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## DIGITAL TRANSFORMATION OF AVIATION INDUSTRY IN UKRAINE

*The article deals with the processes involved in the digital transformation of the economy, both globally and nationally. Government initiatives aimed at digital development include eliminating legislative, institutional, fiscal and other obstacles that hinder the development of the digital economy, introducing incentives and motivations to encourage businesses and the economy as a whole to digitize, create demand and generate citizens' needs for digitization, primarily through the introduction of large-scale digital transformation projects by the state, the creation and development of digital infrastructures as a basis for harnessing the benefits of the digital world in everyday life and platform to achieve economic efficiency in general. The authors explore the concept of digital economy and presents different approaches to its definition. It is noted that there are many approaches to defining the concept of the digital economy, but there is no unified one. The authors conclude that most sources see in the digital economy a new kind of economic relations based on the collection, processing, transfer of information through information technology.*

*It have been shown current trends in digital transformation in the aviation industry and shows the latest digital technologies developed and implemented by aviation market subjects. In today's world, increasing the competitiveness of airlines and airports is seen in increasing passenger satisfaction with flight, which is possible through the development of personalized solutions for a specific person. Existing information technologies, such as blockchain, artificial intelligence, big date, make it possible to collect and process huge amounts of information about a passenger and his preferences, and to develop proposals that are relevant to the interests of that passenger.*

*In the article the legislative and regulatory support for digital transformation processes in Ukraine was analyzed. The author notes that the process of digital transformation in the country is at an early stage, so the digitization of certain sectors of the economy depends on the subjects of this industry. The successful process of digital transformation of airlines and airports depends largely on the available infrastructure. Compared to the world's leading airports, Ukrainian airports have a very low level of infrastructure development and modernization plans do not involve the introduction of the latest digital technologies.*

*Keywords: digital economics, digitalization of aviation industry, digital transformation, information and communication technologies.*

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**Formulation of the problem.** The evolutionary development of humanity is a process that never stops and continues right now. Not so long ago the world survived the industrial revolution and now entered the era of the information revolution. All our modern life is connected with information and communication technologies. Information exchange occurs mainly via devices such as smartphone, tablets, computers. Almost all areas of our lives are connected with digital technologies: interaction with government bodies, healthcare, education, entertainments, shopping, banking, transportation etc. The process of digital transformation in each country takes place in its own way, it depends on political, economic, social factors. There are countries leaders of digitalization and countries that only now recognize the need for change. A strategic plan for digital economic development should include measurements for all industries. Analysis of the industry situation, possible obstacles and threats to the implementation of digital technologies will make it possible to develop a logical, economical roadmap of digital transformation in aviation industry.

**Analysis of recent research and publications.** Recent scientific papers related to the digital economy belongs to such authors as Nicolas Colin, Augustin Landier, Pierre Mohnen and Anne Perrot [1]. The issues of conceptualization of digital economy in Ukrainian conditions were researched by Alla Cherep, Regina Andriukaitiene, Valentyna Voronkova, Roman Oleksenko [2], Sylwia Talar [3]. Interesting research of challenges in airport digital transformation was made by Sorin Zaharia and Casandra Pietreanu [4].

**The purpose of the article** – to analyse all definitions and concepts that are connected with digitalization. Explore which government institutions and international organisations are involved in the digital transformation process and what legislative acts exist. any transformation process provides for the achievement of a specific goal and at the end of this process it is necessary to evaluate how successful it was, or evaluate the individual stages of this process or the current state of the transformed object. For assessment digital economy level it's necessary to investigate existing evaluation methods and indicators. One of the goals of the article is to analyse the existing modern digital solutions in the aviation industry and the possibility of their implementation on the Ukrainian market.

**The main research material.** Modern living conditions are such that digital transformation is taking place not only in the aviation industry, but also in all other industries. This is a global trend and Ukraine does not stand aloof from these changes. In 2018 The Concept of Development of Digital Economy and Society of Ukraine for 2018-2020 was accepted by the decree of the Cabinet of Ministers of Ukraine dated January 17, 2018 №67-p. This concept provides carrying out measures of appropriate incentives implementation for digitization of the economy, public and social spheres, awareness of existing challenges and tools for digital infrastructure development, acquisition of digital competencies by citizens, and identifies critical areas and projects for digitization, promotion of the internal market of production, use and consumption of digital technologies. [5]

For understanding what goals is planned to achieve through the implementation of activities envisaged by the concept it is necessary to define concept of digital economy. With accordance to Wikipedia digital economy refers to an economy that is based on digital computing technologies, although we increasingly perceive this as conducting business through markets based on the internet and the World Wide Web. The digital economy is also referred to as the Internet Economy, New Economy, or Web Economy. [6]

This term was mentioned at the first time by Don Tapscott in his 1995 best-selling book “The Digital Economy: Promise and Peril in the Age of Networked Intelligence”. [7] The researcher attributed the most important consequences of the global economy digitalization to a sharp decrease in transaction costs, the emergence of new business models and, as a result, the exclusion of

intermediaries due to direct interaction between the consumer and the supplier. The author predicted many particular effects of the upcoming digitalization.

Nicholas Negroponte, founder of the Massachusetts Institute of Technology's Media Lab and author of the 1995 book "Being Digital", has described the digital economy as using "bits instead of atoms." [8] According to Negroponte, in comparison with the traditional market, the benefits of digitalization include:

- lack of physical weight of products that can be replaced by information volume;
- significantly lower costs for the production of electronic goods and less space occupied by electronic media;
- the virtual nature of economic relations, leading to a decrease in the need for raw materials;
- the emergence of digital currencies, which today is clearly illustrated by the growing cryptocurrency market;
- instant global movement of goods and services via the Internet.

Let's consider some approaches to the definition of the term "digital economy" (Table 1).

*Table 1. Some approaches to the definition of the term "digital economy"*

№	Definition
1	An economy which functions primarily by means of digital technology, especially electronic transactions made using the Internet.
2	The digital economy is comprised of markets based on digital technologies that facilitate the trade of goods and services through e-commerce.
3	The single most important driver of innovation, competitiveness and growth in the world.
4	One that can provide a high quality of information and communication technologies (ICT) infrastructure and harness the power of ICTs to benefit consumers, businesses and governments.

*Sources:* designed by own, based on information from [9], [10], [11], [12]

Summarizing all definitions we can say that digital economy is new evolutionary form of economy that is based on the use of information technologies.

If we have some process of transformation, of course we want to know is successful this process or not. Accordingly, we should evaluate the level of digitalization in accordance with different criteria. There are a lot of different indicators for evaluation the level of development of the country's digital economy. Some of them are described in the Table 2.

In 2019 Ukraine had rank 67 of NRI from 121 countries (for comparison top 3 countries are Sweden, Singapore and Netherlands). In accordance with UNCTAD B2C E-commerce index, in 2019 Ukraine had rank 52 from 152 countries (top 3 countries are Netherlands, Switzerland and Singapore). The last IDI rating was published in 2017 and Ukraine had rank 79 from 176 countries. The EGDI rank of Ukraine in 2018 was 82 from 180 countries. The DESI is calculated only for EU member states but methodology of this index could be implemented in Ukraine.

It should also be noted that in 2019 was founded Ministry of Digital Transformation of Ukraine. This ministry provides for the formation and implementation of state policy in the field of digitization, digital economy, digital innovation, e-government and e-democracy, development of the information society. To date, Ministry is more focused on building digital interaction between the state and citizens. And in fact, the drivers of digital transformation of industries are enterprises that work in this industry, i.e. airlines and airports.

*Table 2. Indicators for evaluation the level of development of the country's digital economy*

№	Name of indicator	Description
1	Networked Readiness Index (NRI)	The NRI, also referred to as Technology Readiness, measures the propensity for countries to exploit the opportunities offered by information and communications technology (ICT). It is published in collaboration with INSEAD (European Institute of Business Administration), as part of their annual Global Information Technology Report (GITR). The report is regarded as the most authoritative and comprehensive assessment of how ICT impacts the competitiveness and well-being of nations
2	UNCTAD B2C E-commerce Index	The UNCTAD B2C E-commerce Index, which measures an economy's preparedness to support online shopping, has expanded its coverage to include 152 economies. The index is calculated as the average of four indicators: account ownership at a financial institution or with a mobile-money-service provider (% of population ages 15+); individuals using the Internet (% of population); Postal Reliability Index; Secure Internet servers (per 1 million people)
3	Global ICT Development Index (IDI)	The IDI is an index published by the United Nations International Telecommunication Union based on internationally agreed ICT indicators. This makes it a valuable tool for benchmarking the most important indicators for measuring the information society. The IDI is a standard tool that governments, operators, development agencies, researchers and others can use to measure the digital divide and compare ICT performance within and across countries. The ICT Development Index is based on 11 ICT indicators, grouped in three clusters: access, use and skills
4	E-Government Development Index (EGDI)	The EGDI presents the state of E-Government Development of the United Nations Member States. Along with an assessment of the website development patterns in a country, the EGDI incorporates the access characteristics, such as the infrastructure and educational levels, to reflect how a country is using information technologies to promote access and inclusion of its people
5	Digital Economy and Society Index (DESI)	The DESI is a composite index that summarises relevant indicators on Europe's digital performance and tracks the evolution of EU member states in digital competitiveness. The DESI is composed of 6 principal dimensions, each divided in a set of sub-dimensions, which are in turn composed by individual indicators: connectivity; human capital/digital skills; use of internet services by citizens; integration of digital technology by businesses; digital public services; research and development ICT

*Sources: [13]*

There are international associations of airlines and airports such as IATA and ACI. The goals of these associations are to represent, manage and service the airline industry. Also, one of the missions of these associations is to provide digitalization.

The International Air Transport Association (IATA) is the trade association for the world's airlines, representing some 290 airlines. IATA supports many areas of aviation activity and to help formulate industry policy on critical aviation issues.

Airports Council International (ACI) is the only global trade representative of the world's airports. Established in 1991, ACI represents airports interests with Governments and international organizations such as ICAO (International Civil Aviation Organization), develops standards, policies and recommended practices for airports, and provides information and training opportunities to raise standards around the world. This section provides you with information on the structure and background of ACI. There is sub-organisation of ACI, ACI Europe that represent over 500 airports in 46 European countries. Three Ukrainian airports are members of ACI Europe:

Boryspil International Airport, Kharkiv International Airport and Odessa International Airport. One of the goals of this organization is to help its members implement digital transformation activities.

In very competitive environment, airports are focused on expanding and enhancing their appeal to increase their community's share of air travel and tourism, innovating and maintaining a strong focus on enhancing customer experience. While safety and security always remain airports' top priorities, their leaders also focus on ways to streamline airport business and operations. They leverage technology to meet and exceed goals and objectives. In today's digital world there is no escaping the power of data, so harnessing its benefits is key. [14] Airport leaders acknowledge that business success is not just about the deployment of new technologies, simply because IT systems and applications change too quickly. Instead, success is about transforming the business of airports, adapting to customers, staff, community and cultures and leveraging existing and new technologies to meet objectives and goals.

A lot of investments are spent on customer personalisation. The airlines are well aware of the fact that today's digital natives are used to customised interactions and personalised solutions, thanks to the growth of e-commerce and the popularity of social media channels.

For airlines, customer interactions start way before the flight is even boarded; the test begins when the flyer is looking for a flight and extends way after they unboard the plane. It can be a daunting task to keep up with the changing customer demands and provide a seamless and delightful experience throughout the passenger journey.

Opportunities for airlines and airport to use mobile apps on each stage of passenger journey are shown on the Fig. 1.

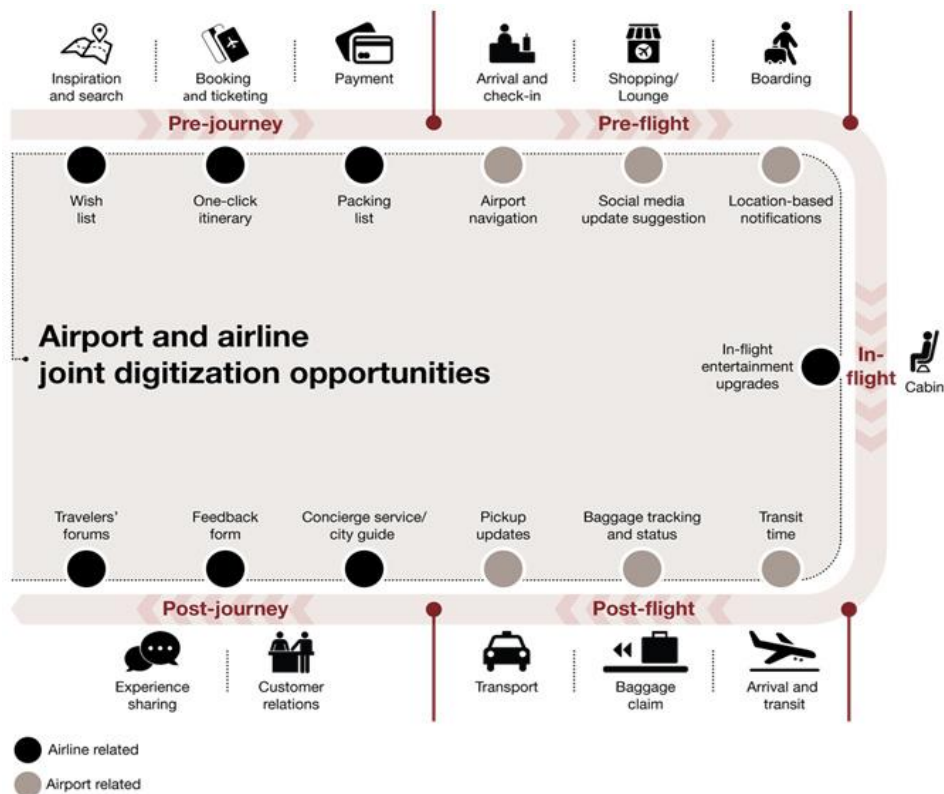


Figure 1. Stages of passenger journey and digital opportunities

Sources: [15]

Travellers can buy tickets, check-in and access the latest flight details via apps. Mobile notifications can include arrival/departure gate changes, traffic delays around the airport, and discounts at airport restaurants, hotels and retail stores.

Airlines are also using SMS texts to provide travellers with service disruption updates, such as flight delays or cancellations.

Having access to details about a traveller's destination and trip duration allows aviation management professionals to provide geo-specific content, such as destination deals and offers, places to visit and weather forecasts.

Digital technologies are being used today to increase consumer satisfaction with the use of aviation services, and therefore to increase customer loyalty.

For airports, it is possible to create a simpler process for passengers to get from the airport entrance to the aircraft, as well as to increase their capabilities in terms of operational safety.

With the increase of passenger traffic through the airport, the use of digital technologies allows to optimize work and ensure its continuity. It also allows airports to perform virtual simulation and simulation activities during peak hours for better allocation of resources and optimal use of the runway.

Let's take a look at the main emerging technologies which are revolutionising the flying experiences and digitally transforming it to a tech-savvy and customer centric industry (Fig. 2).

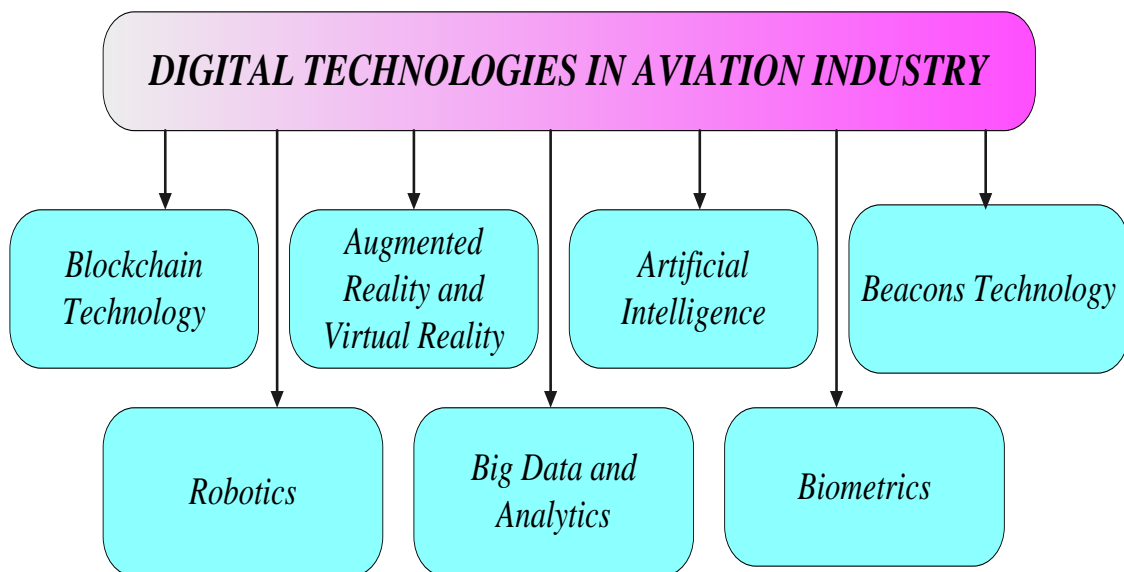


Figure 2. The main digital technologies in aviation industry

Sources: designed by own

1. Blockchain technology. Blockchain is a rule-built, continuous series of blocks containing information. In other words, it is a distributed database in which storage devices are not connected to a single server. According to SITA's 2018 Air Transport IT Insights, 34% of airports are planning blockchain research and development programs by 2021. One area in which airports see blockchain's potential is the ability to help improve passenger identification processes, in part by reducing the need for multiple ID checks. [16] Airlines can use blockchain technology to improve operational efficiencies, security systems and even customer experiences.

2. Augmented Reality and Virtual Reality (AR/VR). The airports can use AR to help passengers navigate the complex layout of the airport, and to help air traffic controllers with the vital job of keeping planes safe. The augmented and virtual reality market in aviation is projected to grow from USD 78 million in 2019 to USD 1,372 million by 2025. [17]

3. Artificial Intelligence (AI). AI and the use of algorithms now make it possible to give the right information to every passenger at the right moment, based on location, time before flight, profile and preference. Whether it is about finding his or her way in the airport, pushing promotional offers for products and services, or reacting to an emergency, every visitor provides a unique, specific context and has different needs and interests - e.g., adapting the way-finding path to the specific airline lounge or gate according to the traveller's membership status, taking into consideration any disabilities, luggage type (count, oversized), family count, etc.

4. Beacons technology. Beacons technology makes navigation easy for travellers between different terminals at the airport. Further, beacons can help airports and vendors at the airport premises to know where passengers are and then send them personalised and relevant information accordingly. These updates can be about boarding gate number, baggage carousel, flight status or also about the shops and eateries around the customer.

5. Robotics. The airline industry is also using robotics in assisting with various tasks like customer management, baggage handling, car parking, etc.

6. Biometrics. The airlines industry is consistently working towards making travel experience delightful and comfortable for their customers. Adopting the biometrics technology at airlines and airport touch points is one such attempt by the industry.

7. Big Data and Analytics. Airlines can drive valuable insights by analysing the vast amount of data available to them to create delightful experiences for travellers, understand customer preferences in real-time based on data of their purchase history, travel itineraries etc. and provide them customised offers etc.

The digital transformation of aviation industry leads to necessity for airports constantly upgrade infrastructure. There are following main objects of infrastructure are needed to support modern services in the airport:

- Wireless Local Area Networks (WLANs) on the airport premises;
- automated document readers linked to border control systems for Machine readable travel documents (MRTDs) such as passports visas, official travel documents and crew member certificates;
- RFID detection infrastructures;
- biometric identification systems;
- electronic tickets readers;
- self-service kiosks;
- security systems.

Let's consider the activities of Ukrainian airports. According to the State Aviation Service of Ukraine in 2020, there are 20 operating airports. [18] For comparison, in 1991 there were 50. But it should be noted that in recent years there has been a positive trend in passenger flows through Ukrainian airports. So, in 2019, the total passenger flow amounted to 24334,5 thousand people (of which 21994,1 on international flights). In comparison with 2018, passenger flow increased by 18,4%. Cargo and mail flows are increased by 6,7% in 2019 and amounted to 60,2 thousand tons. At the same time, about 98% of passenger flows and cargo and mail flows are concentrated at 7 major airports (Boryspil, Kyiv (Zhuliany), Lviv, Odessa, Kharkiv, Zaporozhye and Dnipropetrovsk). The values of passenger flows in 2019 are shown in the Table 3.

Table 3. Passenger flows of Ukrainian airports in 2019

№	Airports	Total passenger flows, people	Passenger flows on international lines, people	Passenger flows on domestic lines, people
1	Boryspil	15260281	14160117	1100164
2	Kyiv	2617900	2559100	58800
3	Lviv	2217400	2008700	208700
4	Odessa	1686365	1395628	290737
5	Kharkiv	1340800	1108800	232000
6	Zaporozhye	434063	326000	108063
7	Dnipropetrovsk	338888	198190	140698
8	Other airports	438803	237565	201238
9	Total by all airports	24334500	21994100	2340400

Sources: designed by own, based on information from [18], [19]

In addition to 7 major airports, also in 2019, such airports carried out air transportation: Kherson, Ivano-Frankivsk, Chernivtsi, Vinnytsia, Kryvyi Rih, Rivne, Mykolaiv, Poltava and Uzhhorod.

All airports that carry out international flights are equipped with readers of electronic passport and visas. Also they are equipped with devices for scanning boarding pass QR or bar code. These devices allow you to scan both from paper and from the smartphone screen. The WLANs are provided in all airports and it should be noted that in Ukraine mainly use fiber optic cables that provide high speed of internet. But it's all digital technologies that now are used in airports. Even Boryspil International Airport, which announces its intention to become a hub, is focused on the modernization of buildings, apron, air navigation facilitates and doesn't mention implementation of modern digital solution.

**Conclusions and recommendations.** The main obstacles of digital transformation are insufficient level of infrastructure development. Speaking about the infrastructure of Ukrainian airports, we can say that the modernization process has just begun. And readiness for digital transformation is expressed only in the presence of desire to join it. Of course, small airports with low passenger flow may not need all the latest digital technology. But for successful functioning in the modern world there are such technologies without which airports can't work. First of all, it's the availability of automated document readers for machine readable travel documents and biometrics passports. Also it's availability of wireless local area networks in airports.

While the world's leading airports are developing solutions based on blockchain, artificial intelligence technologies, augmented and virtual reality, robotics, Ukrainian airports are at the stage of awareness whether this is necessary or not. Airports primarily see the development of their activities in the modernization of buildings, facilities, apron and runways to appropriate level. But almost no one is developing modern digital solutions that can significantly improve activity in the future. Of course, it's difficult to talk about introducing advanced digital solutions while the country's economy is in a rather shaky and difficult situation. But if we do not set high strategic goals and do not seek to achieve them, Ukraine will continue to be an aviation province and not a high-tech hub.

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### ЦИФРОВАЯ ТРАНСФОРМАЦИЯ АВИАЦИОННОЙ ОТРАСЛИ В УКРАИНЕ

*В статье проводится анализ процессов, связанных с цифровой трансформацией экономики, как на глобальном уровне, так и на уровне страны. Государственные инициативы, направленные на развитие цифровой экономики, предусматривают устранение законодательных, институциональных, фискальных и иных препятствий, которые мешают развитию цифровой экономики, создания стимулов и мотиваций для поощрения бизнеса и индустрий экономики в целом к цифровизации, создание спроса и формирование потребностей среди граждан к цифровизации, прежде всего через внедрение государством масштабных проектов цифровых*

трансформаций, создание и развитие цифровых инфраструктур как основы использования преимуществ цифрового мира в повседневной жизни и платформы для достижения эффективности экономики вообще. Авторы исследуют понятие цифровой экономики, приводят различные подходы к ее определению. Отмечается, что существует много подходов к определению концепции цифровой экономики, однако не существует единой системы. Авторы делают вывод о том, что большинство источников усматривают в цифровой экономике новый вид экономических отношений, которые базируются на сборе, обработке, передаче информации с помощью информационных технологий.

Отдельно проанализированы законодательная и нормативная поддержки процессов цифровой трансформации в Украине. Авторы отмечают, что процесс цифровых преобразований в стране находится на начальной стадии, поэтому цифровизация отдельных отраслей экономики зависит от субъектов этой отрасли. Успешный процесс цифровой трансформации авиакомпаний и аэропортов во многом зависит от имеющейся инфраструктуры. Сравнивая с передовыми мировыми аэропортами, украинские аэропорты имеют очень низкий уровень развития инфраструктуры и планы модернизации не предусматривают внедрение последних цифровых технологий.

*Ключевые слова:* цифровая экономика, цифровизация авиационной отрасли, цифровая трансформация, информационно-коммуникационные технологии.

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## ЦИФРОВА ТРАНСФОРМАЦІЯ АВІАЦІЙНОЇ ГАЛУЗІ В УКРАЇНІ

В статті проводиться аналіз процесів, що пов'язані із цифровою трансформацією економіки, як на глобальному рівні, так і на рівні країни. Держані ініціативи, спрямовані на цифровий розвиток, передбачають усунення законодавчих, інституційних, фіскальних та інших перешкод, які заважають розвитку цифрової економіки, впровадження стимулів та мотивацій для заохочення бізнесу та індустрій економіки в цілому до цифровізації, створення попиту та формування потреб серед громадян до цифровізації, насамперед через впровадження державою масштабних проєктів цифрових трансформацій, створення та розвиток цифрових інфраструктур як основи використання переваг цифрового світу у повсякденному житті та платформи для досягнення ефективності економіки взагалі. Авторами досліджується поняття цифрової економіки, наводяться різні підходи до її визначення. Відмічається, що існує багато підходів до визначення концепції цифрової економіки, проте не існує уніфікованого. Автори роблять висновки про те, що більшість джерел вбачають в цифровій економіці новий вид економічних відносин, які базуються на зборі, обробці, передачі інформації за допомогою інформаційних технологій.

Відображені сучасні тенденції цифрової трансформації в авіаційній галузі та наведені останні цифрові технології, які розробляються та впроваджуються суб'єктами авіаційного ринку. В сучасному світі підвищення конкурентоспроможності авіакомпанії та аеропорти вбачають в підвищенні рівня задоволеності пасажирів від перельоту, що можливо завдяки розробці персоналізованих рішень, спрямованих на конкретну людину. Існуючі інформаційні технології, такі як блокчейн, штучний інтелект, біг-дата, дають можливість збирати та обробляти величезні масиви інформації про пасажирів та його уподобання, й розробляти пропозиції, що відповідають інтересам саме цього пасажирів.

*Окремо проаналізовано законодавчу та нормативну підтримку процесів цифрової трансформації в Україні. Автори відмічають, що процес цифрових перетворень в країні знаходиться на початковій стадії, тому цифровізація окремих галузей економіки залежить від суб'єктів цієї галузі. Успішний процес цифрової трансформації авіакомпаній та аеропортів багато в чому залежить від наявної інфраструктури. Порівнюючи із передовими світовими аеропортами, українські аеропорти мають дуже низький рівень розвитку інфраструктури і плани модернізації не передбачають впровадження останніх цифрових технологій.*

*Ключові слова:* цифрова економіка, цифровізація авіаційної галузі, цифрова трансформація, інформаційно-комунікаційні технології.