OPPORTUNITIES AND CHALLENGES OF APPLYING BLOCKCHAIN TECHNOLOGY AT AIRPORTS

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Abstract: *The outbreak of the Covid-19 pandemic has attracted more attention and highlighted the value of public health as well as the need for safe travel. When it comes to the tourism industry affected by the pandemic, the current global situation requires market transformation and innovation in the function of renewing tourist travel. Blockchain technologies in air transport are directing their business solutions towards the most promising opportunities and possibilities of application of this modern technology, now with a focus on overcoming the impact of the Covid-19 pandemic on business in the tourism industry. Blockchain-based applications have the potential to improve the user experience in the process of tracking luggage and goods, tracking the health of passengers, managing digital currency for the purchase of airline tickets, passenger identity management, loyalty programs, and more. Blockchain technology has already found application in financial management, storage and management of our personal data and information through a chain that is interconnected in time as a distributed book that records transactions between the parties involved, securely and permanently. This paper aims to present the possibilities of Blockchain technology and contribute to raising awareness of the great potential of application in the business of the airport within the tourism industry.*

Keywords: *Blockchain, Air traffic, Airport, Tourism.*

1. INTRODUCTION

Air traffic connects the world in a specific way and thus contributes to global economic development. It enables the creation of new jobs, facilitates international trade and tourism development. According to the data of the World Tourism Organization (UNWTO, 2019), 58% of world tourists travel to destinations by plane, which shows that air transport contributes the most to the development of international and domestic tourism. According to ATAG (Air Transport Action Group) data for 2019, the impact that the global aviation industry has had on the economy including direct and indirect impact, induced and through tourism has reached 3.5 trillion USD, of which direct revenues from tourism amount to 1 (one) trillion dollars. Over 87.7 million jobs worldwide are in air transport and related jobs in tourism. Directly in air transport, 11.3 million jobs have been provided, which generate 961.3 billion dollars of GDP through the provision of air transport services. World airlines served 4.5 billion passengers in 2019, 61 million tons of cargo were transported (ATAG, 2020, p. 5-12), and it is predicted that by 2038, air traffic will directly contribute 1.7 trillion dollars to world GDP.

As a repercussions of the Covid-19 virus pandemic during 2020, the world has faced serious health and economic crisis, in which the tourism sector has been severely affected, which also

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affected jobs in air transport, supply chains, and the wider economy. The complete closure of airports and state borders for several months, the introduction of travel restrictions have caused the loss of 46 million jobs. International tourism has faced its worst crisis since 1950 (UNWTO, 2020), and the impact of the crisis will be felt in differing degrees depending on the global region.

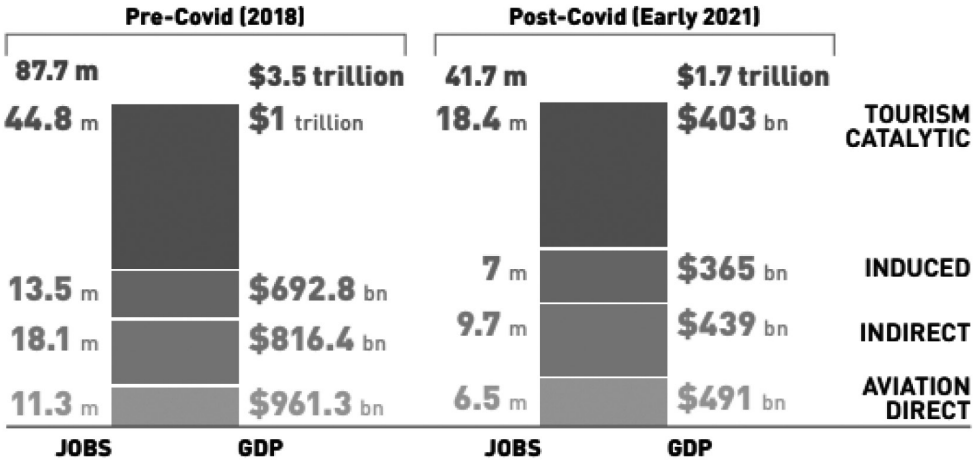

Figure 1. The impact of Covid-19 on the participation of global air traffic
Source: ATAG, Aviation Benefit Beyond Borders 2020. p.5

According to ATAG data, historically observed in proportion to the consequences of previous crises (shown in Figure 2), which had a negative impact on air traffic such as the demolition of the Twin Tower on September 11, 2001, the SARS virus which occurred in 2003, the 2008 global economic crisis, shows us that all previous crises have resulted in a relatively rapid recovery, only the Covid-19 crisis can have a slightly longer recovery period.

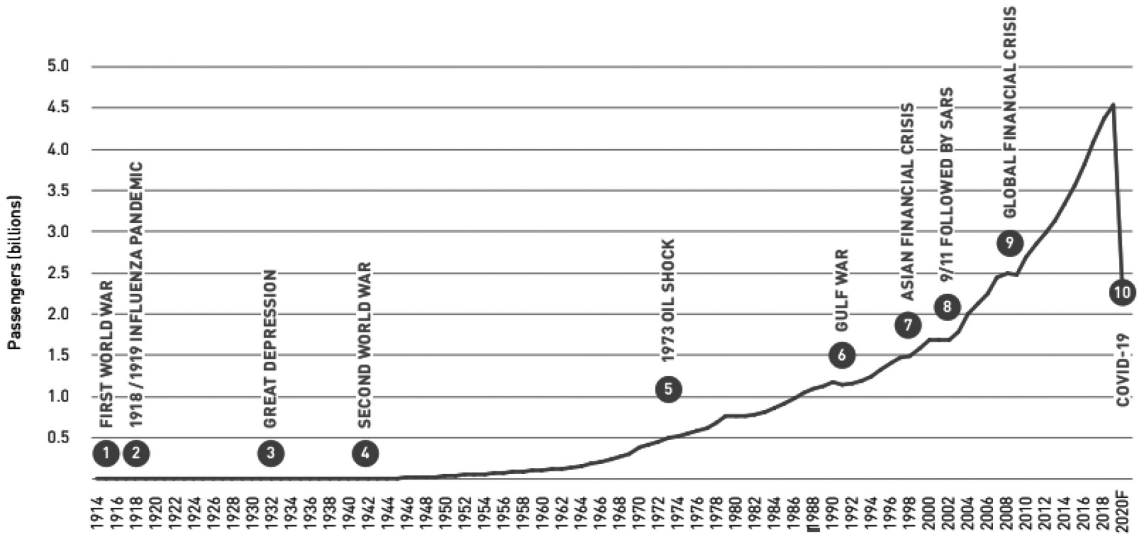

Figure 2. Global growth of air passengers after earlier crises 1914-2020.
Source: Air Transport Action Group (ATAG) – Waypoint 2050, 2020

The restart of air traffic will certainly depend on the adoption of government protective measures due to the restriction of passenger movement. Long-distance routes are most affected due to the concern of passengers to travel far from their homes, and long-distance air traffic represents the largest percentage of revenue per passenger kilometer. With the growing economic stress and uncertainty of reducing air traffic and passenger traffic at airports for their survival and further management, it

is necessary to re-establish new previously established plans based on past experience to improve the ability to manage emergencies such as the Covid-19 pandemic persisted in the future and increased resistance to possible future disturbances (Volchanski J. & Le Bris G., 2021). The need and desire for travel does not stop, and the resumption of travel and air traffic at the level achieved in 2019 due to the consequences of the pandemic and slower recovery can be expected only in 2024 (ATAG, Aviation Benefits Beyond Borders, 2020). Following a longer recovery period in travel demand after Covid-19 will result in a reduction in the world's air traffic forecast, which is estimated to be 16% lower in 2050 than previously thought before Covid-19 (ATAG, Waypoint-2050, 2020).

Air transport involves a complex business process exchanging a large amount of data and information in which the airline or airport is only one of the participants in the supply chain of passenger products or services, but all come together to meet passenger expectations and deliver a complete service that he sees as one from the moment of searching for an airline ticket on the Internet until the moment of its arrival at the final destination. Larger commercial airports have their own data center, but collecting and processing an immense amount of data on the movement of passengers and goods requires their storage and transmission using standards to protect against cyber-attacks. It is Blockchain technology that can help airports and their stakeholders process information exchange and facilitate the validation process. In the long run, this technology will also be available to smaller regional airports with less passenger traffic, but with scalable solutions that would be adapted to them (Le Bris, G., Nguyen, LG, & Tagoe, B., 2020. p. 21-22).

According to Ludeiro (2018), the biggest fear for passengers is lost luggage, especially for those who travel long distances and for passengers who change two or more planes to their final destination. Applying Blockchain technology could locate lost luggage much faster and more efficiently in real time, by sharing information between multiple actors and reducing costs to airlines (p. 451-456). According to Akmeeman (2017), air traffic is one of the most sensitive branches that is subject to various unpredictable challenges that interfere with the normal course of business such as terrorism, government regulations, natural disasters, etc., which has affected the downfall of many airlines. This is one of the challenges for the introduction of technological innovations in air transport, and Blockchain has the ability to provide a set of services to minimize such impacts with a focus on closer and better cooperation between airlines and stakeholders by improving the user experience in flight booking and tickets, implementation of passenger compensation, safe realization of the award from the Frequent flyer program, keeping records of the crew and customs, maximum utilization of the capacity of charter lines, etc. According to Robinson (2017), digitalization is already transforming travel, which not only improves the travel experience, but also develops more cost-effective optimized solutions for airport infrastructure by requiring solutions at the global level in order to achieve trust in data sharing (p. 355-368).

By applying the "desk research" method, quantitative and qualitative analysis and synthesis, we came to the results of the assumption that the application of Blockchain technology has an effect on air traffic which will enable renewal and development. The contribution of this paper is reflected in the presentation of the application of Blockchain technology within airport operations in the function of faster recovery of air traffic from the negative global repercussions of the Covid-19 virus pandemic, and to improve the user experience, especially in monitoring passenger health. In this regard, the following hypotheses were formed:

- **H1:** Blockchain technology is rapidly contributing to the recovery of air traffic
- **H2:** Blockchain technology contributes to passenger confidence in air traffic safety and in business processes at airports.

This paper is organized into four sections. The first section includes an introductory part and gives a brief overview of the impact of the current pandemic on tourist trends. The second segment presents an analysis of the literature on the application of Blockchain technology and explains the importance of using Blockchain at airports. In the third section, data on the areas of application of Blockchain applications at airports are presented, and finally, in the fourth segment, concluding observations are given.

2. LITERATURE REVIEW

2.1. The basics of Blockchain technology

Blockchain technology has gained in importance with the growing popularity and use of Bitcoin in the market, which is based on this technology, as well as other digital currencies. According to Radović et al., (2018), Blockchain is a type of database based on a mathematical algorithm for the distribution of cryptographic information whose specificity is reflected in immutability because data can be entered into the database, but cannot be changed and removed without consensus. All changes are assembled and registered in series called "blocks" and added at the end of the "chain" of blocks created so far, forming a database which, thanks to its structural specificity and formation process, was named Blockchain. Blockchain enables an interconnection of digital data that are not in one place but can be shared on several computers in the network (smaller nodes) connected in an unbreakable chain by exchanging information and data, i.e. transactions that remain recorded through blocks without or with a smaller number of intermediaries reducing transmission costs. Blocks are updated by participants without central authority, which enables that a transaction initiated by a machine or a person cannot be misused, deleted or changed. Each transaction goes through verification and validation with certain rules of decentralized consensus that differ from node to node encoding in the general ledger. Each of the nodes in the chain is encrypted by updating each initiated transaction.

Blockchain technology is a platform that takes note of all transactions and monitors digital assets through a network distributed book (Peters & Panayi, 2016), that is basically a public book of all executed and shared transactions or digital events verified by consensus, which allows that once entered information can never be deleted (Crosby et al, 2016, p. 7-8). It is a digital environment for information management and enables the movement of value through digital channels, which ensures secure transfer of value of money, data or digital assets between organizations or people electronically without the use of intermediaries such as banks, freight forwarders, etc. (Leopold, 2018, p. 7).

Blockchain solutions include certificates, paper elimination, tracking, eliminates human error and extensive manual entries, long data processing times, has the potential for transparency in the supply chain, financial transactions are realized in a lasting and secure way as well as data security and protection. Once entered, the data cannot be changed retroactively without the prior consent of all blocks in the chain, and at the same time transaction transfer costs can be reduced (e.g. credit card fees, exchange rates, bank transaction fees).

According to Adams (2020), there are several different types of Blockchain:

- **Private** (characteristic for this type of chain is that this is an efficient and fast model, but there is a great possibility of hacking because all chains are controlled by only one side)

- **Blockchain consortium** (this chain is managed by several parties who mutually agree on the rules of transaction confirmation, the chain model is efficient, but there is a lack of decentralization)
- **Public** (safest chain model because it is fully decentralized) (p. 4).

2.2. Blockchain for COVID-19

The period of the Covid-19 pandemic pointed to weaknesses in business processes and the need for greater cooperation, the introduction of standardization and tools for data exchange between health care institutions and centralized actors to contribute to connecting the airport, as a major hub for passengers and airlines, hotels, tourist destinations. When technology is successfully established between centralized actors, no one will forbid a healthy traveler to travel (Xin B., 2020, p. 13-14). Blockchain technology could help monitor the health of passengers, i.e. Covid-19 status test results, while personal health records would be protected from misuse, but passengers would be able to share and pass on their test and diagnostic history to those parties who need the data so that the traveler can journey. The biggest problem is that there are a large number of applications for monitoring the pandemic, but there is no interconnection of global scale between customs, government and health institutions in order to securely exchange data, which requires an open interface with other systems such as decentralized technology and it is Blockchain technology that could contribute to connecting all actors in a way that enables data security and privacy. This technology could be useful for a particular application because it facilitates data sharing, includes use where location is recorded, i.e. transactions are recorded as well as the status of changes, which requires a large database that allows very fast data processing, but also entry by several independent executors who have their central body.

According to Xin (2020) "GreenPass" is one of many Blockchain applications that provides challenges and opportunities to develop a health application based on the QR code of personal health status generated and based on the entry of data on passenger health status and report on health assessment, temperature and location of passengers (p. 12-13). According to Marbouh et al, (2020), the application of Blockchain technology creates the possibility to be used in real-time recording of clinical data, which improves the reliability of data exchange, monitoring, recording and auditing of data. Intensive dissemination of misinformation in the system of monitoring data on the Covid-19 virus through the media and other external sources leads to public panic and inappropriate behavior, and all previous platforms lack the confirmation of data authenticity. It is the application of this technology that would make it possible to update the information placed by public and state institutions in the fight against the pandemic. In this regard, the Government of Canada has implemented a "Civitas" application based on Blockchain technology that has helped the government sector and local government control whether or not a person leaves their home during quarantine, which is necessary to minimize the spread of this virus. At the same time, this application allows physicians to monitor the progress or appearance of new adverse symptoms in monitored individuals, as well as to submit a prescription of medication use (Marbouh, D. et al., 2020, p. 1-17).

2.3. Airport operations and areas of Blockchain application

According to Halpern et al. (2021), today's airports have fully embraced the digital changes directed by already existing or innovative technologies such as: augmented reality, Big Data analytics, Blockchain, cyber security, IoT, cloud computing, virtual modeling and simulation,

etc. These technologies allow airports to visualize procedures and activities in real time, as well as connect all stakeholders so that they can implement the changes necessary for digital transformation. There are four phases of digitization that the airport went through during the period:

- Airport 1.0 – an analog model where airport staff perform most of the process operations manually, causing delays in data processing.
- Airport 2.0 – partial digitization of airport technology with a multitude of available passenger-oriented services e.g. during check-in and security, obtaining information about passengers, making it easier to find an exit to the terminal.
- Airport 3.0 – involves the widespread application of passenger-centered digital technology including e-commerce, self-service kiosk, beg drop, mobile boarding pass scanner, body scanner, digital self-service data and location-based amenities.
- Airport 4.0 – a new digital transformation has been applied here where the main goal is passenger satisfaction, allowing the collected data to be shared among stakeholders and used in real time. By showing the movement of passengers at the entrance and through the terminal, as well as following the queues, it provides an even distribution of airport staff and thus provides the passenger with reduced waiting time for border and passport control.

Airport 4.0 is a synonym for the smart airport – the airport of the future and only those airports that want to be more competitive in the market must apply the process of digitization not only passenger and airport operations, but also human resources management, infrastructure and management of all administrative and business operations (Halpern et al., 2021).

According to IATA, White paper (2018), there are five areas of Blockchain application in the aviation industry (Fig. 3):

- **Tokenization** – Represents the conversion of real assets into digital twins as a cryptocurrency. Refers to the issuance of a security token or asset token (display of a specific asset or utility). The advantage of tokenization is that it includes lower costs, faster settlements and reconciliations, and enables greater risk management. Each transaction must pass the check of all blocks in the chain, so the advantage of tokenization is that it prevents double consumption of digital assets, such as a voucher issued to a traveler cannot be spent more than once but only once. Then, compensation vouchers such as points from the Frequent flyer program that remain in the traveler's account until he uses them.
- **Provenance** – Represents the tracking of the source of origin, status of change and place of origin of value of virtual and physical property that changes ownership due to high frequency which can include tracking and tracing of passengers' luggage, cargo and spare parts, in addition, it can also be used to track the movement of the aircraft which, during its life cycle, changes the ownership several times. It is the immutable digital record that could be of great importance to stakeholders and other entities that do not trust each other in the process.
- **Digital Identity** – Blockchain technology is suitable for managing the identity of passengers and crew on and off the plane, protecting privacy and enhancing the passenger experience. Thanks to the digital identity, all actors know who they do business with and can manage risks, and immutability and integrity are one of the main features of its connection. The use of mobile face recognition applications allows the passenger to quickly, securely and easily share their personal data that can be stored in their phone for more comfortable travel organization (e.g. travel document management, visa, health passport), and verified by airlines, airports and authorities without abusing the privacy of passenger data. It allows passengers to create their own digital passports, obtain certificates and share certificates of testing and vaccination, improving the passenger experience.

- **Certification** – Involves the "Confirmation" procedure by which the other party checks the correctness of the data and verifies the record (such as stamping) which allows the creditor to later confirm the correctness of user data, and also includes additional data such as biometrics, tokens, status. It is Blockchain technology that has the ability to simplify the certification of data, persons, equipment, etc. enabling airlines and stakeholders to maintain a high standard of safety and security. Certification would fully support digital identity e.g. with crew members (pilots, flight attendants), then airport staff, security staff, repair and overhaul service providers and more.
- **Smart contracts** over the travel value chain – These are digital contracts that are protected from unauthorized access because they depend on a decentralized consensus by automatic execution (Cong & He, 2018). A smart contract can be initiated when particular circumstances are met, and the transaction can be executed simultaneously without the involvement of a third party (Nzuva, 2019). In air transport, all actors associated with the realization of travel trade in economic consumption which have significantly high costs during the administration of contracts, observing the fulfillment phase, invoicing and more, while smart contracts can significantly eliminate the costs of their business. By applying smart contracts, human errors would be minimized and procedures and administration would be simplified. Their advantage is that they can be programmed to run independently because they are powered by a neutral data source as well as predefined conditions.

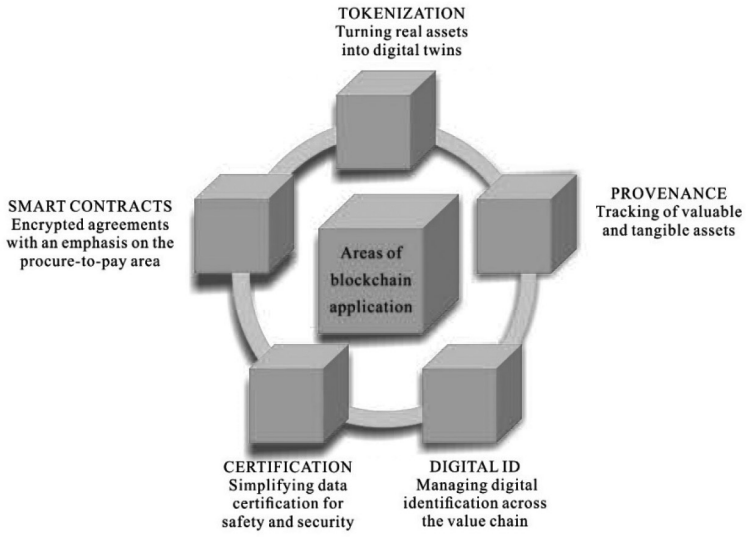

Figure 3. Areas of Blockchain technology application in aviation
Source: IATA, White paper, 2018, p.4.

3. BLOCKCHAIN APPLICATION IN AIRPORTS

At airports, the application of Blockchain technology includes customer-oriented applications, such as: baggage handling, security, ticketing and operational activities such as cargo tracking, chronology and data origin tracking, as well as compliance with legal regulations. At airports, there is the possibility of introducing numerous applications shown in Figure 4. Blockchain could allow users to identify the point where the data has changed, determine how and who changed it if unauthorized or hacked access occurred.

This technology enables the advancement and monitoring of merchandise and travelers in real time through Supply Chain Management (SCM). It improves cyber security and protection of

Operational Management (OM), has a positive impact in reducing costs and provides greater security, and is especially effective in preventing fraud. In spite of the fact that the implementation of Blockchain technology brings an immense amount of benefits, mainly in improving operational management, it still does not guarantee the accomplishment of the leading performance in terms of efficiency, effectiveness as well as, sustainability. Contributions to Sustainable Supply Chain Management (SSCM) are still small (Di Vaio, A., & Varriale, L., 2019).

Figure 4. Opportunities of applying Blockchain technology at airport
Source: Authors

Blockchain is environmentally friendly, because the printing of forms and documents is not applied, which is a significant issue in air traffic and environmental responsibility. In this way, tracking passengers is effectively ensured without compromising the privacy or confidentiality of data, bearing in mind that passengers are reluctant to share their personal data due to uncertainty as to who may have access to the data or possible misuse. The application of this technology gives users complete control over their data, which is encrypted, time-stamped and immutable, which prevents access by unauthorized persons, and promotes transparency of use and completely eliminates discrepancies. Airports, airlines and third parties must share information in real time without interruption and security, and Blockchain could be an application that enables this to happen. It could help improve the accuracy and timeliness of information, which can positively affect customer satisfaction.

Regardless of the type of transport, today's passenger uses, i.e. whether it is an airplane, ship or train, the realization of travel requires activities and methods when tracking property, goods and people, and for data verification it is necessary to support them and respect regulations on transportation, liability claims and accident investigation, warranty management, etc. to improve passenger satisfaction during services as well as during baggage handling (IBM, 2018).

German airline „Hahn Air" was the first to launch an online airline ticket sales service based on Blockchain to minimize the possibility of fraud in the form of issuing fake airline tickets. Also one of the good examples of the introduction of Blockchain was launched by the Singapore airline "Kris Flyer" by automating MRO services (Maintenance, Repair and Overhaul), secure implementation of loyalty programs and reliable cargo tracking, but which even now is in the early stages of expansion and implementation (Ahmad R.W. et al, 2020, p. 8).

In today's specific business environment affected by the Covid-19 virus pandemic, according to Plofchan (2020) travel must be safe and undisturbed which is made possible by the use of biometrics providing seamless and reliable movement of passengers at the airport, but creates a law enforcement problem. Blockchain applications could contribute to solving the problem with the help of verification that corresponds to the verification of the identity of passengers through new technology (p. 31).

A case study conducted at Copenhagen Airport on the application of the Blockchain involved, in addition to the airport, a number of airlines and authorities. The study identified four problems that arise between stakeholders: different business goals, system management process, services and data. The analysis confirmed that there are common interests between the airport and the airlines, only the authorities had their non-financial goal. It was found that there is limited trust between actors in data exchange, but that the acceptance of Blockchain-based technology could solve this. It was confirmed that standards are necessary that would enable easier connections between actors operating in various international locations, otherwise the non-existence of these standards would limit further progress of Blockchain technology. The availability of additional data would enable stakeholders to conduct their business operations more efficiently and thus improve passenger satisfaction which contributes to the creation of other new opportunities (Friis-Hansen, F., & Jeppesen, F. R., 2020).

4. CONCLUSION

Digital passenger information in the form of notifications and alerts requires very fast data processing and settlement of transactions, and is crucial for airlines and their passengers. As the aftermath of the Covid-19 virus pandemic, air transport companies will have to align their operations with the government health measures of each country individually, in order to restart the international air transport sector. The health, safety and security of passengers is of the utmost importance, and it is precisely the opportunities and challenges of applying Blockchain technology that will contribute to a greater extent to the renewal of air traffic and tourism. The experience of passengers during their stay at the airport, as well as during the trip on the plane, must be safe and without major physical contact, so it is necessary to accelerate the application of artificial intelligence. The aftermath of the Covid-19 pandemic has affected the implementation of new adaptation strategies and the resumption of operations of airports and their stakeholders in the post-pandemic period, which will result in adaptation to possible future crises. Adaptation to new needs for travel safety should contribute to the adoption of new innovative technologies, which requires the exchange of data and information at the national and international level in order for airports to progress in the future and the passenger to be satisfied with the service.

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