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# Improvement of data flow management in the air traffic control automation system

**Ganna Kalashnyk, Myroslava Kalashnyk-Rybalko, Artem Mykhailetskyi**

**Purpose**. The research purpose is to improve the data flow management of the air traffic control system of the Danylo Halytskyi International Airport “Lviv”. **Design / Method / Approach**. The following methods and approaches were consistently used in the research: system approach; modeling; content analysis; statistical analysis; project approach; economic analysis. **Findings**. Recommendations have been developed for optimizing data flow processing, including improving technological solutions, increasing the level of automation, and implementing strategies to reduce stress on controllers. The features and effectiveness of air traffic management and the data flow network of the automated control system of the Danylo Halytskyi International Airport “Lviv” have been studied. The program has been developed to improve the effectiveness of air traffic management and the data flow network of the automated control system of the Danylo Halytskyi International Airport “Lviv”. The effectiveness of the implementation of the program to improve air traffic management and the data flow network of the automated control system of the Danylo Halytskyi International Airport “Lviv” has been substantiated. **Theoretical Implications**. Methodological aspects of data flow management of the automated air traffic control system network have been investigated. **Practical Implications**. Directions for increasing the efficiency of air traffic control and data flow management of the automated control system network of the Danylo Halytskyi International Airport “Lviv” have been developed and substantiated. **Originality / Value**. The implementation of the modern technical and methodological solutions proposed in the article for the automation of air traffic control and data processing will contribute to reducing risks, increasing the speed of decision-making and ensuring the stable operation of all aviation processes. **Research Limitations / Future Research**. Future research into mechanisms for improving air traffic management and data flows at airports is an important task from both a scientific and a practical point of view. **Article Type.** Applied Research.

**Keywords:**

data flow management, air traffic control system, information load

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**Мета**. Вдосконалення управління потоком даних системи управління повітряним рухом Міжнародного аеропорту «Львів» ім. Данила Галицького. **Дизайн / Метод / Підхід**. У дослідженні було послідовно використано такі методи і підходи: системний підхід; моделювання; контент-аналіз; статистичний аналіз; проектний підхід; економічний аналіз. **Результати**. Розроблено рекомендації щодо оптимізації обробки потоків даних, включаючи вдосконалення технологічних рішень, підвищення рівня автоматизації та впровадження стратегій зниження стресового навантаження на диспетчерів. Досліджено особливості та ефективність управління повітряним рухом і потоками даних мережі автоматизованої системи управління Міжнародного аеропорту «Львів» ім. Данила Галицького. Розроблено програму підвищення ефективності управління повітряним рухом і потоками даних мережі автоматизованої системи управління Міжнародного аеропорту «Львів» ім. Данила Галицького. Обґрунтовано ефективність реалізації програми удосконалення управління повітряним рухом і потоками даних мережі автоматизованої системи управління Міжнародного аеропорту «Львів» ім. Данила Галицького. **Теоретичне значення**. Досліджено методологічні аспекти управління потоками даних мережі автоматизованої системи управління повітряним рухом. **Практичне значення**. Розроблено й обґрунтовано напрями підвищення ефективності управління повітряним рухом і потоками даних мережі автоматизованої системи управління Міжнародного аеропорту «Львів» ім. Данила Галицького. **Оригінальність / Цінність**. Впровадження запропонованих в статті сучасних технічних та методологічних рішень для управління повітряним рухом і автоматизації обробки даних допоможе зменшити ризики, підвищити швидкість прийняття рішень, забезпечити стабільну роботу всіх авіаційних процесів. **Обмеження дослідження / Майбутні дослідження**. Подальше дослідження механізмів удосконалення управління повітряним рухом і потоками даних в аеропортах є важливим завданням як з наукової, так і з практичної точки зору. **Тип статті**. Прикладне дослідження.

**Ключові слова:**

управління потоками даних, система управління повітряним рухом, інформаційне навантаження

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Modern airports operate in a complex environment, where it is necessary to ensure the coordinated operation of various systems: flight control, ground handling, logistics, security and interaction with airlines. Optimizations of data flows and automation of management processes allow for to increase in the throughput capacity of airports, reduce flight delays, improve passenger service and ensure compliance with international flight safety standards.

Given the constant increase in air traffic and the growing complexity of operations, research into mechanisms for integrating air traffic control systems and airport information networks is important for increasing the efficiency of the industry, reducing costs and minimizing the environmental impact of aviation.

Air traffic management (ATM) is a critically important element of the functioning of the global aviation system, ensuring the safety, efficiency and optimization of aircraft movement in airspace. Modern challenges associated with the growth of air traffic, the development of unmanned aerial vehicles and the need for environmental sustainability require improved methods (Kalashnyk & Kalashnyk-Rybalko, 2024a) and approaches to the organization of air traffic control.

Danylo Halytskyi International Airport "Lviv" is an important part of the transport infrastructure of Western Ukraine, which is of strategic importance for the city of Lviv and the region as a whole. Since its opening in 1929, the airport has gone through various stages of development, from a military facility to an international hub. Of particular significance was the reconstruction before Euro-2012, which provided the airport with new opportunities for serving passengers. Since then, it has been developing steadily, expanding routes and improving service. However, starting in 2022, the airport experienced a significant crisis due to the full-scale Russian invasion, which led to the cessation of civilian air traffic and a shift in emphasis to humanitarian and cargo transportation. This was the main reason for the sharp changes in the airport's financial results, in particular, a sharp reduction in revenues and gross profit. These financial difficulties require a review of the airport's development strategy, including cost optimization and the search for new sources of income.

At the same time, the restoration of air traffic after the end of the war will be an important stage in returning to a stable financial situation. If conditions permit in 2025, the opening of the Danylo Halytskyi International Airport "Lviv" for commercial flights will be an important step towards the economic recovery of not only the Lviv region but also all of Ukraine.

## Formulation of the problem

Theoretical and practical aspects of the problem of air traffic control and automated airport management systems have become the subject of research by such Ukrainian scientists as Nedilko S. M., Baranov G. L., Bezverkha K. S., Borozenets I. O., Shylo S. G., Shcherbak G. V., Brusakova O. V., Vasylenko D. E., Tymochko O. I., Mazhara I. P., Yanovytsky O. K. and others.

However, despite the significant contribution of these scientists to solving this problem, many aspects of this issue remain insufficiently disclosed. In particular, the issue of integrating automated control systems with the latest technologies, such as artificial intelligence, machine learning and Big Data, requires further development.

Cybersecurity issues in the processes of data exchange between airport subsystems, which are of critical importance for ensuring flight safety and the effective operation of the aviation complex, are also insufficiently covered. In addition, the issue of optimizing data flow remains relevant to increase the efficiency of management decision-making, minimize flight delays and reduce operating costs.

The main goal of each airport is to serve the maximum number of aircraft with minimal costs for each of them while ensuring flight safety. Among the requirements of airspace users for the services of the air traffic control system, the following can be distinguished: increasing the throughput capacity of the air traffic management system; flexible use of airspace; the ability to perform flights both along optimal trajectories in the horizontal plane and at optimal altitude; dynamic correction of the flight plan during its execution; reducing time delays for flights arriving at airports; minimal deviations of aircraft from planned trajectories while preventing possible collisions with other aircraft or ground obstacles and when avoiding dangerous meteorological events; simplified and unified procedures for pilot-controller interaction during air traffic control.

The use of modern algorithms allows for significant reductions in delays, increases the efficiency of airspace use and improves schedule consistency (Aditya et al., 2024). At the same time, limitations of existing models have been identified; in particular their insufficient ability to adapt to changes in real time (Aditya et al., 2024; Chen et al., 2024). Modern data-driven models (machine learning, big data, digital twins of airports) demonstrate high accuracy in predicting delays and conflicts, but require significant computing resources and are sensitive to the quality of input data (Chen et al., 2024).

Modern air traffic management systems place all responsibility for flight safety and effective air traffic management on the controller. He not only gives instructions to pilots, but also allows (prohibits) the performance of certain flight procedures. The controller's capabilities are largely limited by the density of air traffic. In turn, the controller's psychological and physiological capabilities to predict and resolve several potentially conflicting situations simultaneously are limited, which is a limiting factor for the growth of air traffic intensity and the development of the entire air traffic management system (Jameel et al., 2023). Among the innovations that will help improve the efficiency of air traffic controllers' information processing, including information overload, the concept of a digital air traffic controller (Jameel et al., 2023) has been proposed, which integrates into the controller's workplace and performs tasks such as conflict detection and resolution, command creation, and communication with pilots via CPDLC (Controller Pilot Data Link Communications).

A new approach to assessing and optimizing air traffic complexity based on system stability metrics by adjusting the departure time of some flights will help significantly reduce the workload on controllers and increase the safety and efficiency of air operations (Wang et al., 2023). To help reduce the stress on controllers, a dynamic routing and scheduling approach for aircraft taxi automation that adapts to the current situation on the airport surface has been developed (Kang et al., 2025). This approach optimizes aircraft movements on the ground, ensuring efficient planning and joint control for all aircraft, as well as more balanced use of runways.

The development of a modern architecture for a real-time air traffic control system that uses big data processing technologies has significant potential for improving the efficiency and predictability of air traffic control (Vaidya et al., 2023). The use of modern data processing technologies allows for rapid response to changes in traffic and provides flexibility in system scaling.

The modern strategy for developing air traffic control systems involves the creation of unified complexes, on the one hand, and the phased modernization of existing complexes, on the other. One example of the creation of unified complexes is the development of a single graphical interface for the Flow Management Data and Services (FMDS) system (Abdulhak et al., 2024), which replaces more than fifty disparate applications of the previous TFMS (Traffic Flow Management System) platform of the US Federal Aviation Administration (FAA). The unified interface significantly reduces the execution time of standard operations and can significantly optimize air traffic management processes, forming a solid foundation for the next stages of implementation in real operating environments.

With the growth of air traffic, such traditional approaches as the use of statistical models, fuzzy logic and data mining algorithms face limitations, including high computational complexity and the inability to effectively process large volumes of data (Aghdam et al., 2021) of airspace. Further increasing the level of automation of solving operational management tasks is possible only with the use of new approaches and information technologies. Among the key approaches and technologies aimed at improving ATC management, the following can be distinguished:

*1. Optimization of air traffic flow management.* Air traffic flow management is the basis of modern aviation, ensuring safe and efficient aircraft movement in conditions of increasing airspace congestion. The study (Aditya et al., 2024), based on an analysis of 162 publications from 2014–2024, emphasizes the importance of optimizing aspects such as delay minimization, airspace congestion management, and schedule planning.

A new approach to air traffic management in dense airspace, based on network flow optimization, includes a model that

represents the airspace as a network with nodes and arcs, where each arc has a limited capacity (Hu et al., 2025). This model allows taking into account dynamic changes in traffic and adapting flight routes in real time, ensuring efficient use of airspace and reducing delays.

*2. Applying Deep Learning to Improve Control Accuracy.* The paper (Pinto Neto et al., 2023) analyzed the current level of the use of deep learning for traffic forecasting, conflict detection, route optimization, speech recognition, and unmanned systems integration. It also considered technical aspects such as architecture selection, data processing, model training, and computational resource requirements. However, many challenges must be overcome to fully implement deep learning in air traffic control optimization, including ensuring data quality and availability, model interpretability, integration with existing systems, and compliance with safety requirements. The authors emphasise the importance of interdisciplinary collaboration to overcome these barriers and further develop intelligent air traffic control systems.

In paper (Aghdam et al., 2021), a hybrid deep learning model is proposed to improve the efficiency of air traffic control by combining two architectures: Bidirectional Long Short-Term Memory (Bi-LSTM) and Extreme Learning Machine (ELM). The model was trained on data from Kaggle and evaluated using MATLAB using various statistical performance criteria. The results showed a significant improvement in the accuracy of aircraft arrival and departure time predictions, as well as a reduction in errors compared to previous methods.

*3. Use of Big data and decision support system.* The paper (Aditya et al., 2024) emphasizes the role of big data in optimizing ATC data flow management. The use of historical flight path data allows balancing air flow density, reducing congestion. For example, the integration of trajectory data with route capacity optimization models resulted in a reduction in operation time by 18.6% (Aditya et al., 2024).

A method for dynamically managing the movement of ground equipment and aircraft at an airport, taking into account the changing traffic situation and the priorities of potential conflicts, based on the analysis of large volumes of traffic data, is proposed in the paper (Bao et al., 2025). The implementation of the proposed approach managed to reduce the average waiting time on taxiways and parking lots by approximately 12–18%, as well as reduce the number of conflict situations to 25% of the initial levels (Bao et al., 2025).

*4. Integration of modern technologies and automation.* Integrating explainable artificial intelligence into air traffic management decision support systems can significantly increase operators' trust in automated decisions, especially under high workload and uncertainty (Xie et al., 2021). The authors developed a machine learning-based operational risk prediction tool using the XGBoost algorithm to analyze data on aviation events and meteorological conditions. The proposed approach demonstrates the potential to improve the safety and efficiency of aviation operations while providing the necessary transparency and human control.

Improving of data flow management in ATC systems requires a comprehensive approach that includes the use of big data, deep learning methods, automation, and modern software architectures. Research shows significant progress in minimizing delays, optimizing airspace capacity, and improving safety. However, challenges remain in integrating new technologies into existing systems, taking into account unforeseen factors and the need for cooperation between all stakeholders. Thus, further research into mechanisms for improving air traffic management and data flows at airports is an important task both from a scientific and a practical point of view.

## The purpose of the research

The purpose of the research is to improve of data flow management of the air traffic control system of the Danylo Halytskyi International Airport "Lviv".

## Research methods and the research information base

The following methods were used in the research: system approach (to consider air traffic control as a complex system); modeling (to study the methodological aspects of data flow management in an automated system); content analysis (to analyze information flows between subsystems of the automated control system); statistical analysis (to characterize and analyze the activities of the Danylo Halytskyi International Airport "Lviv"); project approach (to develop a program to improve the efficiency of air traffic control and data flows); economic analysis (to substantiate the effectiveness of the implementation of the air traffic control improvement program).

The research information base is official data and financial reporting of the Danylo Halytskyi International Airport "Lviv".

## Discussion and results

Modern air traffic control is impossible without automation systems that use artificial intelligence and big data analysis to improve work efficiency. In addition, the environmental aspect is taken into account, as aviation activities have a significant impact on the environment, which encourages the implementation of environmentally friendly routes and technologies (Kalashnyk & Kalashnyk-Rybalko, 2024b). An important challenge today is the integration of unmanned aerial vehicles (UAVs) into the overall airspace management system. With the development of technology, drones are increasingly used for both civil and commercial a purpose, which requires clear coordination and regulation of their movement. The components of air traffic control are given in Table 1.

**Table 1 – Components of Air Traffic Control (Ministry of Transport of Ukraine, 2010; Ukrainian State Air Traffic Services Enterprise, 2025)**

| Components | Characteristics |
|---|---|
| Airspace organization | Planning and allocation of airspace between civil, military and special users to ensure flight safety and efficiency |
| Air Traffic Service (ATS) | Includes air traffic control (ATC), flight control, information and emergency services |
| Air Traffic Control (ATC) | Real-time monitoring and coordination of aircraft movements by controllers to prevent conflict situations |
| Communications, Navigation and Surveillance Systems (CNS) | Ground and satellite navigation systems are used to determine the aircraft's precise location and routing |
| Connection and communication | Organisation of effective interaction between controllers, pilots, airport services and other participants in air traffic |
| Meteorological support | Providing up-to-date information on weather conditions to improve safety and optimise flights |
| Forecasting and Air Traffic Flow Management (ATFM) | Analysis and regulation of air traffic intensity to avoid airspace congestion and minimise delays |
| Automated Air Traffic Management systems (ATM automation) | Using modern digital technologies, artificial intelligence, and big data to optimise the work of dispatch services |
| Aeronautical Information Management (AIM) | Collection, processing and dissemination of aeronautical information for all participants in air traffic |
| Emergency and rescue support | Organisation of emergency response, coordination of rescue operations in aviation incidents |
| Environmental management | Implementing measures to minimise the environmental impact of aviation, reduce noise levels and reduce $CO_2$ emissions. |
| Unmanned Aerial Vehicle Integration (U-Space) | Coordination and regulation of UAV movement in shared airspace together with manned aircraft |

Air traffic control is a complex system that ensures the safe, efficient and orderly movement of aircraft in controlled and uncontrolled airspace. Its main goal is to prevent collisions, optimize routes and reduce flight delays. The air traffic control system covers three main directions (Figure 1).

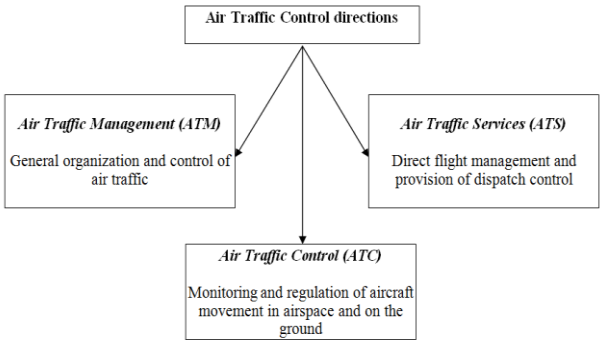


**Figure 1 – Air Traffic Control directions (Ministry of Transport of Ukraine, 2010)**

The air traffic control (ATC) automation system is a key element of modern aviation, ensuring the safety, efficiency and reliability of air traffic. The development of air traffic control service continues, and current trends include the integration of unmanned aerial vehicles, the expanded use of artificial intelligence and the increasing role of digital technologies in the interaction between pilots, controllers and aviation companies. The air traffic control (ATC) automation system is a set of technical, software and organizational tools that provide monitoring, control, planning and coordination of air traffic in real time using modern information technologies and communication means (Ministry of Transport of Ukraine, 2010). The characteristics of the air traffic control automation system are presented in Table 2.

**Table 2 – Components of the Air Traffic Control automation system (Ukrainian State Air Traffic Services Enterprise, 2025)**

| Characteristics | Description |
|---|---|
| Functional purpose | Air traffic control, ensuring flight safety, optimising airspace use |
| Main components | Automated dispatch systems, radars, satellite navigation, digital communications, meteorological services, and traffic forecasting systems |
| Working principle | Real-time data collection, processing and transmission for air traffic coordination |
| Advantages | Improving flight safety, reducing delays, optimising routes, and reducing the impact of the human factor |
| Integration with other systems | Connection to global air navigation systems, military and civil aviation services |
| Development prospects | Using artificial intelligence, integration of unmanned aerial vehicles, and automated management of airport operations |

One of the key components of the air traffic control automation system is the network data streams that provide operational information exchange between control centers, aircraft, satellite and ground stations, meteorological services, airports and other air traffic participants.

Data streams in the ATC network are formed based on a large number of sources and transmit a variety of information, including data on flight trajectories, weather conditions, aircraft telemetry, radar images, controller command signals, automated trajectory calculations and airspace conflict prediction. This data must be transmitted in real or near real time with minimal delay, which requires the use of high-speed, reliable and secure communication channels (Ukrainian State Air Traffic Services Enterprise, 2025).

The air traffic control automation system network data streams are structured digital information flows transmitted between air traffic control system components in real time or with minimal delay to ensure flight coordination, safety, and efficient use of airspace (Brusakova, 2019).

The main purpose of data flow management in the network of the air traffic control automation system is to ensure reliable, fast and secure information exchange, which allows the aviation activity to effectively coordinate aircraft movements, reduce the risk of incidents and improve the quality of air navigation services. The main tasks of data flow management in the network of the ATC automation system, which arise from this purpose, are presented in Figure 2.

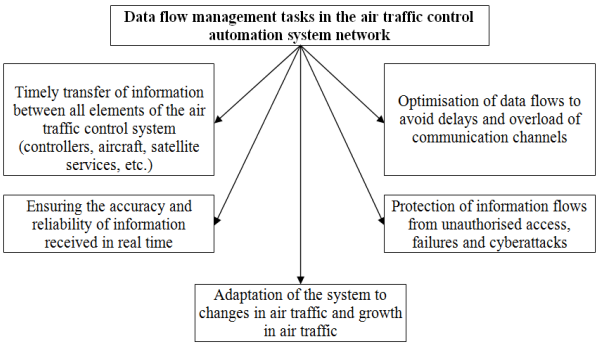


**Figure 2 – Tasks of data flow management in the Air Traffic Control automation system network (Ukrainian State Air Traffic Services Enterprise, 2025)**

Information flow management in the air traffic control system has many features that distinguish it from other areas of data organization and transmission.

1. Real-time implementation, since aviation data must be transmitted instantly without any delays, since even a second of slowdown causes critical situations in air traffic.

2. High level of security and data protection, since aviation information is critical, its transmission must be protected from interception, disruption and potential interference by attackers. Encryption methods, communication channel redundancy and multi-level authentication mechanisms are used.

3. Integration of different types of data. Data flow management involves combining information from many sources, including global navigation satellite systems (GNSS), radars, meteorological stations, automated air traffic control centers and airports.

4. Flexibility and scalability, since the system must adapt to changing air traffic conditions, for example, in the event of an increase in air traffic or the occurrence of emergency situations (e.g. adverse weather conditions, technical failures (Mashkov et al., 2022), aviation incidents).

5. Process automation. Thus, the use of modern technologies (artificial intelligence, machine learning, Big Data) allows for automatic analysis, filtering and distribution of data, reducing the burden on controllers and reducing the likelihood of human error.

6. Global data synchronization, since air traffic is international, data flow management must ensure uninterrupted communication between aviation services of different countries in accordance with the standards of the International Civil Aviation Organization (ICAO).

Therefore, data flow management in the air traffic control automation system network is a key component of modern aviation infrastructure. As technology continues to develop, data flow management in the ATC automation system network also needs to be modernized and improved. The main reasons why effective data flow management is extremely important are shown in Figure 3.

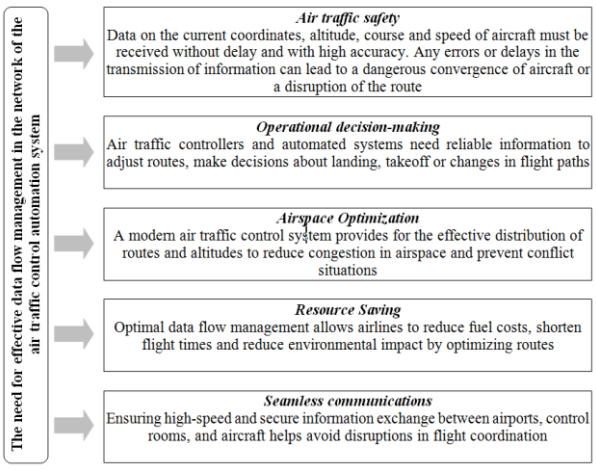


**Figure 3 – The need for effective data flow management in the network of the air traffic control automation system (Source: Developed by the authors)**

The methodology of data flow management in the network of the air traffic control automation system is presented in Table 3.

**Table 3 – The methodology of data flow management in the network of the air traffic control automation system (Ukrainian State Air Traffic Services Enterprise, 2025; Permiakov et al., 2021)**

| Methodological aspect | Description |
|---|---|
| Real-time principle | Data is transmitted, processed and analysed in real time, which ensures instant response to changing air traffic parameters |
| Process automation | Using artificial intelligence, machine learning, and big data algorithms to automatically analyse and optimize information flows |
| Integrating data from different sources | Combining information from radars, satellites, weather stations, navigation systems, airports and air traffic control centres |
| Global synchronization | Data consistency between National and International systems according to ICAO standards for seamless air traffic coordination |
| Information protection | Implementing multi-layered encryption, user authentication, and cybersecurity mechanisms to prevent unauthorised access |
| Flexibility and adaptability | The system is capable of dynamically changing control parameters in response to changes in air traffic, weather conditions, or emergencies |
| Forecasting and risk analysis | Using analytical tools to predict possible threats, failures or network overloads, which allows you to avoid critical situations |
| Data monitoring and quality control | Regularly verify the correctness, accuracy and relevance of information used for air traffic control |
| Scalability | The system is able to support the growth of air traffic without loss of productivity, adapting to new technological standards |
| Efficient load management | Balancing data flows between servers and network nodes to prevent overload and delays in information processing |

This methodology ensures the reliability, safety and efficiency of data flow management in the automated air traffic control system network, which is critically important for the stable functioning of the aviation infrastructure.

Thus, effective data flow management in the air traffic control system network is the basis for safe, reliable and optimized air traffic management. Not only air traffic coordination, but also the overall level of flight safety depends on the quality and speed of data processing. The use of modern technologies, such as artificial intelligence, satellite communications, cloud computing and quantum encryption, makes these processes even more efficient and ready for future challenges in the aviation industry.

Important tasks of data flow management are to minimize delays, ensure the safety and stability of the entire aviation system. Also, an urgent direction of development is the integration of new technologies to ensure more accurate and rapid coordination between controllers, pilots and other participants. Therefore, data flow management is critically important for the effective functioning of aviation infrastructure, and its improvement will become the basis for achieving higher safety standards and optimizing air transportation, in particular at the Danylo Halytskyi International Airport "Lviv".

The Danylo Halytskyi International Airport "Lviv" is an important part of the transport infrastructure of Ukraine, which is of strategic importance for the city of Lviv and the region as a whole. The financial analysis of the airport's activities for 2021-2023 demonstrates a catastrophic decline in revenue and an increase in losses, which is directly related to the cessation of passenger transportation.

In particular, in 2022, net income decreased by 87.1%, and in 2023, by another 98.3% compared to 2021. Expenses also decreased, but this was not enough to maintain financial stability. The net profit indicator turned into significant losses, which reflects the crisis state of the airport.

Despite the difficult conditions, the management is taking measures to support its vital activities, optimizing costs and looking for alternative sources of income. Further development of the airport will depend on the security situation in the country and the possibility of resuming air traffic. The financial condition of the airport is analyzed in Table 4.

**Table 4 – Dynamics of financial condition indicators of the Danylo Halytskyi International Airport "Lviv" in 2021-2023 (Source: Developed by the authors based on official sources of financial reporting data: LLC Clarity App, 2021; LLC Clarity App, 2022; LLC Clarity App, 2023)**

| Indicators | Years | | | Deviation | |
|---|---|---|---|---|---|
| | 2021 | 2022 | 2023 | 2022/ 2021 | 2023/ 2022 |
| *Liquidity indicators* | | | | | |
| Absolute liquidity ratio | 4,13 | 4,54 | 2,41 | 0,41 | -2,13 |
| Coverage ratio | 5,20 | 5,86 | 3,32 | 0,66 | -2,54 |
| Quick liquidity ratio | 4,99 | 5,65 | 3,15 | 0,66 | -2,50 |
| Net working capital, thousand UAH | 348595 | 314294 | 182383 | -34301 | -131911 |
| *Solvency indicators* | | | | | |
| Working capital ratio | 0,81 | 0,83 | 0,70 | 0,02 | -0,13 |
| Equity agility ratio | 0,18 | 0,10 | 0,07 | -0,08 | -0,03 |
| Solvency ratio (autonomy) | 0,96 | 0,98 | 0,97 | 0,02 | -0,01 |
| Funding ratio | 0,05 | 0,02 | 0,03 | -0,03 | 0,01 |
| *Business activity indicators* | | | | | |
| Fixed assets turnover ratio (return on assets) | 2,74 | 0,80 | 0,96 | -1,94 | 0,16 |
| Asset turnover ratio | 3,90 | 1,09 | 1,32 | -2,81 | 0,23 |
| Accounts payable turnover ratio | 178,34 | 63,02 | 159,11 | -115,32 | 96,09 |
| Accounts payable maturity date | 2,05 | 5,79 | 2,29 | 3,74 | -3,5 |
| Accounts receivable turnover ratio | 111,08 | 45,89 | 72,31 | -65,19 | 26,42 |
| Receivables maturity, days | 3,29 | 7,95 | 5,05 | 4,66 | -2,9 |
| Inventory turnover ratio | 420,72 | 201,41 | 270,10 | -219,31 | 68,69 |
| Equity turnover ratio | 4,02 | 1,12 | 1,35 | -2,9 | 0,23 |
| *Profitability indicators* | | | | | |
| Return on assets ratio | 1,03 | -23,55 | 10,26 | -24,58 | 33,81 |
| Return on equity ratio | 1,07 | -24,30 | 10,55 | -25,37 | 34,85 |
| Profitability ratio | 0,27 | -21,65 | 7,79 | -21,92 | 29,44 |
| Product profitability ratio | 0,28 | -19,32 | 8,31 | -19,6 | 27,63 |

Analysis of the dynamics of liquidity indicators allowed us to conclude that at the beginning of the analyzed period, all liquidity ratios had rather high values, indicating the enterprise's ability to promptly cover its obligations. In 2022, there is a tendency to improve these indicators, which is the result of a decrease in short-term liabilities. At the same time, an increase in the value of liquidity indicators in 2022 indicates excessive diversion of the enterprise's resources to the formation of cash, which leads to inefficient use of available financial resources. After all, under normal economic conditions and average expected profitability, it is more efficient for an enterprise to invest its free cash resources in its activities. This situation is a consequence of the closure of airspace and the prohibition of scheduled flights by civil aviation aircraft after the start of the full-scale invasion of the Russian Federation into Ukraine. However, in 2023, there was a significant decrease in all liquidity ratios. This indicates an increase in the company's liabilities, a decrease in its liquid assets, which reduces financial flexibility and increases financial risks. Also, a decrease in net working capital indicates a decrease in the resource base to cover current expenses, which complicates the fulfillment of financial obligations in the short term. In general, the dynamics of the indicators indicate initial stability, temporary improvement in 2022 and further deterioration of liquidity in 2023, which indicates increased financial risks and the need to revise the airport's financial strategy.

Analysis of the dynamics of solvency indicators reflects changes in the financial stability of the enterprise and its capital structure. Thus, the ratio of provision with own working capital demonstrates a slight improvement in 2022, which is evidence of the strengthening of the financial independence of the enterprise; however, in 2023, the indicator decreased, which indicates a deterioration in financial flexibility and an increase in dependence on borrowed funds.

The equity flexibility ratio has a steady downward trend, indicating a decrease in the share of own funds in current financial operations. This means a decrease in the ability of the enterprise to quickly respond to changing market conditions or to finance its activities without attracting additional sources. The autonomy ratio remains stably high, which confirms a significant share of equity in the overall structure of financial resources. Minor fluctuations in the indicator indicate that the enterprise maintains control over its

financial sources without significant influence from external creditors.

The financing ratio demonstrates instability: in 2022, its decrease is observed, indicating a reduction in the share of attracted funds, while in 2023, the indicator recovers somewhat. This indicates changes in financing policy and the need to attract additional financial resources. In general, the dynamics of solvency indicators indicate a gradual deterioration in the enterprise's ability to effectively use equity, maintain financial independence, but at the same time, certain difficulties with the maneuverability of financial resources.

Analysis of the dynamics of business activity indicators indicates significant changes in the financial and economic activities of the enterprise during 2021–2023. The return on assets and asset turnover indicators in 2022 decreased significantly, which indicates a sharp decrease in the efficiency of using assets and fixed assets. This situation is associated with a reduction in activity volumes, a change in the structure of assets, or external economic factors. In 2023, there was a slight improvement, but the indicators are still far from the level of 2021, which indicates a gradual but slow restoration of the efficiency of using assets. The accounts payable turnover ratio in 2022 decreased sharply, which indicates an increase in the period of settlements with suppliers. At the same time, the situation improved in 2023, which is a consequence of the adjustment of financial flows and changes in the terms of cooperation with counterparties. Similarly, the maturity of accounts payable in 2022 increased significantly, but in 2023 it decreased slightly, indicating a certain stabilization of settlements.

The turnover of receivables also decreased significantly in 2022, which means a slowdown in the process of recovering funds from debtors. This was caused by financial difficulties of counterparties or changes in lending conditions. In 2023, the indicator increased, indicating the restoration of payment discipline and more effective management of receivables.

The turnover of inventories in 2022 significantly decreased, indicating a decrease in the speed of their use due to a reduction in the volume of services sold. In 2023, there was a partial improvement, which was a result of inventory optimization. The equity turnover ratio demonstrates similar dynamics: a sharp decrease in 2022 and a slight improvement in 2023 indicate a gradual restoration of the efficiency of using own resources. In general, in 2022, there was a sharp deterioration in business activity indicators, which indicates significant difficulties in the financial and economic activities of the enterprise. In 2023, there was some improvement, but the indicators have not yet returned to the level of 2021, which demonstrates the slow restoration of the efficiency of business processes.

Analysis of the dynamics of profitability indicators indicates significant fluctuations in the efficiency of the enterprise during 2021–2023. Thus, in 2022, all profitability indicators decreased sharply, acquiring negative values. This indicates significant losses and inefficiency in the use of assets, equity and resources of the enterprise. This situation is a consequence of a sharp decrease in income, an increase in expenses and a general deterioration in economic conditions. In 2023, there was a significant improvement in profitability indicators: they returned to positive values, which is confirmation of the gradual restoration of the airport's profitability. This situation is a result of increased revenues, reduced costs and optimization of operational activities. Overall, the profitability analysis indicates a deep crisis in 2022 with further recovery in 2023. However, despite the positive dynamics, the profitability level is still far from the 2021 indicators, which indicates the need to further improve the management of financial resources and operational efficiency.

Air traffic control at Danylo Halytskyi International Airport “Lviv” is an extremely important component of its activities, as this airport is a key transport hub for Ukraine, connecting Lviv with many international destinations. Technological support, in particular integration with international systems such as Eurocontrol, allows Danylo Halytskyi International Airport “Lviv” to effectively interact with other airports and control centers, which, in turn, increases the level of flight safety.

The automated system of air traffic control of the Danylo Halytskyi International Airport "Lviv" includes some high-tech components that ensure effective air traffic control in the airport service area. One of the main components of this system is a complex of automated controller workstations, which provide the ability to promptly monitor and control aircraft movement. To ensure flight safety, radar equipment is used, which allows obtaining accurate data on the location of aircraft in the airport area.

The airport's automated system of air traffic control also has integration with other national and international air traffic control systems, such as Eurocontrol, which ensures effective coordination between different airports and air routes. The characteristics of the automated system of air traffic control of the Danylo Halytskyi International Airport “Lviv” are presented in Table 5.

**Table 5 – The characteristics of the automated system of air traffic control of the Danylo Halytskyi International Airport “Lviv” (Source: Developed by the authors)**

| System components | Characteristic |
|---|---|
| System type | The automated system of air traffic control |
| Main purpose | Ensuring safety and effective air traffic management within the airport and surrounding airspace |
| Functionality | Monitoring and control of aircraft movements |
| | Coordination of takeoffs, landings and aircraft manoeuvres |
| | Interaction with meteorological stations and other airport subsystems |
| | Data exchange with other regional control centres |
| Interface | Interface for controllers that provides access to up-to-date information |
| Technologies | Radar equipment |
| | Navigation technologies |
| | Data exchange systems |
| Advantages | Improving flight safety |
| | Reducing the workload on controllers |
| | Increasing the efficiency of air traffic control |
| Integration with other systems | Interaction with other national and international air traffic control systems |
| Key components | Controller workstations |
| | Radar equipment |
| | Communication and data transmission systems |

The main air traffic control bodies of the Danylo Halytskyi International Airport "Lviv" are the airport dispatch service and the State Enterprise "Ukraerorukh", which exercises control over air traffic in the airspace of Ukraine. Flight coordination and control over their execution are carried out through the issuance of takeoff and landing permits, flight routing and the provision of air navigation services using modern navigation systems. The automated system of air traffic control of the Danylo Halytskyi International Airport "Lviv" includes modern radar and navigation technologies as well as data exchange systems that ensure safety, accuracy and timeliness of management decisions. The system automates the processes of aircraft flow management, monitors and controls the movement of aircraft at all stages of their route (Table 6).

**Table 6 – The characteristics of the automated system of air traffic control of the Danylo Halytskyi International Airport “Lviv” (Ukrainian State Air Traffic Services Enterprise, 2025)**

| Management sphere | Functions and features |
|---|---|
| Management bodies | Airport Dispatch Service, State Enterprise "Ukraerorukh" |
| Flight coordination | Air traffic control, granting takeoff and landing permits, flight routing |
| Air navigation services | Using modern navigation systems to ensure flight accuracy |
| Communication system | Radio communications, satellite systems, automated dispatching complexes |
| Flight safety | Monitoring meteorological conditions, warning of possible risks |
| Interaction with airlines | Coordination of flight schedules, provision of information on air navigation conditions |
| Technological support | Automated air traffic control systems, modern radar systems |
| Infrastructure facilities | Control tower, flight control center, navigation towers |
| Compliance with international standards | Compliance with ICAO and European Organization for the Safety of Air Navigation (Eurocontrol) requirements |

We analyzed the efficiency indicators of data flow management of the automated system of air traffic control network of the Danylo Halytskyi International Airport "Lviv" for the period 2021–2023. This allowed us to identify the main shortcomings in air traffic management and data flows management of the automated control system network at the Danylo Halytskyi International Airport "Lviv" (Table 7).

**Table 7 – Shortcomings in air traffic management and data flow management of the automated control system network at the Danylo Halytskyi International Airport "Lviv" for the period 2021–2023 (Source: Developed by the authors)**

| Shortcoming | Characteristic |
|---|---|
| Increased latency in data exchange | In 2022, the increase latency in data exchange (0.3 sec.) was due to network overload or temporary technical problems, such as insufficient communication channel bandwidth or equipment malfunctions |
| Decrease in data processing speed | In 2022, the decrease in data processing speed (55 msec.) indicated insufficient computing power or inefficiency of the software responsible for data processing |
| Increased number of errors in data transmission | In 2022, the increase in data transmission errors (0.03%) was due to problems with communication equipment or network failures. This causes temporary data loss or incorrect transmission of information, which negatively affects the accuracy and reliability of the system |
| Reduction in communication channel bandwidth | In 2022, the communication channel bandwidth was reduced to 90 Mbps, indicating limitations in the communication infrastructure or the need to upgrade technical equipment to ensure uninterrupted operation with large volumes of data. This leads to delays in information transmission, which is critical for the safety and efficiency of air traffic control. |
| Increased recovery time after failures | In 2022, an increase in the time to restore communication after failures by 1.3 minutes was recorded, which indicates insufficient preparedness of the system for unforeseen failures or technical problems that may arise during operation. The recovery time in 2023 to 1 minute was an improvement, but stilled leaves room for further optimization |

To eliminate shortcomings in air traffic management and data flows of the automated control system network at Danylo Halytskyi International Airport "Lviv", we have developed recommendations, which are schematically presented in Fig. 4.

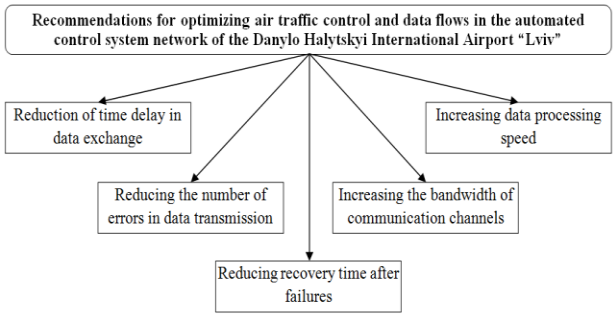


**Figure 4 – Recommendations for improving air traffic management and data flow management in the automated system of air traffic control network of the Danylo Halytskyi International Airport "Lviv" (Source: Developed by the authors)**

Air traffic control and data processing are the main aspects for ensuring the safety and efficiency of modern airports. For Danylo Halytskyi International Airport "Lviv", this is a key factor, since the increase in air traffic requires high accuracy and efficiency of information exchange between various airport services.

Increasing the productivity of information systems, in particular, through the modernization of network equipment and the use of modern technologies, significantly reduces the risks of technical failures and optimizes the operation of all subsystems.

One of the biggest challenges is reducing delays in data exchange and increasing the speed of their processing, which can be achieved through the integration of high-performance server equipment, improving information processing algorithms and using cloud technologies.

Reducing errors in data transmission and increasing the bandwidth of communication channels are important areas for maintaining the stability of the airport. This requires regular updating of network devices, optimizing data transmission through the implementation of reliable protocols and backup communication channels. The use of an intelligent error correction system, the use of error correction algorithms (Forward Error Correction), will allow automatically correcting error correction without resending data. Ensuring cybersecurity is an additional important element, since threats of interference with the system can cause serious consequences. It is also important to use monitoring and analytics systems to identify potential problems before they occur.

Recommendations include the implementation of a traffic prioritization system, increasing channel capacity, the use of modern data processing algorithms (using distributed database management systems (for example, PostgreSQL or MongoDB)), the use of cloud technologies to ensure resource scalability (namely, the use of hybrid solutions for processing large data streams), as well as the integration of artificial intelligence and machine learning to automate the processing of large data streams. All these measures will help ensure the reliability, speed and accuracy of information processing, which is critical for aviation safety. In addition, these measures will not only increase the efficiency of the airport's operations but also ensure its compliance with international aviation safety standards, which will increase its competitiveness in the global air transportation market.

A program has been developed to implement recommended measures to improve air traffic management and data flows at Danylo Halytskyi International Airport “Lviv” (Table 8).

**Table 8 – Program for implementing measures to improve air traffic control and data flow management at the Danylo Halytskyi International Airport "Lviv"(Source: Developed by the authors)**

| Directions | Activities | Responsible |
|---|---|---|
| Reducing of time delay in data exchange | Optimization of network equipment (upgrading switches and routers) | IT Department, Technical Department |
| | Implementation of a traffic prioritization system (QoS) | IT Department |
| | Increasing channel capacity, using reserve channels | IT Department, communication providers |
| | Automatic traffic monitoring to detect congestion | IT Department |
| Increasing data processing speed | Server hardware updates | IT department, Finance Department |
| | Software optimization (processing algorithm updates) | IT Department |
| | Transition to modern databases (distributed systems) | IT Department |
| | Cloud integration for load balancing | IT Department |
| Reducing the number of errors in data transmission | Transition to modern transmission protocols (IPv6) | IT Department |
| | Implementation of backup communication channels (satellite Internet, 5G) | IT Department, communication providers |
| | Using Forward Error Correction (FEC) Algorithms | IT Department |
| | Regular testing of communication equipment | Maintenance Department |
| Increasing the bandwidth of communication channels | Transition to fiber optic communication lines | IT Department, communication providers |
| | Using Multipath TCP | IT Department |
| | Router optimization and load balancing | IT Department |
| | Allocating separate channels for critical processes | IT Department |
| Reducing recovery time after failures | Implementation of automated diagnostic and troubleshooting systems | IT Department |
| | Duplication of critical components (servers, routers) | IT department, Finance Department |
| | Using AI to predict failures and optimize operations | IT Department |
| | Developing a detailed disaster recovery plan | IT Department, Technical Department |

In our opinion, this program will improve the speed and stability of the automated control system, which will increase the efficiency of the airport and the level of flight safety. The proposed

measures will significantly increase the efficiency of air traffic control and improve the stability of the automated control system at the Danylo Halytskyi International Airport "Lviv". The introduction of modern data transmission technologies, the reservation of critical channels, the optimization of network equipment and the use of artificial intelligence will help reduce delays, increase the speed of information processing and minimize failures. This, in turn, will positively impact the level of flight safety, the efficiency of dispatch services and the overall efficiency of the airport. Let us determine the cost of implementing the developed measures (Table 9).

**Table 9 – Costs for implementing a program to improve air traffic control and data flow management of the automated control system network at the Danylo Halytskyi International Airport "Lviv" (Source: Developed by the authors)**

| Activities | Amount of expenses, thousand UAH |
|---|---|
| Implementation of an automated network monitoring and diagnostics system | 180 |
| Modernization of network equipment (routers, switches, servers) | 220 |
| Creation and configuration of backup communication channels (satellite, 5G, fiber optic lines) | 150 |
| Software updates for network devices | 50 |
| Conducting training for personnel on actions to take in the event of communication failures | 30 |
| Regular diagnostics and system stability testing | 70 |
| Administrative costs and unforeseen expenses | 50 |
| **Total expenses** | **750** |

Therefore, the total amount of required investments is 750,000 UAH.

Table 10 shows the summary cash flow that the airport will receive as a result of improving air traffic management and data flows of the automated control system network.

**Table 10 – Consolidated statement of cash flows resulting from the implementation of measures to improve air traffic management and data flow management of the automated control system network, thousand UAH (Source: Developed by the authors)**

| Time period, years | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| **Cash balance at the beginning of the period** | **0** | ***(750)*** | ***(499,5)*** | ***(133,5)*** |
| Operating profit PxN (P=105; N=6,000; 7,000; 8,000) | | 105 x 6,000 = 630,000 | 105 x 7,000 = 735,000 | 105 x 8,000 = 840,000 |
| Fixed costs, FC | | 50,000 | 50,000 | 50,000 |
| Variable costs, VxN (V=9) | | 9 x 6,000 = 54,000 | 9 x 7,000 = 63,000 | 9 x 8,000 = 72,000 |
| **Cash flow from operating activities** | | ***526,000*** | ***622,000*** | ***718,000*** |
| Payments for asset acquisition | | - | - | - |
| Administrative costs and unforeseen expenses | | - | - | - |
| **Cash flow from investing activities** | | ***0*** | ***0*** | ***0*** |
| Loan capital | (750) | | | |
| Loan repayments | | (217) | (217) | (216) |
| Loan interest | | (58,5) | (39,0) | (19,5) |
| **Cash flow from financing activities** | | ***(275,5)*** | ***(256)*** | ***(235,5)*** |
| **Cash balance at the end of the period** | **(750)** | **(499,5)** | **(133,5)** | **349,0** |

To determine the moment when the costs of implementing measures to improve air traffic management and data flows of the automated control system network at the Danylo Halytskyi International Airport “Lviv” will be fully compensated, that is, when the investments will begin to bring economic effect, the calculation of the payback period (Payback Period, PBP) was applied. This indicator allows us to estimate the time required for the net cash flows from the implementation of the measures to fully cover the initial costs. To accurately determine this moment, Formula 1 was used.

$$PBP = II / DACI, \quad (1)$$

where $PBP$ is Payback Period; $II$ is initial investments; $DACI$ is Discounted Annual Cash Inflows.

Initial investments ($II$) are the initial costs that are necessary to implement a project or make changes. One of the methods for assessing the profitability of such costs is the $DACI$ method (Discounted Annual Cash Inflows). This approach involves analyzing the financial flows that a project or business generates annually, taking into account the time value of money. The method allows you to assess the effectiveness of the project, taking into account that money has different values at different points in time.

Discounted annual cash inflows ($DACI$) are calculated using a special formula 2, which includes the time value of money and the net income received from activities:

$$DACI_{\mathrm{t}} = CF_{\mathrm{t}} / (1 + \mathrm{k})\mathrm{t}, \quad (2)$$

where $CF_{\mathrm{t}}$ is cash flows; k is discount rate; t is certain period of time.

Cash flows ($CF_{\mathrm{t}}$) are the amounts of cash inflows received over a certain period of time t, measured in years. They include both income and expenses arising from the implementation of a project or business. Cash flows are the main source of investment efficiency analysis and allow us to assess the financial result of the project in each year.

The discount rate (k) is expressed in decimal form and is used to take into account the time value of money. Since cash flows received in the future have a lower value than today, the discount rate allows us to adjust them over time. This rate shows by what part of future income or expenses their value should be reduced to bring them to their present value. Thus, the discount rate provides a more accurate estimate of how much an investment is worth at the current moment.

Including the discount rate in the calculations makes it possible to determine the net present value (NPV) of cash flows, which reflects their total amount, taking into account future expenses and income. Net present value allows us to assess the effectiveness of investments, because if NPV is positive, it indicates that the project brings more revenue than the costs of its implementation and is profitable. Calculation of annual revenue volumes taking into account the discount rate allows for a more accurate determination of the real financial result of the project to improve air traffic management and data flows of the automated control system network at the Danylo Halytskyi International Airport “Lviv”, and facilitates planning and making informed decisions regarding further investments:

$$CF_1 = 526{,}000 \text{ UAH},$$
$$CF_2 = 622{,}000 \text{ UAH},$$
$$CF_3 = 718{,}000 \text{ UAH}.$$

The assessment of the presented cash revenues is a key stage in the analysis of the effectiveness of the project to improve air traffic management and data flows of the automated control system network at the Danylo Halytskyi International Airport “Lviv”. This process allows for the time value of money to be taken into account, which is important for the accurate calculation of the real value of future cash flows, since money that will be received in the future has a lower value due to inflation, risks, and opportunity costs. Discounting these cash flows using a discount rate allows you to bring them to their current value, which allows you to accurately assess the economic effect of the implementation of measures at the current point in time.

This approach is the basis for making informed investment decisions, as it allows you to determine whether it is worth investing in the project, taking into account the potential profit. In addition, the assessment of the presented cash flows allows you to compare possible investment alternatives, taking into account their profitability and risks, which helps to choose the most effective and profitable ways for the development of the airport:

$$DACI_1 = 526 / (1 + 0.09)^1 = 483{,}000 \text{ UAH},$$
$$DACI_2 = 622 / (1 + 0.09)^2 = 524{,}000 \text{ UAH},$$
$$DACI_3 = 718 / (1 + 0.09)^3 = 554{,}000 \text{ UAH}.$$

Based on the results of calculating the payback period for the implementation of the project to improve air traffic management and data flows of the automated control system network at the Danylo Halytskyi International Airport "Lviv", Table 11 was constructed.

**Table 11 – Calculation of the payback period of costs resulting from the implementation of the project to improve air traffic management and data flows of the automated control system network at the Danylo Halytskyi International Airport "Lviv", thousand UAH (Source: Developed by the authors)**

| Time period, years | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| Cash receipts, thousand UAH | | 483 | 524 | 554 |
| Initial investments, thousand UAH | -750 | | | |
| Coverage of the amount of expenses (investments), thousand UAH | -750 | -267 | 257 | 811 |
| Payback period, years | **x** | **x** | **1 year 6 months** | **x** |

Analysis of Table 11 allows us to conclude the effectiveness of the implementation of the project to improve air traffic management and data flows of the automated control system network at the Danylo Halytskyi International Airport “Lviv”. The initial investment of 750,000 UAH is gradually covered by the cash receipts received. In the 2nd year, costs are covered, which makes it possible to determine the payback period at 1 year and 6 months. This indicates a quick return on investment, which is a sign of high project efficiency.

Thus, the project to improve air traffic management and data flows of the automated control system network at the Danylo Halytskyi International Airport “Lviv” is effective, since it allows you to return the initial investment within a relatively short time (1 year and 6 months).

The positive dynamics of cash receipts indicate the potential of the project in terms of revenue and profit growth in the future. Therefore, investments in this project will not only cover costs but also create conditions for further financial growth of the airport. Optimization of delay time, increasing data processing speed, reducing errors in information transmission, and increasing network bandwidth will contribute to reducing risks and costs. Thanks to the improvement of the technical infrastructure, the airport will be able to improve coordination between services, increase productivity, and increase competitiveness.

## Conclusions

Effective air traffic management and data flows in the automated control system network are extremely important for ensuring the safety, reliability and efficiency of air transportation at modern airports, in particular the Danylo Halytskyi International Airport “Lviv”. The situation requires constant modernization of the infrastructure to reduce the risks associated with technical failures.

Recommendations for improving the technical infrastructure at the Danylo Halytskyi International Airport “Lviv” are proposed. Optimization of communication channels, reducing delays in data exchange and increasing system throughput have a direct impact on the efficiency and accuracy of air traffic management, as well as on the efficiency of airport operations. All the proposed recommendations contribute to improving the quality of service, increasing flight safety and overall efficiency of operations.

The program to improve air traffic control and data flows of the automated control system network of the Danylo Halytskyi International Airport "Lviv" is proposed. The main measures envisaged by the program include the implementation of an automated monitoring system, modernization of network equipment, creation of backup communication channels and software updates for network devices. The estimated costs for these measures are 750,000 UAH.

The implementation of the program will significantly improve key airport performance indicators, such as reducing the delay time in data exchange, increasing the speed of data processing, reducing the number of errors in data transmission and increasing the bandwidth of communication channels. As a result of the measures taken to modernize the flight control system, the Danylo Halytskyi International Airport "Lviv" should ensure reliable and safe operation of air traffic, which allows for the rapid restoration of air transportation after significant obstacles, such as the temporary suspension of flights due to the military aggression of the Russian Federation.

To assess the effectiveness of the program, a consolidated cash flow statement was calculated, which shows positive profitability dynamics already 3 years after implementation. In addition, by calculating the Payback period, it was determined that the investments will begin to have an economic effect in 1 year and 6 months. As a result of the implementation of this program, the airport will not only improve its technical infrastructure, but also ensure increased competitiveness, reduced costs and increased flight safety. This will contribute to increasing the competitiveness of the airport and its compliance with international safety standards.

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