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An Effective Assessment on Optimizing Airport Capacity Management Problems

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***Abstract*—The process of determining the maximum amount of traffic that an airport network system can handle while talking into account resource limitation such fleet composition and node capacity known as capacity estimation and it is as recognized NP- hard issue. In airport operation, runaway systems are frequently the main source of congestion. Thus, it is crucial for airport operations to comprehend their capacity. Nevertheless, it is not easy to build this understanding because runaway system capacity (RSC) is not observable unlike demand or throughput. The purpose of this study is to gather pertinent data regarding the potential relationship between airline operations and air capacity management (ACM) optimization, while also taking the airline business model into account. Due to underdevelopment of the bigger airport facilities, the aviation sector has experienced tremendous growth in demand over the past 20 years with insufficient support in terms of supply. The findings show that the initial airport capacity of a city determines the proportionate size of its investment and the occupancy rate threshold at which investment occurs.**

***Index Terms*— Airport operations; Runway system capacity; airports; commercial structures; observing; tactics.**

I. INTRODUCTION

The greatest quantity of aircraft movements that an airport's runway system is capable of handling in a given amount of time under a specific set of operational parameters is known as the runway system capacity, and it is a significant input to air traffic management and planning [1]. Flow networks' capacity represents the highest possible throughput that a network can provide. If a link achieved its capacity barrier, it was removed from the network based on the update, link cost. Eventually, when a specific origin and destination (OD) pair was disconnected, the network capacity was reached [2]. The route selection is this approach's primary flaw. This essay makes an effort to address this issue.

Capacity limits apply to this hourly rate off low (landings and take offs). The fundamental idea is that an airport's flow can be represented as a steady-state, multi-path network of lines, with a maximum capacity equal to the total of all possible airport operating rates. Throughout the twentieth century, airport transportation has grown steadily [3]. Air transport has shown to be durable and able to rebound from numerous unfavourable events such as economic and political crises by displaying consistent growth over the years, despite several crises that have affected the sector [4].

The Airport Management Strategy Software (AMSS) application may propose a new strategy and a new model. During discussions with the airlines, the airport administration might use this program to get a unique new tool.

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This tool can be used by management to confirm the soundness of their judgments about the introduction of new aircraft, particularly during peak hours, and to analyse potential effects on the infrastructure and operating capacity [5].
The objective of the study is to maximize airport capacity through a methodical observation of airline traffic data and the particulars of their business strategies. The hypothesis was supported by the data, and the study's objective was accomplished. An analysis of the airport was examined using a simulation approach in order to accomplish the objective and validate the model [6].
Comparing Air traffic management (ATM) similar performance metrics at a high level, which is linked to gauging service quality, is described in a document created by federal aviation administration (FAA) [7]. The authors point out that "airport operations depend upon a number of factors as well as on interactions between them, which all affect runway capacity to some degree." It is noted by the authors that in addition to "tactical" issues like aircraft sequencing and weather-specific throughput sustainability. The authors have determined that there are four primary types of delays in scheduling that have an impact on the performance of air transportation Unpredictable weather, delayed or reactive aeroplane arrivals, security, airline plus local turnover, and the ATM system. In addition to airport and enroute capacity shortages air traffic flows and capacity management (ATFCM delays), also contribute to ATM system delays. This study does not address ATFCM-related delays by taking into account the air traffic control (ATC) and Traffic Management Initiatives implemented during the different phases of flight [8].
Section 2 (Airport capacity techniques) outlines a few of the most popular techniques employed in this work in brief. This section focuses on providing a thorough overview of the AMMS application that was just created [1].
Section 3 (Results) gives an accurate explanation of the experimental findings, their interpretation, and the conclusions drawn from the application of air craft and mission management system (AMMS). The Airport case study [15] was used to confirm the model's functionality.
Section 4 (Discussion) displays the findings from the AMSS application's comparative analysis of the responses from airport management. The limitations of the study are also mentioned in this section, along with suggestions for more research. The primary research findings in this work are summarized in the conclusion.

II. AIRPORT CAPACITY TECHNIQUES

The study employed a number of scientific techniques, including the following. Although the descriptive technique is used throughout the study, it is most evident in the first section, which provides a summary of current studies on the topic and outlines modifications to the business plans of important aviation players. The section of the paper that covers the functionality, this method is also applied in the model's phasing and structure, as well as in the AMSS application [9]. In order to offer accurate information and data for the inputs of the model, the business of the primary stakeholders was analysed using the historical, mathematical, and statistical methods. These techniques were also applied in the process of gathering information from the airport investigation and defining the operational and structural capacity (peak hours) of the airport [5]. The approaches of the sections that compared airline business models, their specialties, and distinctiveness analysis, synthesis, and comparison were applied. The equipment, operating capacity, and infrastructure issues at the airport were identified using questionnaires and interviews [10]. Interviews with management-level staff were conducted to get their viewpoint on the issue of incorporating more aircraft into the flight itinerary without first being aware of airport capacity limitations and without first speaking with the operating division, which will manage the extra aircraft. The model and AMSS application were tested using the case study method. The airport that will be used for testing was chosen [11]. All of the information obtained from Airport and its stakeholders, including traffic, economic, infrastructural, and operational data, was used to test the model.
The aforementioned techniques were combined with the usage various sources, both primary and secondary. Secondary data is information that has already been generated or gathered by another party [12].
The Following Analyses are Included In The Primary Sources:

- At Airport, the capacity of each important both intellectual and professional part in the movements of traffic was established, and the passenger processing time was evaluated.
- Stakeholders in air traffic were surveyed. The business plans and requirements of seven worldwide aviation groups and the 19 airlines, 31 airport management boards and ground handling businesses were reviewed.
- Controlled observations were conducted in order to identify the issues brought on by traffic during peak hours. A record of passenger movements and airport staff activities was made.

- Experts from the operational services division of Airport and the national carrier, together with representatives of international airlines.

The following sources of Additional data were utilized in this work: airline and airport business summaries, as well as he databases of special consultancy companies for airlines [13].

- Internal data from the Airport, including internal traffic information sources, the cost list for the annual financial reports, the incentive program, and the fundamental ground handling services and internal capacity-related papers from the Development Department.
- Other writers' scientific and professional works—both domestic and international literature—including pertinent books and scientific and professional publications.
- Annual reports from airlines: 13 airlines' reports were downloaded from their official websites, examined, and utilized to test the AMSS application and analyse the business performance of the airlines.
- Aviation databases: CH-Aviation, Anna Aero, Centre for Aviation (CAPA) database; traffic data for European airports and airlines.

The lack of developing a a special model or technology that will help airport management select aircraft from favoured carriers exactly based on the particulars of their operation plan and illustrate how such a pick would affect airport infrastructure was determined by assessing the available research [14]. The necessary ground handling equipment was determined. The main benefits of the AMSS application are the aircraft model and business plan that will use the available space at the airport without interfering with onward traffic.

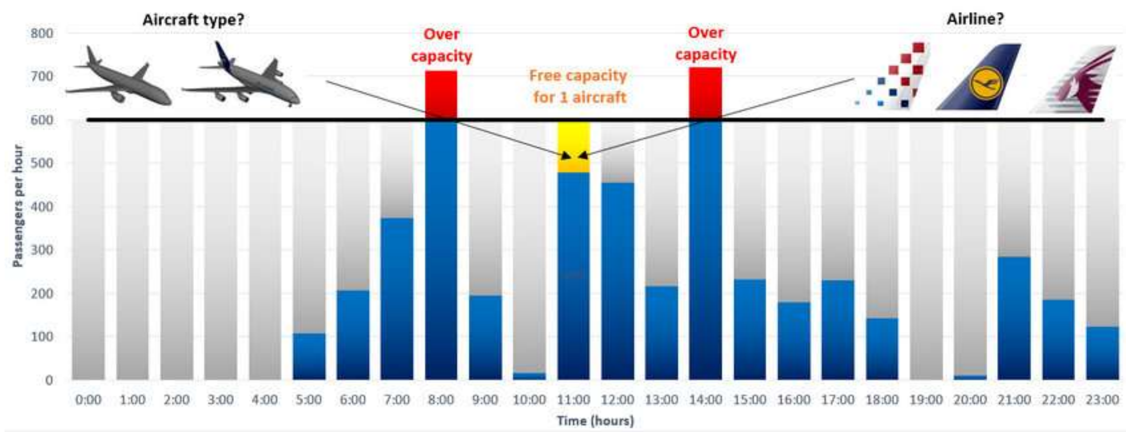

Figure. Ability to take in a new aircraft that is being observed during the day.[15]

In order to construct the model, ascertain the historical performance of the business models, and ascertain the particulars of a potential plan for airport construction, four primary postulates have been taken into consideration [15].

- An summary of the history of the airport's growth, including its current infrastructure and earlier developments.
- Airport geo-traffic characteristics include position, catchment area, and distinctiveness of the region; they also include the percentage of airline structure, current economic practices, and route network expansion.
- Analysing waiting areas upon departure, determining Both the passenger terminal's and the apron existing capacities, selecting the busiest hours for analysis of passenger terminal capacity and assessment the usability and accessibility of ground handling equipment are all examples of airport operational capabilities [16].
- The fiscal factors that draw air lane are those that assess the competitiveness of the airport in the area, with a primary focus on the amount of money generated by aeronautical and non-aeronautical charges.

To obtain a comprehensive understanding of business outcomes and airport development strategies, it is necessary to analyse various other criteria included in Table 1, in addition to the postulates mentioned above, as illustrated below.

III. RESULTS AND DISCUSSION

The model was validated at the Airport on an average busy day in 2017 [16]. You can use the same methodology at any time of day or year. Figure shows the arrival and departure traffic structure on a typical busy day. There are two distinct traffic peaks that are discernible: the highest point in the morning, which occurs between 7 and 8 a.m., and the afternoon peak, which occurs between 1 and 3 p.m., when infrastructural and the use of operating capacity is at its highest [15]. The application looked at the entire busy day to determine the first free hour, and it found the time between 11:00 and 11:59 (highlighted in yellow). Given that the capacity of the airplane cabin and the number of passengers at the airport nearly reached its determining the kind of aircraft and the economic strategy of airlines that might be deployed without impeding or slowing down current travel was key.

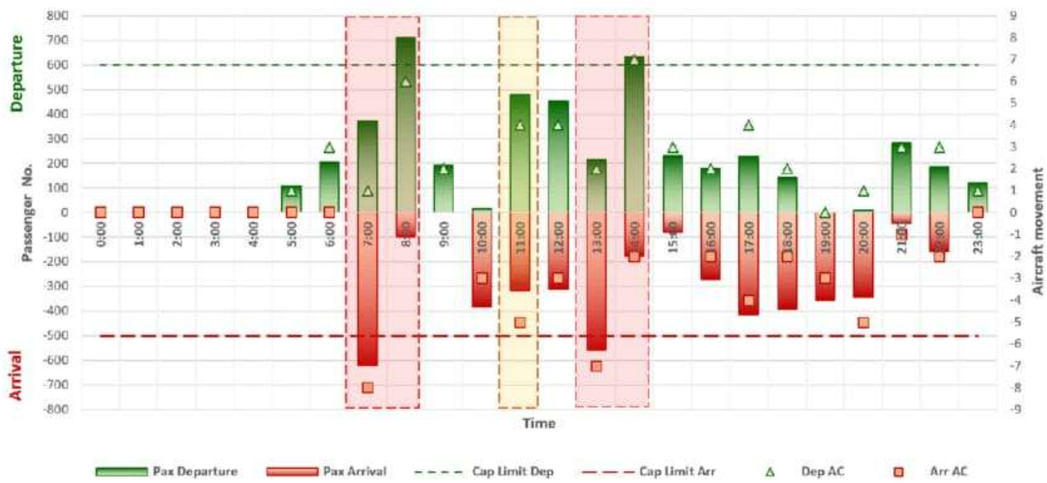

Figure. An summary of the amount of travellers and airplanes during a normal, hectic day. [15]

The majority of the examined aircraft were members of the daily operating aircraft fleet at the airport, which helped to validate the model and create conditions that are exclusive to it that are more precise and realistic. Furthermore, multiple aircrafts were purposefully included to the model in order to highlight non-compliance. Airbus A380 and Tupolev Tu-154 (noise-level-based removal) were used in this. To evaluate the deletion segments of the AMSS, it was imagined that the A380 could not land at Zagreb Airport, even though it is capable of doing so.

A. Findings from the Vertical Assessment: An Analysis of the Airport Case Study

The input variables for the upward evaluation, including the size, cabin capacity, ground handling machinery, and ambient conditions of the aircraft [6]. Airport management has thus far only bargained with airlines based on historical performance; it hasn't examined operational and infrastructure limitations, particularly with regard to the capacity of the apron and terminal or the availability of ground handling equipment. The best course of action is to assess the equipment and airport facilities that are available for each type of aircraft and identify any potential barriers to their introduction. After that, talks with airlines might start

The four segments that are depicted by the red squares are the ground handling equipment, passenger terminal, runway and apron infrastructure, and regulatory framework [3]. If the introduction of the new (planned) aircraft impairs the airport's infrastructure or operational limits and delays current traffic, the AMMS advises management not to accept it at the designated time. The yellow squares indicate that accepting and dispatching the aircraft is an option, but only for specific airline business models that make use of airport equipment and infrastructure. The grey squares imply that there are no limitations on the new aircraft's launch. For a full day of a typical busy day, each of the 13 proposed aircrafts had their limitations on the introduction of new aircraft assessed (312 tests in all) [15].

B. Horizontal Assessment According to the Airlines Business Models–The Case Study of Airport.

Following the identification of the chosen aircraft type, or a group of similar aircraft, and the completion of the vertical assessment, the second stage of research, known as the horizontal assessment, is carried out. The horizontal evaluation determines the preferred airline operating the aircraft with a particular business model, as

Aircraft	Capacity	LF 70%	0:00 0:59	1:00 1:59	2:00 2:59	3:00 3:59	4:00 4:59	5:00 5:59	6:00 6:59	7:00 7:59	8:00 8:59	9:00 9:59	10:00 10:59	11:00 11:59	12:00 12:59	13:00 13:59	14:00 14:59	15:00 15:59	16:00 16:59	17:00 17:59	18:00 18:59	19:00 19:59	20:00 20:59	21:00 21:59	22:00 22:59	23:00 23:59
D328	33	23								x	x		-		-	-	-			-						
CRJ7	70	49								x	x		x		-	x	-			-						
DH84	76	54								x	x		x		-	x	-			-						
CRJ9	86	60								x	x		x		-	x	x		-	-			-			
E190	100	70								x	x		x		-	x	x		-	-			-			
A319	132	93								x	x		x		-	x	x		-	-			-			
TU154	152	106								x	x	x	x	x	x	x	x		-	x			-			
A320	164	115								x	x	x	x	-	x	x	x		-	x			-			
A321	200	140								x	x	x	x	x	x	x	x		-	x			-			
B738	189	132								x	x	x	x	x	x	x	x			-			-			
B752	227	159								x	x	x	x	x	x	x	x		-	x			-			
B788	300	210						x	x	x	x	x	x	x	x	x	x	x	x	x			-	x		
A380	525	368	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Figure. An overview of the outcomes from a vertical assessment regarding the potential introduction of a new aircraft.[15]

well as the preferred aircraft type among a number of comparable aircraft (such as the A319, A320, B737–800, and B737–900). The distinctiveness of the airline's business plans, their approach to working with airports, and the caliber of services they offer are the primary factors for the horizontal evaluation [4]. The horizontal evaluation at Airport was verified between 11:00 and 11:59 on a regular workday. The AMSS retrieves specific data for each airline from the database, performs a multi-criteria analysis, takes into account the "weight factors" discussed in the previous section, and displays a side-by-side comparison of the overall results for each aircraft and its operator after the selected aircraft types and their operators are input. The results of the multi-criteria analysis of 12 aircraft are shown in Figure, where the Croatia Airlines A320 aircraft scored best (16.59), followed by the Croatia Airlines A319 aircraft (16.29). The fact that Airport is the home airport of Croatia Airlines, the nation's flag carrier, surely helped this section earn positive evaluations [7]. In line with the airport's plan, Figure 8 also shows how the initial two Croatia Airlines aircraft be succeeded by one low-cost carrier, easyJet A320, and two network carriers, Lufthansa and Qatar Airways. Without performing any extra analysis, the airport administration would introduce any aircraft based on the ratings shown for each aircraft during the selected time frame of 11:00 to 11:59. This suggests that, based solely on the specifics of the airline's business model, they wouldn't consider whether the arrival of any of the aforementioned aircraft could have an influence on the seamless running of present traffic [15].

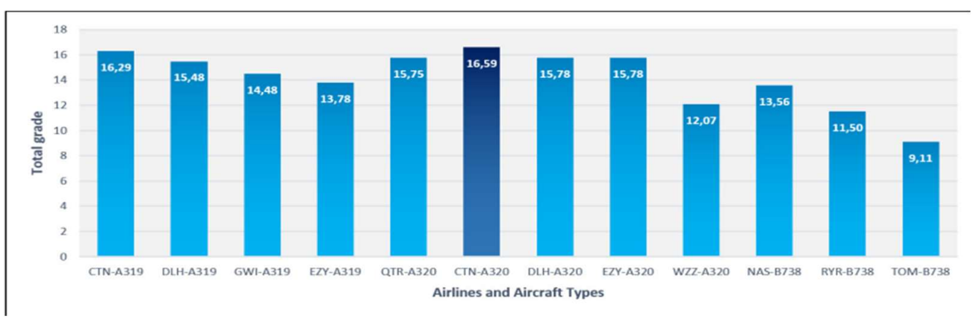

Figure. Summary of all the rating outcomes for the chosen airlines and aircraft following a horizontal assessment of the airport between 11:00 and 11:59

As was already said, the goal of the airport case study was to write this paper and test the operation of the AMSS model. Based on past experiences, it is most common for airline officials and Airport representatives to first meet during the specialist international "Routes Conference." Further one-on-one meetings were arranged with prospective airlines to showcase the area's capacities and airport amenities, and discuss potential flight schedules and business terminology. The first flights would follow the signing of the SGHA and SLA contracts, if both sides were in agreement on the terms. If the operation was successfully finished from their point of view and the negotiating team believes that the task was completed satisfactorily if a new flight or airline was added to Airport [15].

The negotiation team may have a difficulty if they inadvertently inflict operational harm to the airport due to ignorance about the capacity, GH equipment, and staff restrictions of the airport. The first invisible issue that may arise is whether the airport has the operational capacity or infrastructure to handle and accept the extra planes on the suggested days and times by the carrier [3]. This may occur if the planning is not carried out effectively and in close enough cooperation with the traffic department.

Because the SLA contract also contains penalty provisions, if the airport does not do any of the agreed-upon responsibilities that the airline requests, these clauses may be activated to compensate the airline for any damages. A small number of these activations won't have a major impact on the airport's budget, but if the airport frequently performs poorly and the aircraft's specific arrival and departure are stated, it will damage the airport's reputation and may result in the airline and airport terminating their contract [7].

Interviews with the airport negotiation team served as one means of verifying the AMSS application's functionality. They were asked if they would accept the aircraft at the Airport in the precise schedule that the airlines had requested after being given details about the aircraft that were included in the scenario [16].

The traditional literature on predicting air travel has a tendency to concentrate on micro characteristics, such as airline service, pricing, and quality, and macro factors, such as population demographics, geography, economy, consumption spending, and deregulation (Wang and Song, 2010; Valdes, 2015). Although these criteria continue to be significant in influencing demand for air travel, they do not account for fluctuations in demand during a pandemic, particularly one as unusual as COVID-19. This is a first for the aviation industry; not even the September 11 attacks have come close. With a high degree of uncertainty, the effects of Covid-19 on transportation behaviour and society are dynamic and unpredictable. Therefore, the capacity to accurately forecast the dynamic nature of the epidemic and the shift in people's travel habits is essential [17].

The multi-airport system (MAS) is becoming more widespread globally because to the ongoing expansion of air travel (Noruzoliaee et al., 2015; O'Connor and Fuellhart, 2016; Sidiropoulos et al., 2018; Chen, 2020a). O'Connor and Fuellhart (2016) noted that marketplaces that cover multiple airports in an area should be taken into consideration, as concentrating only on a single airport frequently offers a narrow perspective [18].

There is a substantial difference between the number of aircrafts the AMSS application planned and the number the negotiating team would add at a given hour, it can be concluded after examining the responses from the AMSS application and the interview with the airport negotiating team. The proposal demonstrates that the majority of the suggested time intervals have substantial limits, and adding planes will considerably disrupt existing traffic. This undoubtedly demonstrates the accuracy of the AMSS system with respect to the choices made by the negotiation team. Additionally, it shows how a negotiating team may utilize an application like the AMSS to make fast, accurate, and better decisions made about the airline during negotiations to avoid any traffic interruptions brought on by the addition of a new aircraft to the current itinerary [12].

We investigate the effects of usage agreements and governance arrangements on excess capacity, taking into account the opportunities and limitations deriving from airport business operations. In addition, we incorporate into our research variables like cargo specialisation, airline competition, hub size, and the prevalence of low-cost carriers in order to efficiently control and lessen their effects on capacity utilisation. To the best of our knowledge, this study is the first to look at the connection between idle capacity and airport business practices. By filling this research vacuum, we hope to offer insightful information about the variables affecting capacity that goes underused in the airport sector. Furthermore, this paper provides a thorough examination of the benefits and drawbacks of various use agreements and governance structures, particularly as they relate to capacity [19].

This research highlights the negotiation process's flaw, which is the negotiating team's ignorance of the real capacity utilisation, precise operation congestion times, suggestions for which hours to consider, and the effects of adding a new aircraft on existing traffic. They had prepared basic information regarding the airport's equipment and infrastructure, as well as fundamental traffic parameters linked to destination coverage [10]. When new flights are added, these oversimplified analyses could cause problems with the airport's operational efficiency and infrastructure.

The study's drawback stems from the fact that some information about airline operations isn't publicly available because it's confidential. The majority of this data is made up of specific internal indicator values that airlines use to track the profitability and stability of their routes. Publication of details regarding the commercial discounts that were obtained during the airport-airline agreements was also banned [9]. Finally, in response to questions on the talks and route growth strategy in the questionnaire, a few airlines and airports provided the response "confidential".

III. CONCLUSION

Even though making money is the primary goal of the aviation industry nowadays, it's still important to strike the best possible balance between the infrastructure needs and the operating capacity things the airport is able to provide. It's imperative that the airport's administration ensures it has all the infrastructure and operational capabilities needed to integrate them into the current flight schedule without interfering with or endangering the punctuality of the current traffic [15].

Because of the intense competition at the moment, the majority of airports prioritize luring airlines rather than checking the availability of their capacity, a shortcoming that is only discovered after the contract is signed and the first flights take off [2]. There's a possibility that there will be numerous delays following this due to capacity issues and inadequate passenger level of service, which could harm the reputation of the airport.

Using both vertical and horizontal validation, this model calculates a wide range of metrics and key performance indicators (KPIs) to determine which airline, based on its business model and aircraft type, is the most suitable to occupy the available airport slots [13].

This approach aims to precisely determine the aircraft that can be added to an airport in order to increase and maximize its efficiency, the potential free capacity of the airport's operations and infrastructure, and the airline business model that is most appropriate for the airport at that particular time and in accordance with its strategy. This strategy increases the likelihood of identifying the most suitable aircraft and airline business models while preventing the airport's available capacity from collapsing [15].

REFERENCES

[1] Rothengatter, W. (2011). Economic crisis and consequences for the transport sector. In *Transport Moving to Climate Intelligence: New Chances for Controlling Climate Impacts of Transport after the Economic Crisis* (pp. 9-28). New York, NY: Springer New York.

[2] De la Fuente, L. (2009). Economic crisis stops air transport growth.

[3] Štimac, I., Vince, D., & Vidović, A. (2012). Effect of Economic Crisis on the changes of low-cost carriers business models. In *15th International Conference on Transport Science ICTS* (p. 27).

[4] Dahlmann, K., Koch, A., Linke, F., Lührs, B., Grewe, V., Otten, T., ... & Schumann, U. (2016). Climate-compatible air transport system—Climate impact mitigation potential for actual and future aircraft. *Aerospace*, *3*(4), 38.

[5] Macário, R., & Van de Voorde, E. (2009). The impact of the economic crisis on the EU air transport sector.

[6] BRASS, J. (2011). *Market Share of Low Fares Airlines in Europe*. York Aviation.

[7] Doganis, R. (2013). *Flying off course: The economics of international airlines*. Routledge.

[8] Tugores-García, A. (2012). Analysis of global airline alliances as a strategy for international network development (Doctoral dissertation, Massachusetts Institute of Technology).

[9] Koelman, H., Koelle, R., Shetty, K., & Gulding, J. (2019, April). Comparison of ATFM Practices and Performance in The US and Europe (2015-2018). In *2019 Integrated Communications, Navigation and Surveillance Conference (ICNS)* (pp. 1-16). IEEE.

[10] Baxter, G., Srisaeng, P., & Wild, G. (2020). Airport related emissions and their impact on air quality at a major Japanese Airport: the case of Kansai International Airport. Transport and Telecommunication Journal, 21(2), 95-109.

[11] Doganis, R. (2006). The Airline Business, 2nd edn. 101, 234, 327.

[12] Bilotkach, V., Gorodnichenko, Y., & Talavera, O. (2010). Are airlines' price-setting strategies different?. Journal of Air Transport Management, 16(1), 1-6.

[13] Pearce, B. (2012). The state of air transport markets and the airline industry after the great recession. *Journal of Air Transport Management*, *21*, 3-9.

[14] Dobruszkes, F. (2006). An analysis of European low-cost airlines and their networks. Journal of Transport Geography, 14(4), 249-264.

[15] Štimac, I., Vidović, A., Mihetec, T., & Drljača, M. (2020). Optimization of airport capacity efficiency by selecting optimal aircraft and airline business model. Sustainability, 12(10), 3988.

[16] Malakis, S., Psaros, P., Kontogiannis, T., & Malaki, C. (2020). Classification of air traffic control scenarios using decision trees: insights from a field study in terminal approach radar environment. *Cognition, Technology & Work*, *22*(1), 159-179.

[17] Yu, M., & Chen, Z. (2021). The effect of aviation responses to the control of imported COVID-19 cases. Journal of air transport management, 97, 102140.

[18] Hu, R., Huang, M., Zhang, J., & Witlox, F. (2023). On the Matthew effect in a multi-airport system: Evidence from the viewpoint of airport green efficiency. *Journal of Air Transport Management*, *106*, 102304.

[19] Karanki, F., & Bilotkach, V. (2024). The impact of Airport business practices and governance forms on excess capacity. Economics of Transportation, 38, 100353.