database of the ICAO. But suggested by author approach to analysis of air transport network have the sufficient level of generality to include domestic and non-schedule air transportations data (if there are) into general structure of data.

In the ICAO database two forms of international traffic accounting for city pairs are provided:

1) Form of a type "B" – OFOD "On-flight Origin and Destination" - regular and irregular transportations of passengers, cargo and mail on international air routes between the origin and the destination points of the flight (quarterly data);

2) Form of a type "C" - TFS "Traffic by Flight Stage" - regular service flights on international air routes by the flight stages (annual data).

It should be noted, that the statistics of the OFOD is provided on condition of confidentiality and paid access for the interested parties. Also, there are restrictions on their publications, both in content and timing of release of these data. Therefore a database of air transportation in Ukraine in the form of reporting of the "C" type is more accessible and informative, though only for a regular transportation. However, this information is sufficient to perform the calculations for determining the adequacy of the proposed method.

The objective of this paper is the statement of the methodology and the results of functioning analysis of the air transport network of Ukraine as a major subsystem of civil aviation industry of the country.

1. The method of analysis of the air transport network functioning

The size and complexity of the air transport network of a country is determined by the number of airports and routes in the network, frequency of flights on certain routes, time of aircraft operation which depends on the distance traveled and a type of aircraft. For the purposes of the air transportation management becomes important analysis of the distribution of air routes by lengths and the dependence of the passenger traffic volumes on the length of air routes. All these factors are very important for determining the efficiency of the air transport network. In this study airlines were not considered as a network element because their functioning is reflected in the next elements: aircraft, staff, air routes network.

Let each air route $(x, y) \in A$ of network G corresponds to a nonnegative number $p(x, y)$, which we call *the capacity of the air route* (x, y). The function P is called *a function of network's G capacity*, which in its general form can be written as follows:

$$P = \sum_{(x,y)\in A} p(x, y) = f\langle MC, TS, TP, TH\rangle, \tag{2}$$

where MC is the maximum capacity of the nodes (airports) of the G network; TS is a total capacity of the aircraft operated on the air routes A; TP is the number of staff involved in the service of the G network; TH is the total volume of block-hours flown by the aircraft operated on air routes A.

The function P can be also interpreted as the *performance* or *capacity* of the network. Note that in the case of the analysis of the functioning air transport network during the retrospective period the actual and not the maximum traffic capacity is being considered.

We define a matrix A of a given network G as a rectangular matrix $d \times m$, with element $a_{xy} = 1$, if a direct regular air route exists between nodes $x \in X$, $x = \overline{1, d}$, and $y \in Y$, $y = \overline{1, m}$, and $a_{xy} = 0$ – otherwise.

According to the theory of graphs each node of the set X can be characterized by index k_x – the degree of the node. In this case it is the number of air routes originating from the node $x \in X$ to the nodes $y \in Y$ of the G network. The degree of a node x can be calculated according to the formula

$$k_x = \sum_{y\in Y} a_{xy} \quad \text{for } \forall x \in X. \tag{3}$$

An important feature of the network is the nodes degree distribution function $P(k)$, which is defined as the probability that the node x has a $k_x = k$ degree. Many air transport networks have nodes with a very high degree (hubs), and namely they determine many important properties of these networks.

To characterize the air transport network, we introduce the parameter «strength of node» s_x, which is necessary for the actual representation of the «weight» of the air routes of the x node. This index can be calculated as:

$$s_x = \sum_{y\in Y} a_{xy} w_{xy} \quad \text{для} \quad \forall x \in X, \tag{4}$$

where w_{xy} is the frequency of flights or the number of passengers during the concerned period on the air route $(x, y) \in A$. The analysis of the statistics shows that the assumption $w_{xy} = w_{yx}$ is correct.

The betweenness centrality (briefly *betweenness*) of the node can be considered as an indicator of the most important airports in the network. This indicator is important in the study of the flows in the air transport network, as it characterizes the part of the shortest routes passing through a node.

In general, the betweenness of the node $x \in X$ in the G network can be defined as

$$B_x = \frac{\sum_{s \neq t} \sigma_{st}(x)}{\sum_{s \neq t} \sigma_{st}}, \quad (5)$$

where $\sigma_{st}(x)$ is the number of shortest routes from node $s \neq x$ to node $t \neq x$ through a node x, σ_{st} is the total number of routes between $s \neq x$ and $t \neq x$, $s,t \in N$.

Unlike the concept of a node's degree, the concept of the node's betweenness reflects the topology of the whole network.

The clustering coefficient is the local characteristic of the network, which corresponds to the level of network's nodes connectivity. In this case, it is likely that the two closest airports of the node $x \in X$ have a direct air route. Thus, the clustering coefficient characterizes the statistics of the cycles (triangles) in the network.

To calculate the clustering coefficient of the node, we can use the expression:

$$c_x = \frac{2r_x}{k_x(k_x - 1)}, \quad (6)$$

where r_x - is the number of links between the neighbors of the node x.

Obtaining the dependence: the higher is a level of clustering, the better is the development of air routes within the network.

The clustering coefficient of the G network can be obtained as the average clustering coefficient of the nodes $x \in X$, that is:

$$C_x^G = \frac{\sum_{x=1}^{d} c_x}{d}. \quad (7)$$

Indicators (3)-(7) correspond to the theory of the complex networks, the main statements of which are defined in the papers of Newman M. E. J. (2003) [4], Albert and Barabási (2002) [5].

2. The description of the elements of the air transport network of Ukraine

2.1. Airports

In Ukraine, there are about 42 airports and airfields. Each region has at least one airport. However the main international scheduled flights are operated only from the following airports: KBP, SIP, ODS, DNK, DOK, HRK, LWO, which is $x = \overline{1,7}$. From these airports, according to the ICAO, in the 2011, flies to the 89 worldwide airports were made $\left(y = \overline{1,89}\right)$.

The evaluation of the index of the AC airports from the subset X is needed to determine the actual workload of the node and the reserve capacity in order to develop the air transport network.

The analysis shows that the current state of infrastructure of the considered Ukrainian airports is sufficient for carrying out the existing passenger traffic (freight traffic are not considered because of the small volumes). So, «Borispol» airport passenger terminal (KBP), which consists of three terminals, has a capacity of about 20 million passengers per year.

After the completion of the construction and renovation works, by June 2012, the capacity of the «Lviv» airport (LWO) has reached 2,000 passengers per hour (about 6 million passengers per year). Currently, the airport is able to serve for up to 20 departures per hour (175 thousand per year).

The total area of the passenger terminal of the International airport «Donetsk» (DOK) is 58 thousand m^2, capacity - 3100 passengers per hour (about 10 million passengers per year). The runway length of 4,000 m and width of 60m can receive all types of aircraft twenty-four-hour, even in the conditions of restricted visibility. Noting, that according to the 2011-2012 data the annual passenger traffic of the airport is approximately 1 million passengers. Notably, the airport's resources are significantly higher than the actual demand for air travel in the region.

The «Odessa» airport terminal (ODS), the capacity of which is 400 passengers per hour (about 800 thousand passengers per year), from 2012 is being reconstructed. It is planned to increase the capacity up to 2 million passengers per year.

The public corporation «International airport «Simferopol» (SIP) can provide service of the aircraft of any take-off weight. Its capacity is about 2 million passengers per year, which 2 times exceeds the passenger traffic of the 2012.

Airports «Kharkiv» (HRK) and «Dnipropetrovsk» (DNK) are already reconstructed; the traffic-carrying capacity of each is 1.5 to 2 million passengers per year.

In 2012 Ukraine's airports handled 14.1 million passengers. This figure is significantly lower than the total carrying capacity of the airports under consideration. The airport ODS can be named as the one with the nodes' capacity problem.

2.2. Aircraft

The airline fleet registered in Ukraine (Table 1) consists mainly of the aircraft of type B737 in different modifications, fly range of which is from 4400 to 5765 km. Also, the A320 and A321 are operated, with the fly range of less than 6000 km. The seating capacity of the B737and A320, 321 depends on the configuration, but usually not more than 220 seats.

The airlines' fleet also has the Boeing 767 – wide body airliner designed for the operation of flights for middle and long distances (9400-9700 km), with the number of seats up to 295.

In 2011 the airline «Aerosvit» began to operate the Embraer ERJ 145 (up to 50 seats) from a family of regional jets. The maximum range of this aircraft is 3019 km. In 2011in the park of this airline appeared the Embraer ERJ- 195 - the newest and the largest representative of the family of Embraer E-Jet aircrafts. In various variants of the interior layout Embraer 195 is able to carry 106 – 122 passengers. It allowed the aircraft successfully operate on the routes of short and medium range (up to 3350 km).

In 2011 the An-148 – a short-range, narrow-body passenger aircraft developed by ANTONOV Company entered for the operation. Flight range of this aircraft is up to 4400 km, passenger capacity - up to 80 seats. Thus, we can conclude that the existing aircraft fleet of the Ukrainian airlines is designed for operation on the middle and medium-range air routes, and there is a tendency to the regional aircraft with a seating capacity of 100 seats. This airlines' policy is likely linked to the actual demand at the Ukrainian airline market.

Using data from Table 1 we can estimate the approximate capacity of the operated aircraft fleet. So, if assuming that each aircraft carries at least one flight per day, provided by the G network capacity is 6,804,695 seats, which is comparable with the data of statistical reports by ICAO (the major airlines of Ukraine, whose aircraft fleet was analyzed in 2011, carried 6,924,641 passengers).

Table 1 – The structure of the airlines' fleet of Ukraine, 2011 (compiled from ICAO)

Model	At End of Year	No. of Seats	Avg. Payload Capacity (in tons)	Average Utilization (hours/day)
A320	20	171	17	11,0
A321	3	203	21	13,5
AN148	1	68	9	0,9
ATR42	5	66	9	4,7
B 737 300	11	135	16	9,5
B 737 400	19	156	19	5,6
B 737 500	22	111	16	7,0
B 737 800	4	186	18	11,5
B 767 200	16	230	38	15,4
F27	1	50	7	4,6
EMB145	32	48	5	1,6
ERJ195	2	118	13	0,7
DC9 82	2	157	12	4,8
DC9 83	2	165	13	0,8
AN24	9	48	1	1,4
Cessna 170	1	3	-	0,9

2.3. The personnel

Aviation personnel are the staff of the aviation enterprise, organization, department, educational organization, which is composed from the aviation professionals on a professional basis. A person who belongs to the aviation staff must be certified for his/hers compliance with the existing in Ukraine qualifications on a professional basis. The rules and procedure of the certification of the aviation personnel is established by relevant government authority of the aviation's activity regulation.

According to the State statistics service of Ukraine (2012) [7] the number of full-time employees of the Ukrainian airlines in 2011 decreased by 18.9% compared with 2000. In 2010 the total number of employees of air transport was 11.1 thousand people. This is the lowest figure for the period. Interesting is the volume ratio of the air traffic and the number of Ukrainian airline staff (Fig. 2). The minimum values of the number of passengers and cargo (1.2 million passengers and 23,000 tonnes) over the considered period correspond to the maximum number of personnel in the sector (14.3 thousand people). The growth in traffic volume has not caused the need to increase staff. Most likely, this trend is explained by the active implementation of the information technologies for the organization and technology of passenger services and the cargo handling at the airports and airlines.

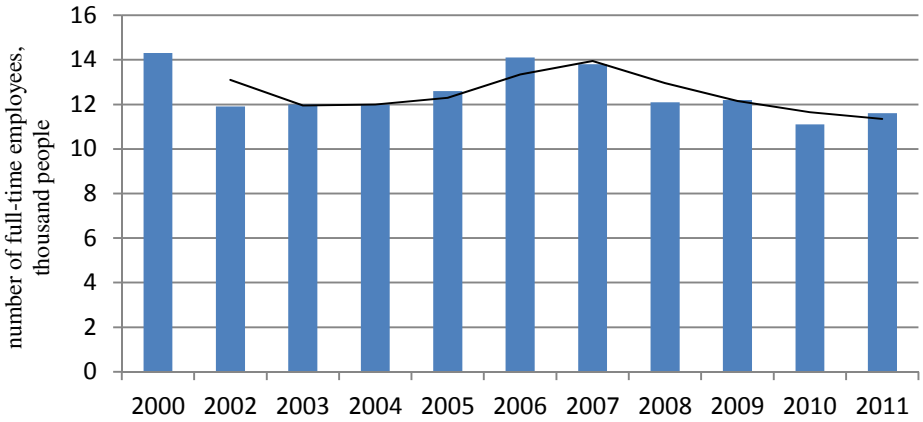


Figure 1 – The number of full-time employees of the Ukrainian air transport enterprises (compiled from the State statistics service of Ukraine)

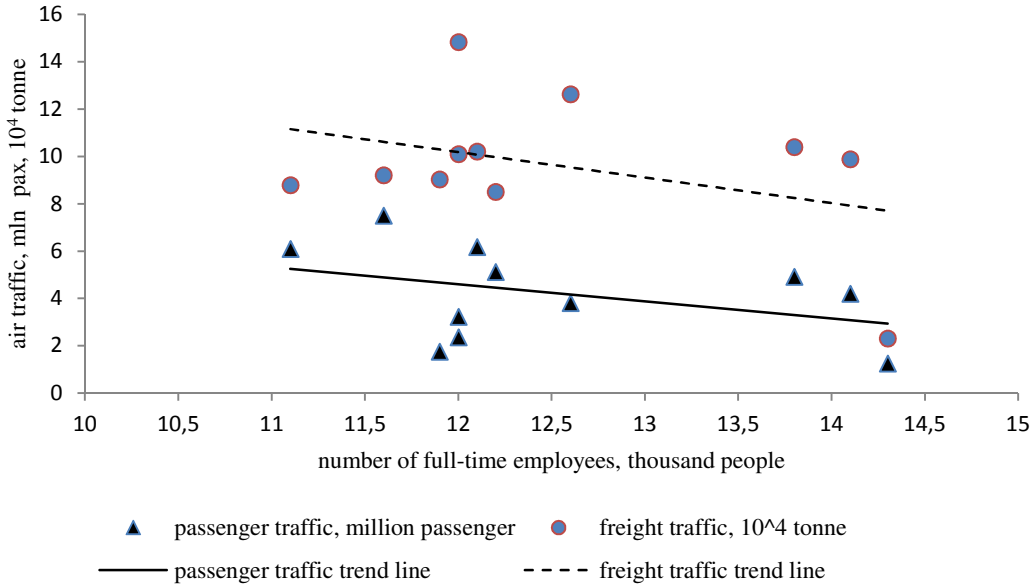


Figure 2 – The dependence of the air transportation upon the number of the regular employees of air transport enterprises of Ukraine (compiled from the State statistics service of Ukraine)

It is important to analyze the structure of aviation personnel. According to the ICAO (Fig. 3) in 2011, the number of pilots and flight attendants in the airlines of Ukraine has increased by more than 200% compared to 2009 while demand for other specialists remained practically at the same level. In 2002 one of the leading airlines of Ukraine «Ukrainian International Airlines» possessed the staff of 44 pilots and 95 flight attendants. In 2011 the number of these employees was 189 and 426 people respectively. In the «Aerosvit» airline the number of pilots has increased significantly in 2011 (193 people at the beginning of the year and 525 by the end of the year). Also, in 2011 the 234 flight attendants joined the staff of the airlines (at the end of the year the number was 648 people).

Training, retraining and advanced training of aviation personnel of Ukraine with the issuance of the relevant certificates may be accomplished in the aviation educational institutions, training centers of the

advanced training of the aviation professionals and other organizations, including foreign ones, having a certificate that is recognized in Ukraine.

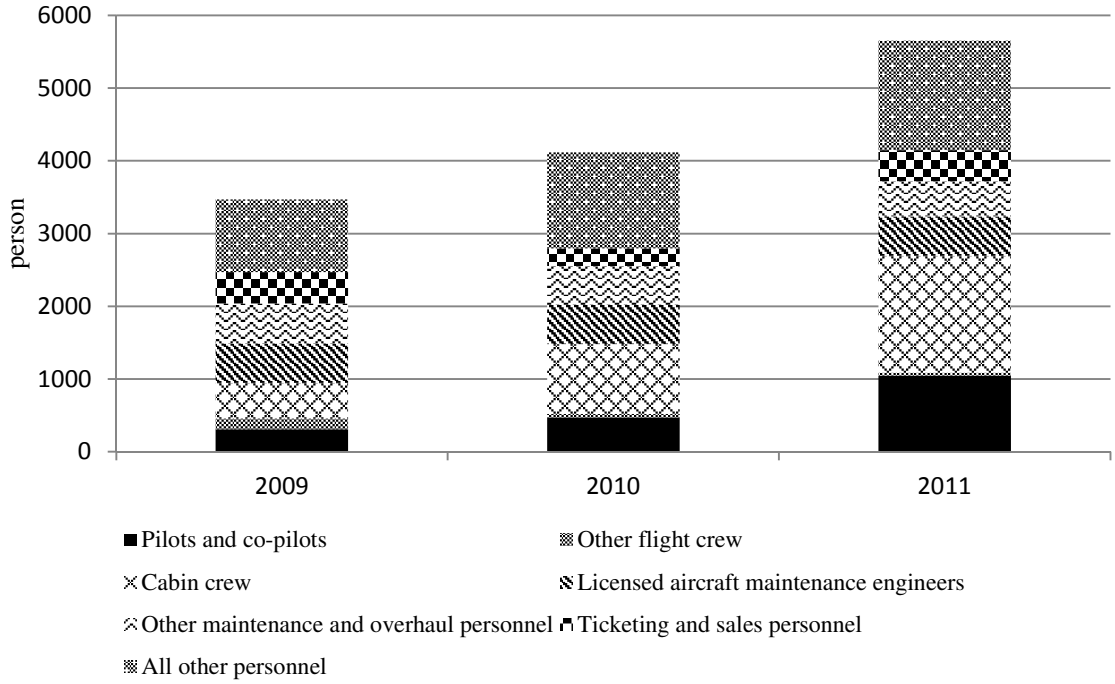


Figure 3 – Number of aviation personnel in the airlines of Ukraine (compiled from the ICAO)

In the conditions of the increase in the Ukraine's aircraft fleet the west production share, a serious shortage of the flight personnel properly trained can appear, as the training centers possesses only the simulators of the Soviet aircraft types (Tu -134, Tu- 154, AN-24, AN-26, IL -62 and others). Relying on the staff trained abroad, it is necessary to take into account the recent researches of the ICAO (2012) [6], which states that in the world in general and Europe in particular, the problem of training and possible shortages of the new generation of qualified aviation personnel also exists.

2.4. The air routes network

The results of operation of air routes network to and from Ukraine according to ICAO 2010, 2011 testifies that Kyiv - is the point at which the passenger traffic is formed for the hub airports of Moscow, Frankfurt-am-Main, London, Tel Aviv, Vienna and Prague (Fig. 4). Data on the number of flights executed from Odessa, Dnepropetrovsk, Donetsk, Lviv, Simferopol also show the gravity of main passenger traffic to the Moscow airports. The main points in Europe are: for Donetsk - Munich, Lviv - Warsaw, Dnepropetrovsk - Berlin and Istanbul, Odessa - Istanbul, Warsaw, Vienna, Prague. The same results are obtained by analysis of the volume of passengers transported by routs.

Considering the poor performance of domestic traffic, it can be assumed that Kyiv does not play a role as a hub for Ukrainian airports, as well as for European, because of the small number of long-haul flights. Moscow is the main transfer point for the passengers that come from and to Ukraine.

The results of the study on passenger traffic at the air routes of the major airports in Ukraine showed that the number of the transported passengers is mostly in the range of 1,000 to 50,000 people per year (Fig. 5). The length of the main part of the air routes is from 800 to 2,000 km. A trend in decreasing the total volume of passenger traffic on the network with increasing of the length of the air route is also visible, which is explained by a small number of long-haul flights and the preference of the transfer flights via Moscow and European hubs by Ukrainian passengers.

The frequency of flights on the air routes from airports in Ukraine also has a tendency to decrease with the increasing of the length (Fig. 6 a, b), though, is largely determined by economic constraints and other factors.

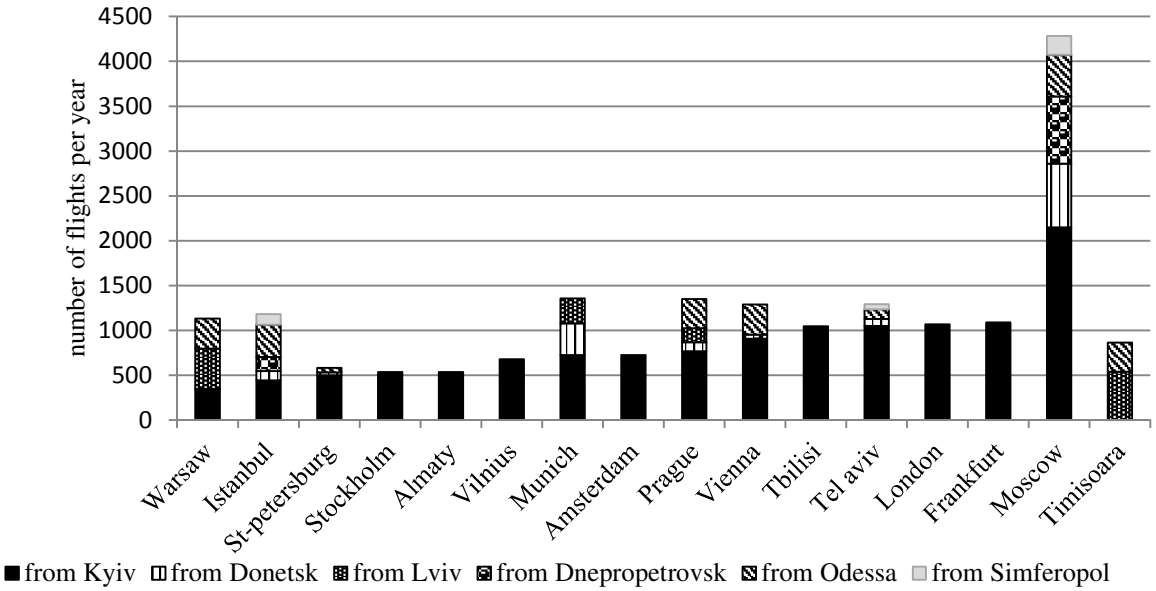


Figure 4 – The number of trips per year on major air routes from Ukraine (compiled from ICAO, 2011)

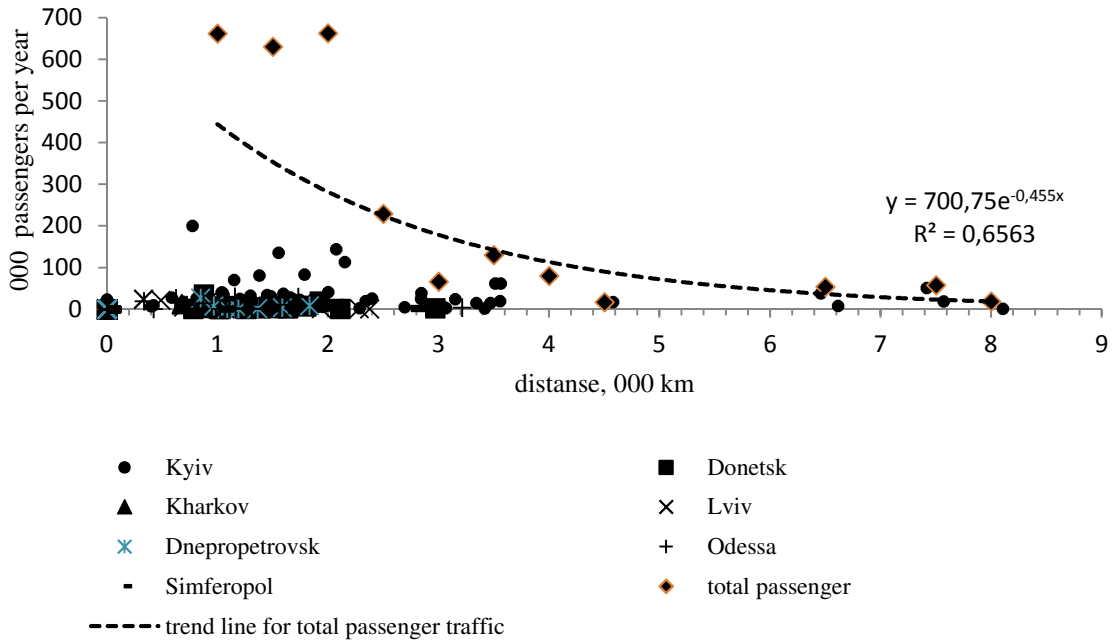


Figure 5 – The distribution of passenger traffic on the length of air routes (compiled from ICAO, 2011)

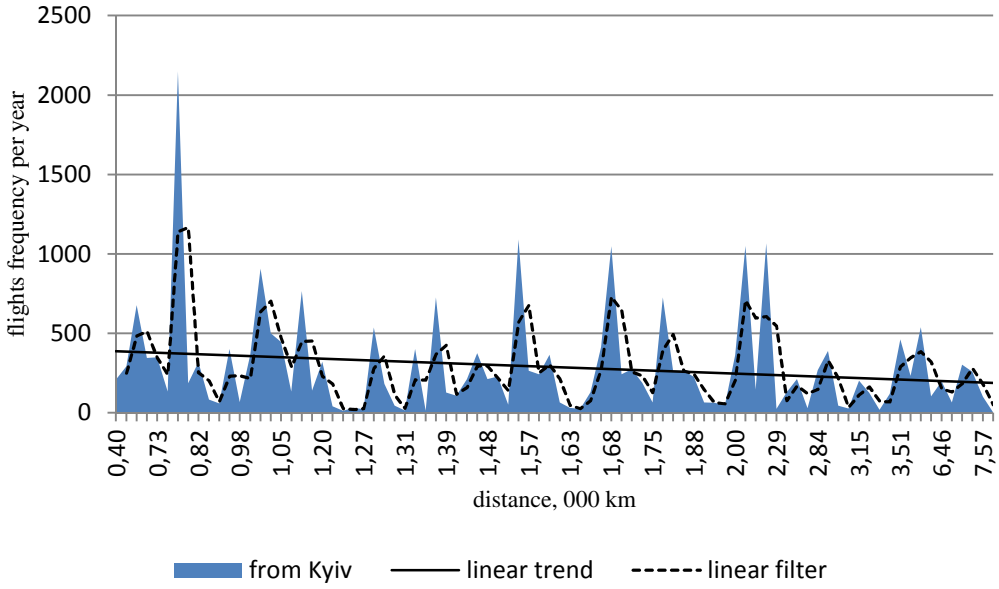
3. The results of calculations of the main characteristics of the air transport network of Ukraine

3.1.The degree of the nodes

The analysis of the air transport network Gin Ukraine was conducted according to the data of 2011. The G network consisted of $n = 96$ vertices (7 Ukrainian airports and 89 foreign) and $E = 1,070$ edges that indicate the presence of the direct flights between the airports of the network. The average degree of the network $\langle k_N^G \rangle = \frac{2E}{n} = 22.06$, while the maximum is 86 (the KBP airport, Table 2).

For comparison, the study of the global air transport network on IATA statistics for 2002 Barrat *et al.* (2004) [8], the maximal degree of a node is 318. More than 300 direct air routes (considering the global air transport system) have some of the airports in Europe, included to the subset Y, for example: VIE, FRA, LHR.

a)



b)

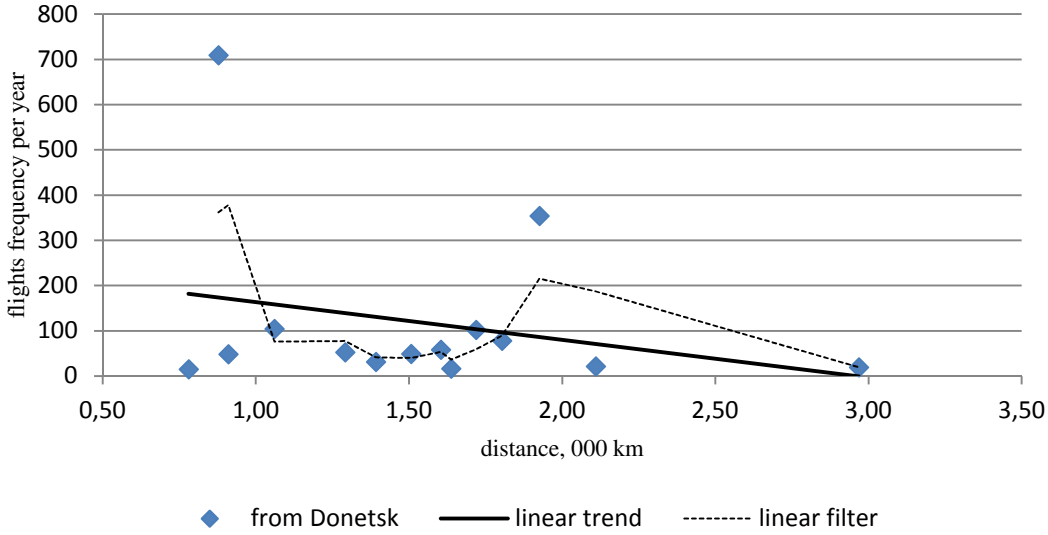


Figure 6 – The frequency of flights per year, depending on the length of air routes (compiled from ICAO in 2011): a) the number of flights from Kiev; b) the number of flights from Donetsk

The degrees of the nodes of subset X have an equiprobability probable distribution. Considering the nodes of a subset Y, the degree of nodes is approaching to a power law of the probability distribution (Fig.7), which is a hallmark of many complex systems and corresponds to the scale-free network model.

The main feature of scale-free networks is the existence of the hub, the degree of which is very large compared with the degrees of the other nodes. Call back, the nature of the power-law distribution is related to the strong interdependence of events.

3.2. The strength of nodes

The number of flights from Kyiv is much more than from the regional airports. Significant by the strength of node are also airports in Odessa, Donetsk, Lviv and Dnipropetrovsk.

The ratio of the degree and the strength of nodes is well described by a second degree polynomial trend (Fig.8):

$$s(x) = 2,324k^2(x) + 88,885k(x) - 44,862$$
$$R^2 = 0,999 \qquad (8)$$

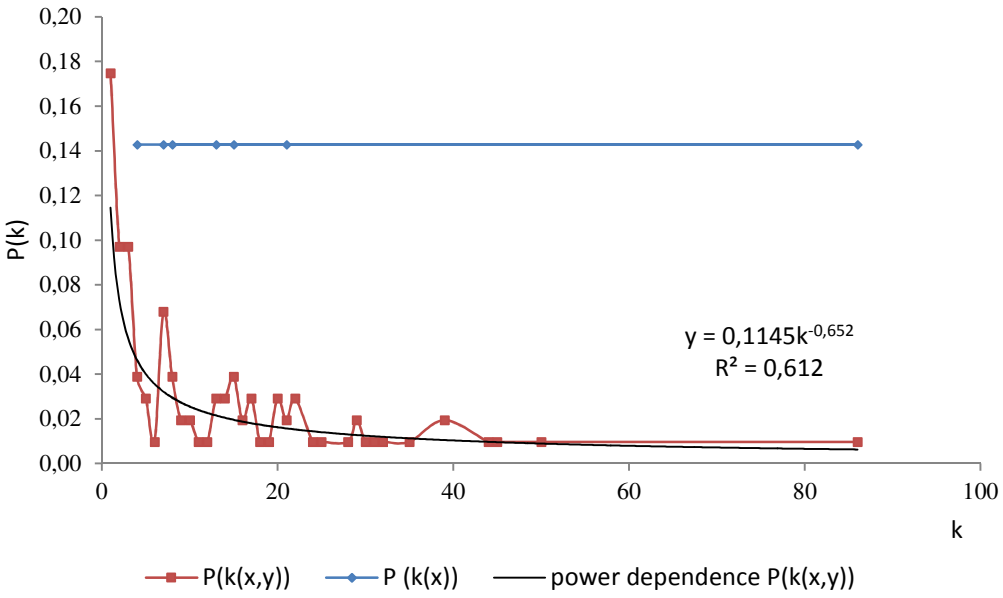


Figure 7 – Distribution of the nodes' degree in the G network

The dependence (8) allows forecasting possible change of number of flights from Ukraine airports on depends of change of number air routes in Gnetwork.

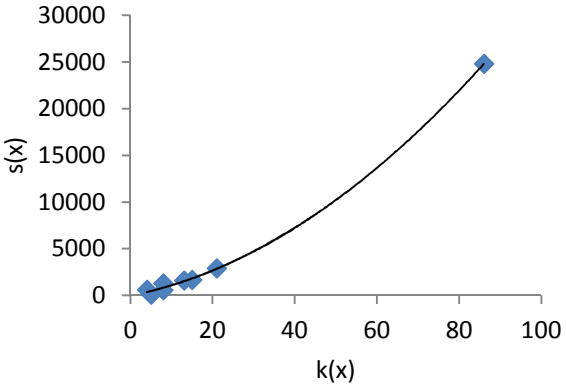


Figure 8 – The $s_x - k_x$ quadratic dependence

Table 2 – Parameters of the air transport network of Ukraine

Airport	k_x	s_x	$B(x)$	c_x
Kyiv	86	24787	0.724	0.249
Donetsk	15	1663	0.002	0.514
Kharkov	4	583	0.000	0.667
Lviv	13	1570	0.003	0.513
Dnepropetrovsk	8	1261	0.000	0.571
Odessa	21	2888	0.016	0.448
Simferopol	8	551	0.002	0.500
C_x^G	0.495			

3.3. Betweenness centrality

By indicator B_x apart from the KBP, the ODS is important by its routes (betweenness). However, the values of this index for the KBP and the ODS are incomparable. Kyiv is the only betweenness centrality (important) point in the development of the air transport network in Ukraine.

3.4. The clustering coefficient

In the issue of calculations the average clustering coefficient of the air transport network in Ukraine is equal to 0.520, which indicates the presence of the links between the airports of the subset γ . However, the main airport of Ukraine KBP has the lowest clustering coefficient equal to 0.249, indicating a large number of connections (air routes) with the airports of a low node degree (for example: Batumi, Astana, Bishkek, Cologne, etc.).

Conclusions

The proposed approach to the study of the air transport network of Ukraine includes background information about the elements of the network (airports, aircraft, aviation staff and network of air routes) and the analysis of the functioning of the air transport network based on regression analysis techniques, graph theory and complex networks.

The implementation of this approach is possible only with relevant and reliable statistical database, the structure of which need to be optimized. This problem in Ukraine is not solved yet.

The description of the elements of air transport network reveals possible reserves (excess) and the lack of resources. So, for Ukraine the significant reserves of the capacity of the reconstructed airports, accepting any type of aircraft, almost homogeneous structure of the aircraft fleet in range and passenger capacity, the possible shortage of pilots and flight attendants, the homogeneous structure of the network of air routes with predominantly medium-range flights are actual. In a network of air routes a single destination from the airports of Ukraine (except from Lviv) – Moscow is clearly dominated most likely due to the transfer passenger traffic, following through this hub.

The analysis of the interdependence of the various indicators within the air transport network is needed to study and evaluate the effect of one factor on the other. So, for the Ukrainian air transport network is typical of the tendency to reduce the frequency of flights and passenger traffic with an increase of the length of the routes. There is a need to find the main factors shaping the volume indicators of the air transport network operation.

The usage of graph theory and the theory of complex networks can provide a quantitative characterization of the air transport network for the understanding of the laws of the functioning of this complex system. In this work the confirmation received that the considered network can be described as a scale-free. Despite the high betweenness of the «Kyiv» node, its low clustering coefficient proves the need for more detailed study and optimization of the structure of the air routes network. Also used in the theory of complex networks characteristics allowed to quantify the role of Ukrainian regional airports in the formation of the passenger traffic. Low scores on the degree, strength and betweenness of the nodes confirm the presence of unrealized potential.

Further research will focus on the description and the analysis of the air transport network of Ukraine as a weighted graph.

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РЕФЕРАТ

Марінцева К.В. Аналіз авіаційної транспортної мережі України. / Марінцева Крістіна Валеріївна // Управління проектами, системний аналіз і логістика. – К.: НТУ – 2013. – Вип. 12.

В статті подано результати аналізу авіаційної транспортної мережі України.

Предмет дослідження – авіаційна транспортна мережа України.

Мета роботи – виклад методики і результатів аналізу функціонування авіатранспортної мережі України як основної підсистеми галузі цивільної авіації країни.

Метод дослідження – методи регресійного аналізу, теорії графів і складних мереж.

У вирішенні проблем розвитку авіаційних перевезень в Україні в останні десятиліття спостерігається криза. Про це свідчать відсутність глибоких науково обґрунтованих оцінок функціонування як авіаційної галузі в цілому, так і авіапідприємств зокрема. Враховуючи кардинальні зміни в функціонуванні та взаємозв'язки підсистем авіатранспортної системи України, актуальним є якісний аналіз даної системи з позиції незалежного суб'єкта (експерта). В даній статті запропоновано комплексний підхід до аналізу функціонування авіатранспортної мережі України з використанням методів регресійного аналізу, теорії графів і складних мереж. Проведені розрахунки авіатранспортної мережі України виявили значні резерви пропускної спроможності реконструйованих аеропортів, практично однорідну структуру парку повітряних суден по дальності і ємності, можливий дефіцит пілотів і бортпровідників, однорідну структуру мережі авіамаршрутів з переважно середньомагістральними рейсами. У мережі авіамаршрутів явно переважає один пункт призначення з аеропортів України – це Москва. Теорія складних мереж дозволила дати кількісну характеристику авіатранспортної мережі. Незважаючи на високий коефіцієнт завантаженості аеропортів Києва, їх низький коефіцієнт кластеризації доводить необхідність більш детального вивчення та оптимізації структури мережі маршрутів. Низькі показники ступеня, сили і завантаженості регіональних аеропортів України підтверджують наявність їх нереалізованого потенціалу у формуванні пасажиропотоків

КЛЮЧОВІ СЛОВА: АЕРОПОРТ, АВІАМАРШРУТ, ЄМНІСТЬ, МЕРЕЖА, СТУПІНЬ ВУЗЛА, КОЕФІЦІЄНТ КЛАСТЕРИЗАЦІЇ, ЗАВАНТАЖЕНІСТЬ ВУЗЛА

ABSTRACT

Marintseva K.V. Analysis of air transport network of Ukraine. Management of projects, system analysis andLogistics. Kyiv. National Transport University. 2013. Vol. 12.

The results of the air transport network of Ukraine are submitted in the paper.

Subject of research is the air transport network of Ukraine.

The objective of this paper is the statement of the methodology and the results of functioning analysis of the air transport network of Ukraine as a major subsystem of civil aviation industry of the country.

Methods of research are regression analysis, graph theory, and complex networks theory.

There is the crisis in the problem solution of air transport development in Ukraine in the past few decades. This is evidenced by the lack of deep scientific and reasonable estimates of the functioning of the aviation industry in whole and airlines, airports in particular. Taking into account the fundamental changes in the functioning and relationships of the subsystems of the air transport system of Ukraine, the topical problem is the qualitative analysis of this system from the position of independent party (expert). In this article we propose a comprehensive approach to the analysis of the functioning of the air transport network of Ukraine, by using regression analysis, graph theory and complex networks. Ukrainian air transport network calculations have showed significant capacity reserves of reconstructed airports; almost homogeneous structure on range and capacity of the aircraft fleet; possible shortage of pilots and flight attendants; homogeneous structure of the air routes network with mainly medium-haul flights. One destination from the airports of Ukraine to Moscow clearly dominate in the air routes network. The theory of complex networks gives possibility to get a quantitative characteristic of the air transport network. Despite the highest betweenness centrality of airports in Kyiv, their low clustering coefficient proves the necessity of more detailed study and optimization of the routes network structure. The low indices of the degree, strength and betweenness centrality of the regional airports of Ukraine confirm the presence of their untapped potential in the formation of passenger traffic.

KEY WORDS: AIRPORT, AIR ROUTE, CAPACITY, NETWORK, DEGREE OF A NODE, CLUSTERING COEFFICIENT, BETWEENNESS CENTRALITY

РЕФЕРАТ

Маринцева К.В. Анализ авиационной транспортной сети Украины. / Маринцева Кристина Валерьевна // Управление проектами, системный анализ и логистика. - К.: НТУ - 2013. - Вып. 12.

В статье представлены результаты анализа авиационной транспортной сети Украины.

Предмет исследования – авиационная транспортная сеть Украины.

Цель работы – изложение методики и результатов анализа функционирования авиатранспортной сети Украины как основной подсистемы отрасли гражданской авиации страны.

Метод исследования – методы регрессионного анализа, теории графов и сложных сетей.

В решении проблем развития авиационных перевозок в Украине в последние десятилетия наблюдается кризис. Об этом свидетельствуют отсутствие глубоких научно обоснованных оценок функционирования как авиационной отрасли в целом, так и авиапредприятий в частности. Учитывая кардинальные изменения в функционировании и взаимосвязях подсистем авиатранспортной системы Украины, актуальным является качественный анализ данной системы с позиции независимого субъекта (эксперта). В данной статье предложен комплексный подход к анализу функционирования авиатранспортной сети Украины с использованием методов регрессионного анализа, теории графов и сложных сетей. Проведенные расчеты авиатранспортной сети Украины выявили значительные резервы пропускной способности реконструированных аэропортов, практически однородную структуру парка воздушных судов по дальности и емкости, возможный дефицит пилотов и бортпроводников, однородную структуру сети авиамаршрутов с преимущественно среднемагистральными рейсами. В сети авиамаршрутов явно преобладает один пункт назначения из аэропортов Украины - это Москва. Теория сложных сетей позволила дать количественную характеристику авиатранспортной сети. Несмотря на высокий коэффициент загруженности аэропортов Киева, их низкий коэффициент кластеризации доказывает необходимость более детального изучения и оптимизации структуры сети маршрутов. Низкие показатели степени, силы и загруженности региональных аэропортов Украины подтверждают наличие их нереализованного потенциала в формировании пассажиропотоков.

КЛЮЧЕВЫЕ СЛОВА: АЭРОПОРТ, АВИАМАРШРУТ, ЕМКОСТЬ, СЕТЬ, СТЕПЕНЬ УЗЛА, КОЭФФИЦИЕНТ КЛАСТЕРИЗАЦИИ, ЗАГРУЖЕННОСТЬ УЗЛА

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