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DEVELOPMENT OF AIR TRANSPORT IN INDUSTRY 4.0:
PROSPECTS, PREREQUISITES, CHALLENGES

Abstract. The article analyzes the economic activity of air transport in Ukraine, formed ideas about the state and prospects for improving the competitiveness of domestic airlines in the market of passenger air service. The indicators of airlines activity have been analyzed and the dynamics of passenger and cargo air transportation volume has been shown. The directions of development of air transport in the conditions of Industry 4.0 and the basic principles of transition of air transport to Industry 4.0 are suggested. The unfavorable situations affecting the level of air transportation in Ukraine and some ways to overcome the crisis phenomena were determined. The authors have formed the main trends in the development of air transport and identified internal and external influencing factors. The analysis of strategic potential and possibilities of aviation transport development has been performed. Practical recommendations are given for increasing the competitiveness of the Ukrainian aviation market.

Keywords: air transport, air transportation, Industry 4.0, airlines, development of air transport, trends and prerequisites of development, aviation industry.

Statement of the problem. Air transport in Ukraine is one of the most important branches of national economy, effective functioning of which is a guarantee of stabilization, structural transformations, development of economy and foreign trade activities, ensuring protection of economic interests of the country [1]. Aviation transport compared to other types of transport (road, railway, water, etc.) is more globalized, which leads to the need to establish international cooperation in this area and bring national legislation into conformity with generally recognized standards. Given that the aviation industry is a high-tech sector of any state's...
economy, the multiplicity of which contributes to the development of related industries. Its dynamic changes require intellectualization of both business processes and managerial work of enterprises, application of principles of digitalization and technological renewal and implementation of innovations. In today's economic conditions Ukraine is moving towards Industry 4.0, and aviation industry is no exception, as it belongs to the basic, strategically important sectors of the Ukrainian economy. However, today the existing potential is underused, and aviation industry itself is influenced by the growing manifestations of systemic crisis. Therefore, the analysis of the current state, prospects and trends in the aviation industry of Ukraine, identifying the causes of the current situation and working out proposals for its possible improvement is quite relevant.

**Analysis of recent studies and publications.** A wide range of scientists, including Arefieva O.V. [2], Buhayko D.O. [3], Marintseva K.V. [4], Kulayev Y.F. [5], Poberezhna Z.M. [6], and other well-known domestic scientists in the field of air transport. The scientists analyzed the activities of airline companies and identified promising areas for their development. Features and trends in the development of the Ukrainian aviation market were studied by Vovnyanko A., Ivanytska O. [7-8]. Regarding the prerequisites, components, tendencies of Industry 4.0 the attention is given by Tytykalo V., Fobel, P., Kuzior, A. [12-13], the ways of implementation and advantages are proposed. However, the actual question is how to work out a development strategy for air transport in Ukraine in terms of Industry 4.0, the formation of the main directions of improvement and development with the current trends in the market, the political and economic situation.

**Presentation of the basic material.** Transformational processes in the market environment create prerequisites for increased competition on the national and global markets. There is risk of aggravation of socio-and-environmental, innovation and economic, organizational and managerial contradictions both in adapting to changes in the external environment and the implementation of development processes.
Specialization of enterprises by type of activity allows creating competitive needs for the reproduction of resources, the prospects for updating of equipment and technology, the definition of development prospects, the formation of market segments at the national and global levels. This is caused by different trends in the intellectualization of labor, the pace of introduction of robotization, automation of production processes, as well as the strengthening of the limitations of both raw material resources and the level of competence of workers. This is due to the development of such elements of the aviation sphere as airlines, airports, aircraft construction, requiring special knowledge, the term of training of specialists with active ability of highly qualified professionals to make decisions when overcoming hazards.

It is also advisable to highlight another trend in the development of the latest information penetration technologies in the virtual spaces of economic entities integrated into a single digital global system, which further actualizes the problem of preserving the eco-environment, creating prerequisites for maintaining environmental safety when using high-tech processes. Therefore, adaptation to the parameters of the new neo-technological society within Industry 4.0, requires the reduction of potential threats and a radical change in the field of personalization and personal service [12]. Changing the way of identifying and eliminating socio-environmental problems reinforces the need to develop approaches to assess the possibility and ability of the development of aviation transport of Ukraine in the conditions of Industry 4.0 in creating a network economy based on the latest production and management technologies, generating and processing a large amount of information, branched out implementation of artificial intelligence.

Acceleration the pace of neo-technological renewal should be based on abilities and qualities a leader-innovator that will create benefits for both teams and enterprises as a whole. Mastering new competencies and satisfaction economic
interests of the parties becomes the main prerequisite for accelerated development in the long run and provide leadership positions itself enterprises [14].

In this context, it should be noted that it is necessary to identify and expand the potential of aviation sphere, in particular the market of air transportation in Ukraine, which is significant in cost and organizational aspects. The proximity to Europe and Asian transit corridors provides a unique opportunity to earn on the transit of passengers and cargo, which creates the preconditions for strengthening the sustainability of the market participants. "But there are reasons restraining the growth of air transportation, namely the situation of local airports, i.e. the condition of runways, air navigation equipment; organization of the transportation process; high tariffs, etc. That is why bringing air transport infrastructure in line with international requirements should be an important component of the strategy to ensure Industry 4.0 of Ukrainian economy in the world market" [9].

The availability of high-tech competitive air transport and aviation infrastructure becomes an important condition for combining the processes of production of air transport and consumption of services rendered using it. The confirmation of the efficiency of air transport industry functioning is not only the economic development of the state, in this context the creation of conditions to ensure the safety of passenger and cargo transportation, minimizing the negative impact on the environment, but also ensuring the quality and efficient use of energy (fuel), focusing primarily on the needs of businesses and passengers, improving the mobility of citizens in Ukraine and abroad are of great importance.

However, in the current operating conditions the existing potential of aviation transport is not used effectively enough, and the aviation industry itself is under the influence of the growing manifestations of the systemic global crisis. This applies to almost all major components of the aviation industry, including air transportation. Now the Ukrainian civil aviation sector is characterized by institutional imperfection of state management in the sector, non-compliance with high safety standards and
outdated regulation of economic activities, which all have a negative impact on the efficiency of the sector and complicate the integration of Ukraine into the international aviation space [1].

Industry 4.0 for air transport is characterized by the following areas of development: institutionalization of air transport development at the state level based on the implementation of structural changes; application of innovations in all elements of the system of aviation enterprises to save resources in time and space; acceleration of clustering in area 4.0 at both the regional and national levels through the identification of common geographic interests of stakeholders and development strategies; full-scale digitalization of key sectors of the aviation industry, with mutual supplementation of information support in making management decisions and implementing common (similar) areas of development; intellectualization of all business processes in the aviation enterprises and the implementation of integration in accordance with the requirements of the World Space 4.0. The main principles of transition of air transport to Industry 4.0 are shown in Fig.1

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**Fig.1. Principles of transition to Industry 4.0**

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The primary problem of the enterprise development in information economy conditions is a constant market research and revealing of consumer demand on this basis, fast development and mastering of new goods, informing buyers about its advantages. The importance of information about the situation in the market comes to the forefront in determining the necessity of the very existence of the firm: if the firm cannot meet the needs, it will not be demanded by the market [10]. The functional purpose of internal and external information support determines their characteristics, requirements for operational updating, general and local mechanisms of construction of components and their interaction.

The situation in the world, associated with the outbreak of COVID-19 and the restrictions imposed by states to counter its spread, had a direct impact on the aviation industry of the world, including Ukraine. Thus, based on the results of 2020 there is a significant reduction in the performance of aviation enterprises compared with the previous year, which had a negative impact on the financial and economic condition of airports and airlines due to downtime of staff and aircraft. Thus, passenger and cargo transportation was carried out by 26 domestic airlines (29 in 2019), which in total performed 45.3 thousand commercial flights (in 2019 - 103.3 thousand flights), are shown in Table 1.

Table 1

Airline and airport activity for 2019-2020

<table>
<thead>
<tr>
<th>Activity of airlines</th>
<th>Units of measure</th>
<th>Total</th>
<th>% 20/19</th>
<th>Including international ones</th>
<th>% 20/19</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2019</td>
<td>2020</td>
<td>2019</td>
<td>2020</td>
</tr>
<tr>
<td>Transportation of passengers</td>
<td>Thousand people</td>
<td>13705,7</td>
<td>4797,5</td>
<td>35,0</td>
<td>12547,1</td>
</tr>
<tr>
<td>Including scheduled lines</td>
<td>-</td>
<td>8267,8</td>
<td>1788,1</td>
<td>21,6</td>
<td>7122,6</td>
</tr>
<tr>
<td>Passenger-kilometers performed</td>
<td>Bln. pass/km</td>
<td>30,2</td>
<td>10,1</td>
<td>33,5</td>
<td>29,7</td>
</tr>
<tr>
<td>Including scheduled lines</td>
<td>-</td>
<td>17,5</td>
<td>3,1</td>
<td>17,7</td>
<td>17,0</td>
</tr>
<tr>
<td>Cargo and mail transportation</td>
<td>Thousand tons</td>
<td>92,6</td>
<td>88,3</td>
<td>95,4</td>
<td>92,0</td>
</tr>
</tbody>
</table>
Continuation of the table 1

<table>
<thead>
<tr>
<th></th>
<th>&quot;-&quot;</th>
<th>19,6</th>
<th>5,7</th>
<th>29,1</th>
<th>19,4</th>
<th>5,6</th>
<th>28,9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tonne-kilometers</td>
<td>295,6</td>
<td>316,2</td>
<td>107,0</td>
<td>295,2</td>
<td>316,1</td>
<td>107,1</td>
<td></td>
</tr>
<tr>
<td>performed (cargo + mail)</td>
<td>&quot;-&quot;</td>
<td>93,0</td>
<td>18,4</td>
<td>19,8</td>
<td>92,9</td>
<td>18,4</td>
<td>19,8</td>
</tr>
<tr>
<td>Tonne-kilometers</td>
<td>103,3</td>
<td>45,3</td>
<td>43,9</td>
<td>86,7</td>
<td>35,3</td>
<td>40,7</td>
<td></td>
</tr>
<tr>
<td>performed (cargo + mail)</td>
<td>&quot;-&quot;</td>
<td>66,6</td>
<td>20,4</td>
<td>30,6</td>
<td>51,7</td>
<td>11,8</td>
<td>22,8</td>
</tr>
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</table>

Airports activities

<table>
<thead>
<tr>
<th></th>
<th>Thousand</th>
<th>Thousand</th>
<th>Thousand</th>
<th>Thousand</th>
<th>Thousand</th>
<th>Thousand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Departed and arrived aircraft</td>
<td>201,2</td>
<td>94,0</td>
<td>46,7</td>
<td>162,7</td>
<td>69,0</td>
<td>42,4</td>
</tr>
<tr>
<td>Including regular airlines</td>
<td>&quot;-&quot;</td>
<td>153,6</td>
<td>58,6</td>
<td>38,2</td>
<td>124,9</td>
<td>41,7</td>
</tr>
<tr>
<td>Passenger traffic</td>
<td>24334,5</td>
<td>8664,5</td>
<td>35,6</td>
<td>21994,1</td>
<td>7628,9</td>
<td>34,7</td>
</tr>
<tr>
<td>Including scheduled lines</td>
<td>&quot;-&quot;</td>
<td>18833,0</td>
<td>5643,5</td>
<td>30,0</td>
<td>16530,2</td>
<td>4627,2</td>
</tr>
<tr>
<td>Mail and cargo traffic</td>
<td>60,2</td>
<td>52,2</td>
<td>86,7</td>
<td>58,4</td>
<td>51,5</td>
<td>88,2</td>
</tr>
<tr>
<td>Including scheduled lines</td>
<td>&quot;-&quot;</td>
<td>54,1</td>
<td>40,8</td>
<td>75,4</td>
<td>53,0</td>
<td>40,4</td>
</tr>
</tbody>
</table>

* According to the State Aviation Service [11]

The complication of the epidemic situation in Ukraine and in the world led to a slump in demand for air transportation and reduction in the commercial load of flights at the end of 1st quarter of 2020, due to which airlines were forced to reduce the frequency or even cancel the vast majority of flights.

These factors have had a negative impact on the dynamics of passenger traffic of Ukrainian airlines. Thus, for the 1st quarter of 2020 the decrease compared to the same period of 2019 was 17.7%, and for the 2nd quarter, which was the peak of restrictive measures - 98.3%. However, after the restoration of passenger air traffic in June, the rate of decline in traffic slowed significantly and according to the results of the 2nd and 4th quarters amounted to 61.4% and 66.2% respectively [9]. Dynamics of passenger air transportation in Ukraine for 2011-2020 is shown in Fig. 2. At the same time, it should be noted that the aviation industry has a high organizational and technical potential, the activation of which will contribute to the rapid recovery of economic results.
In general, during the reporting year the number of passengers who used the services of domestic airlines has decreased by 65% compared to 2019 and amounted to 4797.5 thousand people. At the same time, the volume of passenger transportation by air transport in Ukraine returned approximately to the level of 2006-2007, when the specified indicator was 4208.3 thousand and 4928.6 thousand people, respectively. With the creation of positive trends in the demand for air transportation associated with the opening of the countries of the sky, the intensification of financial support for the development of air transport in Ukraine.

Passenger traffic during 2020 was carried out by 14 domestic air carriers. The largest volumes were performed by "Ukraine International Airlines", "SkyUp", "Azure Air Ukraine" and "Windrose" airlines, which accounted for almost 98% of the total passenger traffic of Ukrainian airlines. The number of aircraft that departed and arrived during 2020 amounted to 94 thousand (against 201.2 thousand in the previous year). At this passenger traffic through airports of Ukraine was reduced by 64.4%, mail and cargo traffic decreased by 13.3% and amounted to 8664.5 thousand people.
and 52.2 thousand tons respectively. The dynamics of passenger traffic through the airports of Ukraine is presented in Fig.3.

Fig.3. Dynamics of passenger traffic through the airports of Ukraine, 2011-2020, thousand people. (* according to the State Aviation Service [11])

Commercial flights of domestic and foreign airlines during 2020 are served by 19 Ukrainian airports and airfields. It should be noted that 97% of all passenger traffic and almost 99% of mail and cargo traffic is concentrated in 6 major airports – Kyiv (Boryspil), Lviv, Kiev (Zhulyany), Odessa, Kharkiv and Zaporizhzhia) [9].

Since the airline is an open system consisting of individual elements that together ensure its stability, balance and the ability to function and develop under the influence of internal and external influences, an important condition for its viability is the interaction with the external environment. Each airline, on the one hand, is under the constant influence of macroeconomic factors of the external environment, the dynamics of which is characterized by cyclicality and crisis. On the other hand, it reflects its cycles of development and they together form the entire socio-and-economic system [6].

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It should be noted that, despite all forecasts, concerning the unfavorable situation due to the pandemic, the level of air traffic in Ukraine tends to grow. This positive process can be maintained only with:

– improving the quality of service, introducing a variety of discounts, promotions and special programs for passengers on the background of cost optimization;

– more active work of low-cost airlines, as the demand for them is growing throughout Europe;

– increase of international flights by opening new routes;

– restructuring of domestic air travel in Ukraine on small aircraft with a capacity of 25-30 passengers in small airports [1].

Given the growth rate of air traffic and the potential prospects of strategic airports, especially their transit capacity, it should be noted that it is becoming increasingly important to focus efforts on bringing the infrastructure of major airports in line with the requirements of Industry 4.0 [13].

Despite the speed of change that Industry 4.0 brings, the general trend of industry development in Ukraine is its strategic nature, that is, the activities of enterprises are carried out within the framework of industry, regional, national or local strategies.

Thus, the development of air transport has the following main trends:

– consolidation at the national level, manifested in the merger or absorption of competitive airlines, the reduction in the number of independent producers, the formation of powerful national groupings – consortiums, corporations, concerns, which leads to a reduction in excess production capacity;

– increased cooperation and integration at the transnational level, identified in the creation of major international associations capable of developing and implementing international systems and programs;
– ensure the transition of the aircraft industry to new technologies through Industry 4.0;
– solving the problem of reducing production costs;
– increase productivity, product quality and competitiveness (by introducing intellectualization and digitalization of processes);
– improve the quality of customer service at all stages of service provision.

The system to ensure economic sustainability of the enterprise should cover a number of elements, the main among which is the monitoring of the stability of business processes of the enterprise under the influence of external and internal environment, in the context of investment and security aspects, as well as the development of effective measures to prevent the risks of unstable activity [2]. That is why the determination of external and internal factors is a priority to determine the trends of the aviation industry (Fig. 4).

![Fig. 4. Interrelation of factors influence on aviation industry and development trends](image-url)

However, it should be stated that the implementation of the strategy is impossible without an analysis of the strategic potential and opportunities for the development of aviation transport by the most acceptable in this case method of
SWOT-analysis. The conducted analysis of the advantages of the domestic aviation industry allows to single out such strengths and weaknesses, which are shown in Table 2.

Table 2

Strategic matrix of SWOT-analysis for aviation industry of Ukraine

<table>
<thead>
<tr>
<th>Common points</th>
<th>Significance level of the factor</th>
<th>Weak points</th>
<th>Significance level of the factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advantageous geographic location</td>
<td>5</td>
<td>Outdated fixed assets</td>
<td>3</td>
</tr>
<tr>
<td>State priority to industry</td>
<td>4</td>
<td>Insignificant state support</td>
<td>3</td>
</tr>
<tr>
<td>High quality/priceratio</td>
<td>4</td>
<td>Low level of innovativeness</td>
<td>5</td>
</tr>
<tr>
<td>Services (products) meet international standards</td>
<td>3</td>
<td>Difficult financial situation of companies in the industry</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Significance level of the factor</th>
<th>Threats</th>
<th>Significance level of the factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growing demand for passenger and cargo aircraft in the world</td>
<td>4</td>
<td>High barriers to enter the global market</td>
<td>4</td>
</tr>
<tr>
<td>Growing aircraft production and exports</td>
<td>5</td>
<td>Increased competition on the global market</td>
<td>5</td>
</tr>
<tr>
<td>Increased domestic demand for military aircraft</td>
<td>3</td>
<td>Increased demand for low-energy aircraft</td>
<td>4</td>
</tr>
</tbody>
</table>

Accordingly, it is recommended for the development of the aviation industry of Ukraine:

– management reform in the aviation industry and corporatization;
– need to improve investment policy and promotion of the aviation industry;
– improvement of trade policy on the global market;
– maintenance of long-term stability of employees' qualification and intellectualization of labor;
– government support for the aviation industry and customers.
Conclusions. Summarizing the above, it should be noted that today it is important to develop an effective mechanism of measures to overcome the consequences of the 2020 financial crisis caused by the COVID-19 pandemic coronavirus infection. Also, as part of the creation of appropriate financial conditions for the development of the aviation industry, it is advisable to consider granting state monetary support and subsidies to aviation enterprises to finance the provision of services in the aviation sphere. In this context, it is extremely relevant to study the global experience of stabilizing the aviation industry enterprises in conditions of pandemic, taking into account the requirements of international standards of regulatory activity, further development of multimodal corridors and updating approaches to the functioning of transport and logistics systems. Exactly now it is necessary to take real steps to enhance competitiveness of Ukrainian aviation market on the threshold of air traffic liberalization by increasing investment attractiveness of airports and air companies, stimulating domestic aviation mobility, creating national low-cost airlines, adjusting Ukrainian foreign transport policy towards Industry 4.0. Development and implementation of these measures through the state will be able to overcome the current state of affairs in the aviation market of Ukraine and rapidly increase the competitive potential of domestic air carriers and ensure passenger safety.

References


9. The concept of the State program for the development of the aviation industry for the period up to 2030. URL: http://www.mtu.gov.ua.


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РОЗВИТОК АВІАТРАНСПОРТУ В ІНДУСТРІЇ 4.0:
ПЕРСПЕКТИВИ, ПЕРЕДУМОВИ, ВИКЛИКИ

Анотація. У статті узагальнено напрями розвитку авіаційного транспорту в Україні при функціонуванні на глобальних ринках, розкрито стан та перспективи підвищення конкурентоспроможності вітчизняних авіакомпаній на ринку пасажирських авіаперевезень. Встановлено передумови розвитку авіаційної сфери в період структурних трансформацій, розширення надання послуг, підвищення темпів авіаперевезень. Доведено, що функціональне призначення внутрішнього і зовнішнього інформаційного забезпечення обумовлює їхні характеристики, вимоги до оперативного оновлення, загальний і локальні механізми побудови складових і їхньої взаємодії.

Проаналізовано основні показники діяльності авіакомпаній, визначено динаміку обсягів пасажирських і вантажних авіаперевезень, встановлено основні тенденції розвитку авіаційного ринку. Запропоновано напрями розвитку авіатранспорту в умовах Індустрії 4.0 та основні принципи переходу за визначеними рівнями на підставі інформатизації і діджиталізації.

Виокремлено чинники, що впливають на рівень авіаперевезень в Україні, шляхи подолання кризових явищ, узагальнено умови для забезпечення безпеки перевезення пасажирів та вантажів, можливості мінімізації негативного впливу на навколишнє середовище.

Встановлено основні тенденції розвитку повітряного транспорту на підставі визначення внутрішніх та зовнішніх факторів впливу на стан і перспективи здійснення адаптаційних процесів в авіаційній сфері через інтелектуалізацію управління в період реалізації переваг Індустрії 4.0.

Здійснено аналіз стратегічного потенціалу та можливостей розвитку авіаційного транспорту, запропоновано шляхи його удосконалення на інноваційних засадах в розрізі безпекового аспекту і ефективні заходи запобігання ризикам нестабільної діяльності, підвищення конкурентоспроможності українського авіаринку з урахуванням визначення і розширення потенціалу.

Ключові слова: авіаційні перевезення, Індустрія 4.0, авіалінії, розвиток авіаційного транспорту, конкурентоспроможність, діджиталізація, тенденції та передумови розвитку, авіаційна сфера, здатність до розвитку.