International Journal of Social Sciences and Management Review

Volume: 08, Issue: 05 September - October 2025

ISSN 2582-0176

OPTIMIZATION IN THE FUNCTION OF FLIGHT NETWORK PLANNING

ANA LAZAROVSKA[1], VIOLETA MANEVSKA[2] & VERICA DANCEVSKA[3]

https://doi.org/10.37602/IJSSMR.2025.8520

ABSTRACT

This research explores the interrelationship between transport economics and sustainable development through the establishment of a mathematical model tailored for a new sports and school airport in Gevgelija, Macedonia. By applying the theory of equilibrium and conducting a cost-benefit analysis, the study aims to assess the airport infrastructure's development and its contribution to sustainable growth in air traffic. The ultimate goal is to inform decision-making processes that prioritize projects with substantial indirect benefits, thereby aligning with European aviation standards and enhancing Macedonia's integration into the modern aviation network. This comprehensive approach not only addresses the specific needs of sports and school aviation but also seeks to optimize resource allocation for the overall development of the transport economy in the region. The optimization of airport infrastructure is critical for efficient air transport, necessitating a comprehensive approach that considers the airspace around a planned airport. This process requires the integration of neighboring airports, fostering collaboration to allocate an optimal number of aircraft according to flight schedules while maintaining safety and efficiency. By treating the optimization model as an interactive process, stakeholders can enhance overall air traffic management, improve operational capacity, and ensure that airports operate synergistically within the regional airspace network, ultimately leading to a more effective and sustainable aviation system.

Keywords: Planning, Optimal, Supply, Demand, Model.

1.0 INTRODUCTION

Sport- shool airport infrastructure is crucial for safe and efficient air traffic, enhancing trade both domestically and internationally. Effective transport economics informs strategic decisions regarding air traffic growth and airport development, aligning with the principles of sustainable development to address the challenges posed by resource exploitation and environmental concerns. Research suggests that a well-managed air traffic system, coupled with stakeholder adaptability, can positively influence the transportation economy, promoting higher quality standards in airport infrastructure in the Republic of Macedonia and aligning it with those of advanced European nations.

[1] Ph.D. Ana Lazarovska post-doctorate of Science with a major in Aeronautical Science management Atlantic International University Honolulu, Pioneer Plaza, 900 Fort Street Mall #905, Honolulu, HI 96813, United States

[2] Prof. dr. sc. Violeta Manevska University St Kliment Ohridski Bitola, Faculty of Information and Communication Technologies, Partizanska bb, 7000 Bitola

[3] Prof. dr. sc. Verica Dancevska University St Kliment Ohridski Bitola, Faculty of Technical Sciences, Makedonska falanga 33, 7000 Bitola

Volume: 08, Issue: 05 September - October 2025

ISSN 2582-0176

The scientific hypothesis posits that air traffic and airport infrastructure are vital for the growth of the international transport economy, especially in sustainable development contexts, illustrated by the Gevgelija sports and school airport project. It highlights the importance of legal frameworks, cost management, and optimization strategies in enhancing national and international transport connections. However, while it provides insights into reverse knowledge transfer and airport categorization, it also identifies limitations, such as insufficient industry differentiation and a lack of focus on airport infrastructure preservation in Macedonia. The study's transverse methodology suggests the potential for more comprehensive longitudinal research in the future, reinforcing the link between equilibrium theory and sustainable airport development while advocating for deeper stakeholder engagement and collaborative practices for improved airport-community relations.

2.0 STATIC MODELS

Static models for analyzing the demand and supply of transport services are separated and described with the basic models[4].

A. Planning the Optimal Number of Aircraft in the Network

- By definition, there are two basic types of planning in aviation: strategic planning, which focuses on long-term goals and framework for the airport network, including infrastructure development and market positioning, and tactical planning, which deals with shorter-term decisions related to scheduling, fleet allocation, and operational efficiency. Both types are essential for optimizing the aircraft deployment strategy to meet demand and regulatory requirements effectively while adapting to market fluctuations and operational constraints.
- Strategic planning long-term plans,
- Operational planning by individual sectors or subsystems.

The air traffic planning process is a complex and strategic effort that integrates problem diagnosis with the establishment of developmental goals and performance metrics, aiming to enhance air traffic management. It underscores the critical interplay between demand activities, planning concepts, and design functions, optimizing the delivery of transport services while considering various influences such as policy frameworks, community requirements, and existing infrastructures. Achieving effective air traffic management requires a holistic approach that acknowledges the intricate interdependencies and processes that significantly affect spatial, economic, and social environments[5].

B. Planning the Optimal Number of Aircraft for a Given Flight Schedule in the Network

An example of a relationship is presented by the flight schedule that determines the supply of transport services between the three places A, B and C at time t.

[4] Mehanović, M.: Mreže u saobraćaju i komunikacijama, Fakultet za saobraćaj i komunikacije, Sarajevo, 2015
[5] Ibidem

Volume: 08, Issue: 05 September - October 2025
ISSN 2582-0176

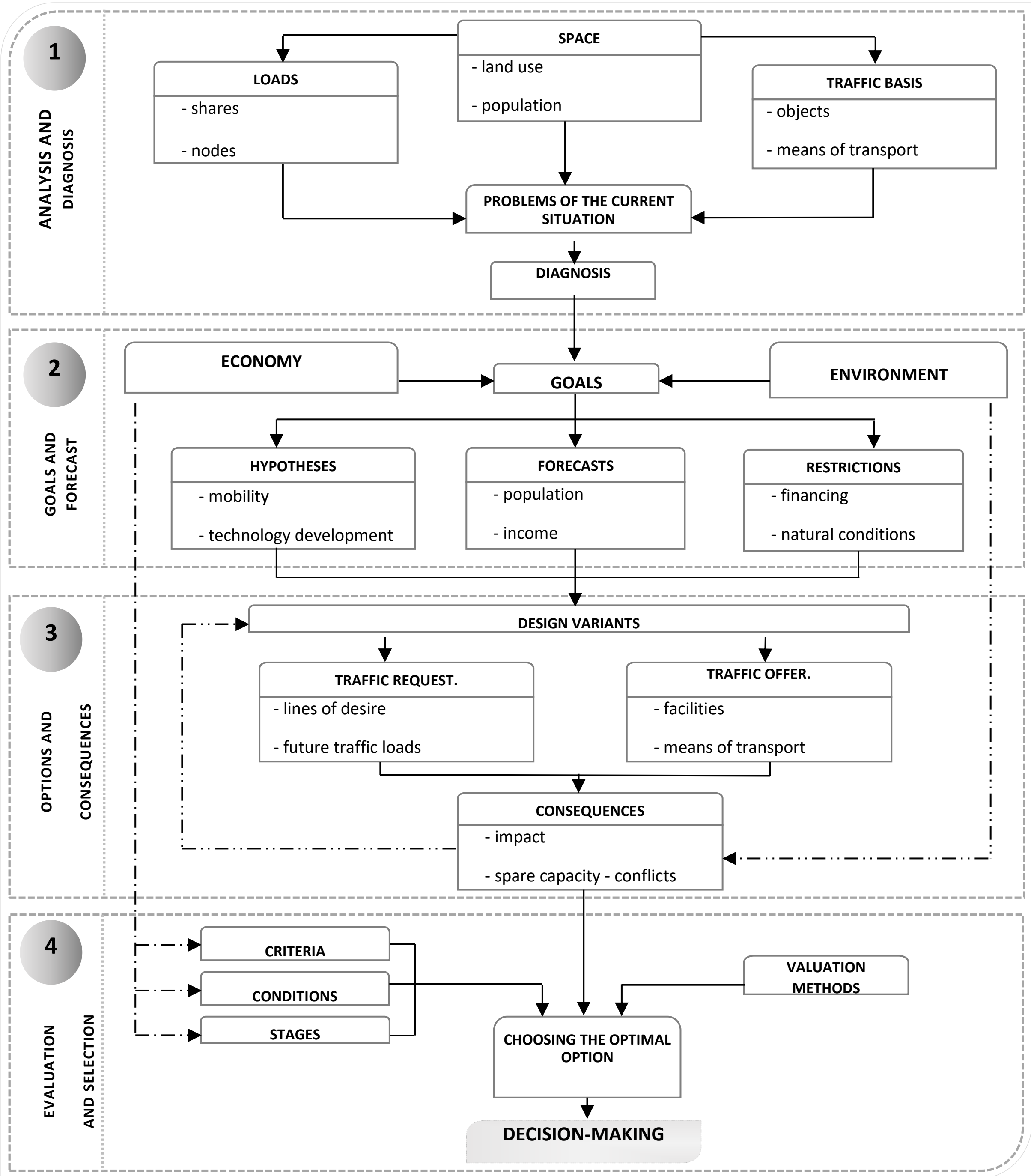

Figure 1, Basic steps in traffic planning

For the planned 13 flights, the question is what is the minimum number of aircraft with which transportation can be organized, assuming that the flights are nodes of the network xi and the path along which one aircraft can make a chain in the network.

The flight schedule is in the form of a grid following the flight, which is realized by moving the vehicle from location A to location B, performing flights 5,6,9,10,13, meaning that from nodes x1 there is a branch orientation towards nodes x5, x6, x9, x10, x13.

In this network there is a branch directed from node xi to the node xj only if the flying xj can be done after flying xi, i.e. flying xi ends at the same location where driving begins xj, and the start of the ride xj is after the end of the ride xi, so that:

- the minimum number of aircraft is determined,
- an example of determining the minimum number of aircraft to execute the planned flight schedule,
- according to the set flight schedule, the calculation of the minimum required number of aircraft is presented to maximize the flow.

A bichromatic graph for a network represents a sequence of departures from a node s1, and those are the branches (s1,t5), (s1,t6), (s1,t9), (s1,t10) and (s1,t13), that is, the first branch (s1,t5) assign intensity flow 1. From the node s1 can emit a stream with the highest intensity 1, that the other branches (s1,t6), (s1,t9), (s1,t10) and (s1,t13) have a flow of intensity 0 which leads to the conclusion that all branches entering the node t5 have flow 0, given that in the node t5 the flow of intensity is already penetrating 1. The flows for other nodes are determined in the same way (s2, s3,.....s13) while branches of the bichromatic graph whose flow equals 1 are indicated by a thicker line on the graph.

The marked branches of the biochromatic graph in which the flow intensity is 1 mean that the maximum value of the total flow through the biochromatic graph|D|=8.

The number of nodes in the initial graph INI=13 is the minimum number of aircraft required to execute a given flight schedule

|C|=|N|-|D|=13-8=5

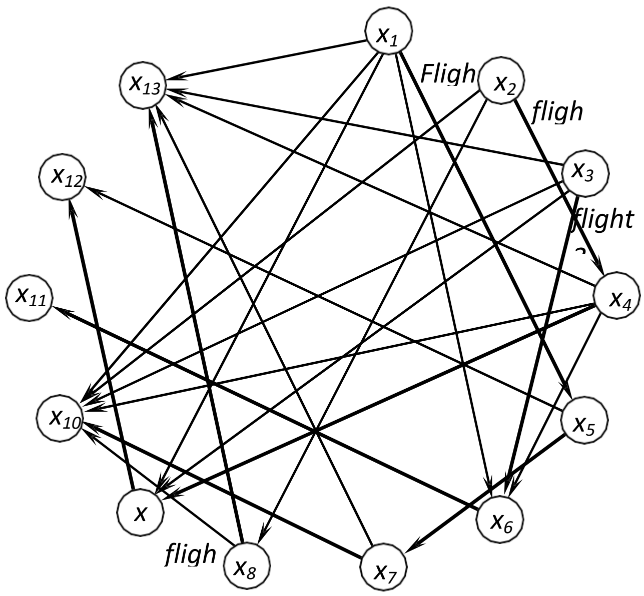

Figure 2, Aircraft paths on decomposed acyclic graphic chains[6]

[6] Ibidem

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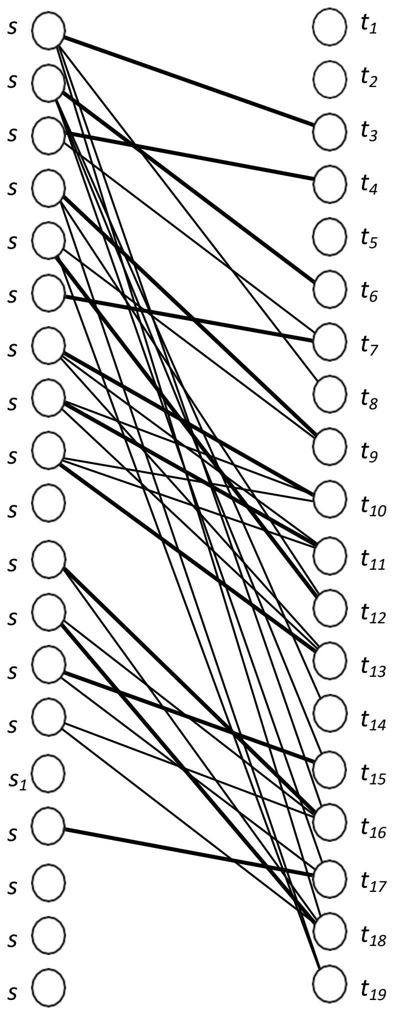
The procedure of maximizing the flow through the biochromatic graph by constructing all branches from nodes si is performed by assigning a flow with intensity 1 to the first 10 branches out of 13 branches and the maximum value of the total flow through the biochromatic graph |D|=13

If the number of nodes in the initial graph is |N|=19, The minimum number of aircraft required to execute a given flight schedule can be calculated as |C|=|N|-|D|=18-13=5.

If the number of flights Vr = 5 represents the minimum number that can perform the flight, provided that the aircraft fly at places is:

Location-S - 2 take-off and 1 landing,
Location-T - 1 take-off and 2 landing,
Location-L - 1 take-off and 1 landing,
Location-B - 1 take-off and 1 landing,
Location-N - 1 take-off and 1 landing.



Graph 3, Bichromatic fly plot with flow intensity limits marked 1310F[7]

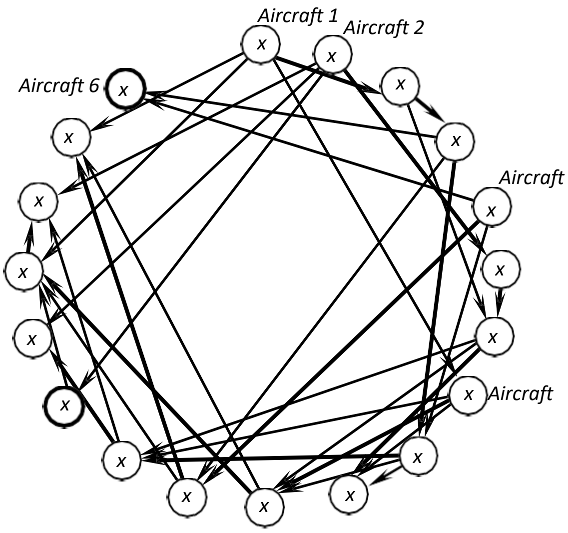


Figure 4, Aircraft chain network

The aircraft can arrive at any location after the end of the flight until the start of the next flight by connecting a certain number of routes and reducing the number of aircraft to 13 to perform flights 1,3,4,9,10,13,15 and 17 starting at location-S and ending at location-B. The second aircraft performs flights 2,6,7,12,14,16 and 19 starting and ending at location-S and the third aircraft will perform flights 5,8,11 and 18, starting at location-L and ending at location-N

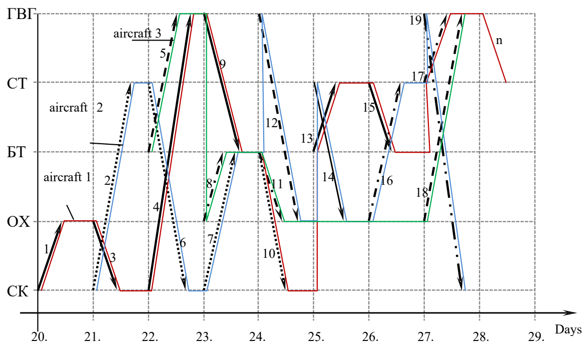


Figure 5, Flying from specific location under the animation where each plane can start flying at a different location

3.0 DISCUSSION OF THE RESULTS

In summary, the preliminary assessment of the airport construction project near Gevgelija underscores the importance of a comprehensive evaluation of financial viability, economic impact, and associated risks, offering valuable insights for informed decision-making and strategic planning as we progress with the project's development. The financial analysis highlights that the total investments incorporating EU funds have a negative net present value,

[7] Ibidem

indicating that these funds are essential for the project's viability. Furthermore, since EU funding accounts for 75% of the total investment in constructing international airports without causing over-financing, it suggests that the resources are allocated efficiently, which is crucial for the project's success. The project's profitability has been affirmed through rigorous sensitivity and risk analyses, revealing resilience against a 10% investment increase and a 50% decrease in benefits, while maintaining favorable economic indicators. With a low risk profile, the project is poised for progression to detailed research and design phases, supported by a potential 75% co-financing from EU funds if alternative financing is not pursued. Furthermore, in addressing sustainable development within modern general aviation airports, the application of game theory, particularly the Nash equilibrium, emerges as a vital tool for optimizing resource management and operational strategies, reflecting the complexities of these optimization challenges. It addresses challenges such as inadequate documentation and data access, offering a model designed specifically for Macedonia to enhance the precision of runway obstacle assessments. By supporting risk-based decision-making on airport location, it highlights the importance of minimizing operational risks and protecting public health and the environment. However, the model's effectiveness is limited by the absence of flight data, indicating the need for future studies to refine this framework and align it with sustainable development goals for improved applicability at the Gevgelija airport.

4.0 CONCLUSION

The continuous scientific research and thoughtful deliberation culminated in a formulation grounded in a wealth of empirical data, which highlighted the essential interplay between transport economics and the optimal functioning of air traffic systems. By synthesizing insights from doctoral dissertations and comparing literature across different languages, I developed a model for airport infrastructure that addresses the unique needs of the region around Gevgelija. This model leverages a multi-index framework to effectively tackle the complexities of the air traffic system, underscoring the significant role of transport economics in fostering developmental progress.

5.0 CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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Thanks to the Faculty of Transport and Traffic Sciences of Zagreb, Economic Faculty of Zagreb, Faculty of Traffic and Communications of Sarajevo, Faculty of Technical Sciences of Bitola and International Atlantic University of Honolulu for increasing my level of education and advising me in all phases of doing my education of all four circle. Thanks to my parents for full support in my life especially expressing my- self and work in the aviation sector.

