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The Integration Chosen of Innovative Technologies Focusing on Adoption of Space Technologies and Management Digital Systems in Aviation Security

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Abstract:

Purpose: *This research aims to conduct an analysis and assessment of an industrial enterprise of air transport, which is playing a significant role in supply chain cargo e.g. transport dangerous goods like medical supplies etc.*
Design/Methodology/Approach: *This research focuses on the analysis of the new technologies used in aviation security processes which is supported by safety engineering for the operational techniques and technologies in space. Moreover, this development of air transport is dedicated to logistics supply chain supported by space technologies. The new achievements in aviation technologies is quite important for space technology as these achievements directly affect the range of air transportation. The development of air transport is remarkable especially when there are improvements in the space technologies undergoing. As the improvement of space technologies requires ensuring of the wide-ranging continuous information for assuring of safety and security of people and businesses when terrestrial network connections are disrupted. The article investigates the integration of innovative technologies in aviation logistics, focusing particularly on enhancing security processes through the adoption of space technologies and management digital systems. The study utilizes a chosen of research methodologies, including SWOT analysis, expert interviews, and statistical inference to address the central research question concerning the impact of technological advancements on aviation security. The analysis, synthesis, comparison, search of normative acts and literature review on the subject, abstraction, and inference methodologies were used to solve the main research question.*
Findings: *The rapid progress of information systems plays a crucial role in logistics and supply chain management. These processes are aimed at improving enterprise competitiveness what is one of the main goals of company functioning in the market economy. New technologies, or rather management digital ecosystems, have the ability to compile data from dispersed, often global, sources and so forth they support managerial processes.*

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Practical Implications: *The article attempted to cover an expansive subject area, interlinking space technologies with logistics security. The linkage between space technologies and their direct impact on aviation logistics security processes is attempt adequately explored and substantiated.*
Originality/Value: *A key factor influencing future logistic solutions will be the implementation of modern, often innovative, technical and technological solutions from various areas of economic activity.*
The wide spectrum of current, as well as continuously evolving, modern technologies, computer systems, communication systems, and intelligent solutions in the field of robotics and automation has laid the foundation for creating and developing modern logistic systems.

Keywords: *Safety engineering, space, management, safety, security, innovation.*

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1. Introduction

New technologies increasingly directly and indirectly impact logistics within logistical processes, thereby implying its continuous evolution and presenting new challenges. The Fourth Industrial Revolution and the resulting development of management digital systems blurring the boundaries between the sphere of real processes and the sphere of management digital processes which becomes a reality in every aspect of socio-economic life.

Management of digital technology ecosystems continually develop new operating environments and dictate new rules of competition (Reddy *et al*., 2021). As a result, new business models emerge, new relationships and alliances are formed cooperative networks are established.

In view of the above, discussing the innovative technologies influencing the aviation-technical security process is very important (Rodrigue, Comtois, and Slack, 2013). To achieve this goal, the focus is on the aviation-technical security process of aviation operations and the information technologies applied in an aviation unit. Additionally, for the sake of clarity, the military supply chain was specified using relevant literature enterprise examples.

The achievement of this goal was accomplished by identifying the main problem using relevant literature.

The authors adopted the following hypothesis: the participation of space technologies in efficiency of air transport depends on space technologies security. Mainly the security of Deep Space Network and Navigation Systems can support safe air transport.

The main research problem is presented in the form of a question:

- What are the development trends in the technological environment and what is their impact on the aviation and technical safety process?

To answer the main research question, the following detailed research questions were additionally specified:

- Which metrics most accurately determine reliability in the aviation-technical security process of aviation operations and how do they impact safety?
- How do industrial revolutions influence the development of the technological environment in logistics?

Considering the main research problem, the following research hypothesis is proposed: "The continuous development of the global technological environment has led to the dynamic implementation of innovative technologies in aviation-technical security".

To resolve specific research problems and confirm the hypothesis, the following research methods were used:

- Analysis, synthesis, and abstraction of scientific literature,
- SWOT analysis,
- Expert interviews,
- Statistical inference,
- Pareto-Lorenz analysis,
- Indicator method.

The research methodologies employed e.g., SWOT and Pareto-Lorenz analysis, expert interviews are presented with adequate detail on their execution. For example, the selection criteria for expert interviewed:

– practiced and experienced no less than 15 years as manager of management digital systems in space or aviation logistics security,

and design of interview questions are disclosed which concerns about reliability and validity of the findings in following aspects:

- how prepare o good plan and innovation technologies to implement for safety and security of supply logistics management?
- how prepare a good numbers of team's project for new challenges?
- how to be perfect in safety and security of aviation logistics operations?
- how avoid mistakes during adoption of space technologies?

Furthermore, the use of SWOT and Pareto-Lorenz analysis are generally considered a basic qualitative tools and might be sufficient, that is why also use of the indicator method provides the depth of analysis for such a complex science topic. What the more, abstraction of scientific literature largely relies a critical examination of the findings.

It appears to accept research outcomes at face value with addressing alternative scientific data information. Moreover, the implications of the findings for practical application in aviation logistics are convincingly argued leaving the real-word applicability of the research. Theoretical analysis and primary empirical data are strengthened the arguments and supported the hypothesis.

2. Literature Review

At a time when advanced tools are being deployed, there is a definite progression of technological advances that is affecting all sectors of the economy, including the aviation supply logistics management. Management digital systems in aviation around the world are competing in the introduction of new equipment and solutions in the security fields of digital processes.

Satellite navigation systems are undoubtedly an integral part in the process of securing logistics operations. The evolution of this technology became the premise for the purpose of the work, which is to present the application of technology - Global Navigation Satellite System (GNSS) in the process of positioning logistics assets (Pervan, 2017).

The rapid digital progress of information systems plays a significant role in logistics and supply chain management (Ayers, 2002). These processes are aimed at improving enterprise competitiveness and the direct use of innovative technologies can contribute to achieving such goals.

New technologies, or rather management digital ecosystems, have the ability to compile data from dispersed, often global, sources (Jafari *et al.,* 2022). Consequently, it is challenging to find better resources that allow for dynamic responses to environmental changes while simultaneously improving the efficiency of flows.

The positioning of logistics assets by the Global Navigation Satellite System, affects the security of logistics operations through the ability to monitor and track assets.

Moreover, the use of this system improves efficiency and accuracy of logistics operations and enables the provision of accurate digital information on the location by using of availability of resources. The positioning of logistics assets using GNSS allows the rapid detection of possible avoid problems to steal logistics assets (Crandell, 2021).

In addition, the risks of the application of the GNSS and its development trends capable of affecting the security of logistics operations are presented (Baijal, R. 2009). Based on Pareto-Lorenz analysis diagram of the quality of the transmitted signal by the GNSS transmitter, which affects the decision-making process in the aviation logistics supply chain management, dependencies and factors affecting the system are shown too.

3. Study of the Aviation-Technical Security Process Using the Example from Aviation

Aviation-Technical Security Process (ATSP) is significant in the aircraft operations and maintenance process, responsible for supplying the system in terms of usage and maintaining readiness with material and technical resources.

In military aviation, ATSP is responsible for supplying aircraft with fuel, oils, hydraulic fluids, technical gases, weapons, as well as spare parts and other consumables. To verify the functioning of the aviation-technical security process, the research will be conducted using the example of an aviation unit, which has the following main tasks:

- passenger air transport,
- periodic maintenance and servicing of aircrafts and ground equipment,
- maintenance of airport infrastructure and ensuring readiness for operation,
- execution of military complexes protective tasks and foreign delegations' visits securing the unit possesses helicopters for general-purpose air transport, long-range passenger aircraft and small business jet aircraft with ultra-long-range capabilities. For the purpose of this research, the technical security process of aircraft will be examined, focusing on the more developed servicing process.

In aviation-technical security, the supply process of spare parts and aviation products plays a significant role, encompassing not only their storage but also the execution of maintenance services. Storage conditions, quality and timeliness of performing these services affect the technical condition of stored goods and materials. In the examined aviation unit, modern information systems are widely used in the supply process.

They are very helpful not only in recording and continuously monitoring inventory levels or controlling the deadlines for required maintenance work but also in forecasting future needs. Often, the period of aircraft unsuitability depends on the time of delivery of parts subject to replacement. Therefore, efforts should be made to minimize this time. For this reason, the organizational structure and location of the warehouse network should ensure its efficient utilization, and the ordering and issuing procedures for necessary parts should be as simple as possible and free from unnecessary bureaucrat.

After a brief presentation of the operation process and its logistic security for aviation equipment in the examined aviation unit, an assessment of the entire aviation-technical security process will be conducted. To evaluate the aviation-technical security process, SWOT analysis will be used (Woźniak and Sołtysik, 2012).

Before starting the analysis, the collected data should be divided into these four groups, where the first two relate to the company, and the next two pertain to its environment.

From the presented characteristics of the aviation unit, it is evident that the group of strong features contains thirteen factors. Meanwhile, the second group contains fourteen factors and is the more numerous.

Both opportunities and threats, defining external factors for the examined unit, include seven factors each. After isolating these features, it can be stated that the level of aviation-technical security in the studied company is at a moderate level.

To clearly illustrate the above-mentioned features and thoroughly examine the aviation-technical security process, the authors present in Table 1 an analysis using quantitative assessment and calculates the weighted average for the strong and weak features of analyzed aviation unit.

Table 1. *SWOT Analysis for the Strong and Weak Points of aviation unit (self-development)*

Strengths of the Company	**Weight**	**Rating (1-5)**	**Weaknesses of the Company**	**Weight**	**Rating (1-5)**
Modern aircraft equipment	0,10	5	Inefficient use of warehouse space	0,08	3
Own main warehouse	0,10	4	Main warehouse in multiple locations	0,06	3
Individual warehouses in aviation engineering service	0,10	5	Legal restrictions in tenders	0,06	2
Large inventory of spare parts	0,10	4	Incidents related to damaged goods	0,07	3

Strengths of the Company	**Weight**	**Rating (1-5)**	**Weaknesses of the Company**	**Weight**	**Rating (1-5)**
Experienced staff	0,04	4	Incomplete workforce	0,06	4
Low employee turnover	0,03	3	Incompatible procedures for collaboration with foreign entities	0,08	3
Continuous employee training	0,05	4	Difficult collaboration with foreign aircraft manufacturers	0,06	3
Use of modern IT systems	0,10	5	Financial constraints	0,07	4
Appropriate organizational structure	0,05	3	Difficulty in planning future needs	0,08	3
High reliability of aircraft equipment	0,07	4	Limited hangar infrastructure	0,06	3
Implementation of new technological solutions in warehouses	0,09	4	Limited working hours of the main warehouse	0,09	3
Advanced diagnostic systems and programs for aircraft equipment	0,10	4	Limited resources of individual SIL warehouses	0,09	4
Collaboration with international companies	0,07	4	Long waiting times for foreign orders - "bottlenecks" at customs	0,08	3
			Outdated and complicated procedures	0,06	4
	Total	**Strengths Rating**		**Total**	**Weaknesses Rating**
	1	4,07		1	3,21

Source: *Own elaboration.*

Below in Table 2, an analysis and quantitative assessment are presented. Additionally, the weighted average of the remaining two groups, namely opportunities and threats, is calculated.

Table 2. *SWOT Analysis for opportunities and threats of aviation unit*

Opportunities	**Weight**	**Rating (1-5)**	**Threats**	**Weight**	**Rating (1-5)**
Collaboration with other logistics companies	0,12	3	Increase in prices of aviation parts	0,16	3
Technological development	0,16	4	High costs of service agreements with foreign entities	0,21	4
Location	0,15	4	Requirement for the use of new costly technologies	0,15	3
Broad logistic support from foreign entities	0,12	4	Inflation	0,13	3
Service agreements with manufacturers of specific aircraft	0,20	4	End of warranty period on new aircraft	0,15	3
Acquisition of new experience by employees	0,10	5	Competitive salaries in the civilian market	0,10	3
Modernization and improvement of operational procedures	0,15	4	Dependence on state policies	0,10	3
	Total	**Opportunities Rating**		**Total**	**Threats Rating**
	1	4,00		1	3,14

Source: *Own elaboration.*

The next step in the SWOT analysis is to develop a set of possible actions and calculate the point on the coordinate axis containing four types of strategies (Woźniak and Sołtysik, 2012):

- aggressive - maxi-maxi (predominance of strengths and opportunities),
- competitive - mini-maxi (predominance of weaknesses and opportunities),
- conservative- maxi-mini (predominance of strengths and threats),
- defensive- mini-mini (predominance of weaknesses and threats).

To calculate the coordinate values "x" and "y" the formulas (1) and (2) will be used.

$$X = (Sum\ of\ rating\ for\ strengths) - (Sum\ of\ ratings\ for\ weakness), \quad (1)$$

$$y = (Sum\ of\ rating\ for\ opportunities) - (Sum\ of\ ratings\ for\ threats), \quad (2)$$

Using the obtained analysis results and substituting them into the above formulas, we get the following calculations:

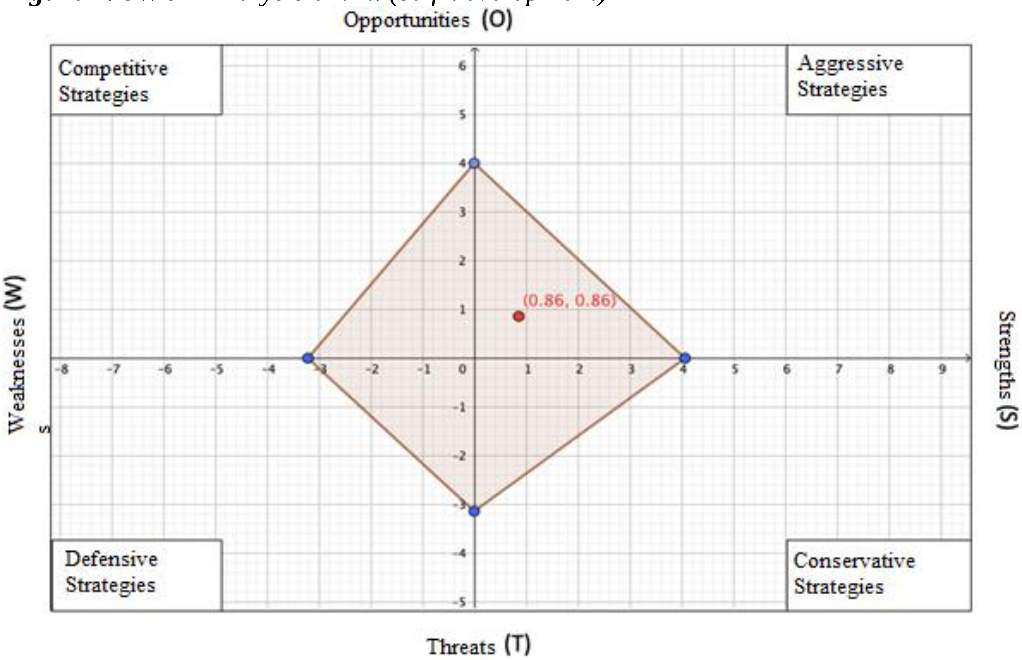
$$X = 4.07 - 3.21 = 0.86$$
$$Y = 4.00 - 3.14 = 0.86$$

The coordinate values of ''x'' and ''y'' are the same. The strategy that the examined aviation unit should choose can be determined by analyzing the coordinate system, as presented in Figure 1.

As seen on the above-presented chart, the red dot reflecting the SWOT analysis result falls within the first quadrant of the coordinate system. This means that the examined aviation unit should apply an aggressive strategy in its actions, which is based on maximizing its strengths and opportunities. Furthermore, such result of the analysis also indicates that the given enterprise operates in a stable environment. Summarizing the collected results of the SWOT analysis, one can conclude that the level of security in the aviation-technical aspect of aircraft is at a good level.

Factors included in the threats or weaknesses group are mainly related to the emergence of technologically advanced aviation equipment and various circumstances dependent on the complex handling of aircraft, including bureaucracy, with the examined aviation unit must cope.

Figure 1. *SWOT Analysis chart. (self-development)*



Source: *Own elaboration.*

4. Discussion - Evaluation of the Aviation-Technical Security Process of the Aviation Unit

From the perspective of aviation-technical security, the process of storing aviation products and their preservation plays a significant role in the logistical supply chain.

Storage conditions, the quality and timeliness of performing the mentioned services impact the technical condition of stored products and materials, which consequently affects the subsequent usability level of operated aircraft. It is essential that the assortment of these stocks be rationally adjusted to current needs and regularly replenished.

Computer support systems are tools that can support rational planning of spare parts purchases, monitoring warehouse stock levels, and supervising maintenance activities of stored components that require periodic activities. User access enables multi-level information delivery, which supports the organization of the entire enterprise. Enterprise Resource Planning (ERP) software is such a support system.

For users involved in the broadly understood operation of aircraft, including personnel performing aircraft maintenance, planning purchases, creating orders, etc., a particularly useful tool is the specialized warehouse software Warehouse Management System (WMS) (Warehouse Program, 2018). Faced with material needs involving thousands of components with varying time limits and maintenance intervals, such tools and Electronic Data Interchange (EDI) systems, as well as Radio-Frequency Identification (RFID) technology, become a necessity.

The fundamental indicators of the reliability of the aviation-technical security process include:

- Labor performance indicator,
- Warehouse worker intensity indicator,
- Picking efficiency indicator,
- Picking accuracy indicator,
- Readiness indicator,
- Average daily issue indicator.

The labor performance indicator, presented in the formula (3) below, is calculated by dividing the warehouse turnover, which is the sum of receipts and issues, by the average number of workers employed in the warehouse.

$$\text{Work efficiency} = \frac{Inventory\ Turnover}{Averrage\ Number\ of\ Employed\ in\ the\ Warehouse}\left[\frac{volume}{worker}\right], \qquad (3)$$

The measure of warehouse worker productivity, presented in formula (4), is calculated by dividing the inventory turnover by the number of hours worked by warehouse employees.

$$\text{Warehouse Work Intensity} = \frac{Inventory\ Turnover}{Number\ of\ Hours\ Worked\ in\ the\ Warehouse}\ \left[\frac{Kg}{man-hourker}\right], \quad (4)$$

The picking performance indicator shown in formula (5) is calculated by dividing the number of items picked by the product of the number of workers and the standard working time.

$$\text{Picking Efficiency} = \frac{Number\ of\ Items\ Picked}{Number\ of\ Workers\ x\ Standard\ Working\ Time}\ \left[\frac{position}{man-hourker}\right], \quad (5)$$

The accuracy of picking indicator presented in formula (6) is the ratio of the number of correctly picked items to the total number of picked items; this ratio is multiplied by 100%.

$$\text{Picking Accuracy} = \frac{Number\ of\ items\ Picked\ Correctly}{NTotal\ Number\ of\ Picked\ Items} * 100\ [100\%], \quad (6)$$

The indicator of average daily receipts, presented in formula (7), is the result of dividing the sum of receipts by the number of days within the specified period.

$$\text{Readiness of a Given Tech} = \frac{Number\ of\ completed\ Tasks\ in\ the\ Appropriate\ Time}{Total\ Number\ of\ Completed\ Tasks} * 100[\%] \quad (7)$$

The indicator of average daily expenditure, presented in formula (8), is the quotient of the sum of expenditures divided by the number of days in the examined period.

$$\text{Average Daily Expenditure} = \frac{Ntotal\ Expenditure}{Number\ of\ Days\ in\ the\ Examined\ Period} * 100[\%] \quad (8)$$

Key indicators of the reliability of an economic system include:

- Inventory coverage ratio,
- Turnover ratio,
- Timeliness ratio,
- Accuracy in documentation ratio,
- Supplier reliability ratio,
- Integrity ratio,
- Damage-free and error-free delivery ratio.

The inventory coverage ratio, presented in formula (9), is the result of dividing the average inventory by the average daily demand over the examined period, with both quantities expressed in the same units.

$$\text{Coverage Ratio} = \frac{average\ Inventory}{Average\ Daily\ Demand\ during\ the\ Measured\ Period}[day] \qquad (9)$$

The turnover ratio (10) has the same components as the inventory coverage ratio, but its result is expressed in a different unit.

$$\text{Turnover Ratio} = \frac{Demand\ during\ the\ Measured\ Period}{Average\ Inventory} \qquad (10)$$

The timeliness ratio given in formula (11) is an indicator used to calculate orders fulfilled on time.

$$\text{Timeliness} = \frac{Orders\ Fulfilled\ on\ Time}{All\ Accepted\ Orders} * 100[\%] \qquad (11)$$

The documentation accuracy ratio in formula (12) is used to calculate the quantity of correctly issued documents in the enterprise.

$$\text{Document Accuracy} = \frac{Correctly\ Issued\ Documents}{All\ Issued\ Documents} * 100[\%] \qquad (12)$$

The indicator of damage-free and error-free deliveries, presented in formula (13), is used to calculate the number of fulfilled orders that were executed without any errors.

$$\text{Damage free and Error Free Delivery} = \frac{Orders\ Fulfilled\ without\ Errors}{All\ Received\ Orders} * 100[\%] \qquad (13)$$

The integrity indicators (14) are the ratio of the number of tasks correctly executed using a specific technology to the total number of tasks executed using that technology.

$$\text{Integrity} = \frac{Number\ of\ Tasks\ Executed\ Correctly}{All\ Completed\ Tasks} * 100[\%] \qquad (14)$$

The delivery reliability indicator, presented in formula (15), is an indicator used to calculate the share of deliveries that were delivered on time and were in accordance with the order. Every company aims for this indicator to be close to 100%, but it is practically impossible due to frequent random situations in external companies that cause delays in deliveries.

$$\text{Delivery Reliability} = \frac{\text{Number of Deliveries in Compliance with Parameters}}{\text{Total Number of Deliveries}} * 100[\%] \quad (15)$$

The significance of implementing technologies supporting the reliability of the aviation-technical security process for operated aircraft in the examined aviation unit was determined based on information obtained through expert interviews. Table 3 contains the respondents' answers compiled with the included average rating expressed as a percentage and readiness indicated using the readiness indicator presented in formula (8).

Table 3. *Readiness of Examined Technologies (Self-development)*

Technology	Average Respondent Rating [%]	Readiness Indicator [%]
Barcode	81	90
RFID Technology	90	92
Information System	88	94
Electronic Security Systems	91	78
Mobile Racks	85	88

Source: *Own elaboration.*

In Table 3, similar to Table 4, respondents' answers are presented with the calculated average rating, as well as integrity expressed using the integrity indicator presented in the first subsection in formula (15).

Table 4. *Readiness of Examined Technologies (Self-development)*

Technology	Average Respondent Rating [%]	Integrity Indicator [%]
Barcode	94	95
RFID Technology	94	97
Information System	97	98
Electronic Security Systems	87	91
Mobile Racks	86	85

Source: *Own elaboration.*

Based on the conducted study, it can be inferred that the respondents' answers, regarding the readiness and integrity of the examined technologies, have divergent values. Among the mentioned technologies, the highest readiness coefficient was obtained by the information system, with a readiness indicator of 94%. Similarly, in terms of the integrity coefficient, the information system also had the highest indicator, reaching 98%. Based on this data, it can be concluded that among the examined technologies, the information system is the most reliable.

The next stage of the study, important in the assessment of the aviation technical security process, is to conduct a Pareto-Lorenz analysis (MFiles, 2024), determining at which stage of storing material the most problems in the functioning of this process occur.

The analysis covered problems with storing materials in the examined aviation unit main warehouse.

The following components can be distinguished:

- incorrect placement of devices in the storage zone,
- materials damage during storage,
- improper handling of the information system,
- improper recording of materials,
- incorrectly assigned Uniform Material Index,
- staff shortages,
- other.

Based on the above-mentioned discrepancies, a checklist in the form of statistical data was presented in Table 5.

Table 5. *Number of occurrences of non-compliance during the storage of materials in the surveyed company (Self-development)*

Type of Discrepancy	**Number of Occurrences in the Examined Quarter**	**Share [%]**
Incorrect Placement of Devices in the Storage Zone	74	39
Goods Damage During Storage	5	3
Incorrectly Assigned Uniform Material Index	13	7
Improper Recording of Aggregates	15	8
Improper Handling of the Information System	45	24
Staff Shortages	34	18
Other	5	3
Total Number of Occurrences	191	100

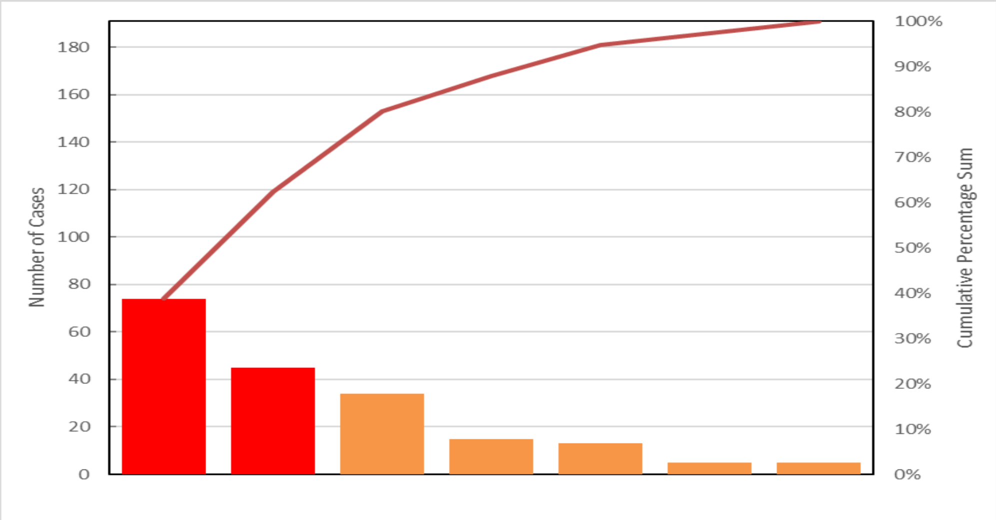
Source: *Own elaboration.*

The next stage in the analysis is to create a Pareto-Lorenz chart, which graphically illustrates the frequency of specific discrepancy occurrence. The curve of the chart is presented from the component that occurred most frequently to the one that appeared least in the examined period (Figure 2).

The most significant advantages of using the Pareto-Lorenz diagram include:

- Effectively resolving occurring discrepancies by prioritizing them according to the most significant causes,
- Quickly determining priorities that are essential and should be focused on to eliminate existing problems,
- Enabling the proper concentration of resources on eliminating one cause to avoid dispersing efforts across all causes simultaneously,
- Simplifying communication and, most importantly, presenting in a simple, graphical manner where efforts should be concentrated.

Figure 2. *Pareto-Lorenza Analysis (Self-development)*



Source: *Own elaboration.*

In the above-presented Pareto-Lorenz analysis chart, it can be observed that the main issues in the examined aviation unit are incorrect placement of materials and improper handling of the information system in the process of receiving into the warehouse.

These issues account for approximately 80% of all identified cases. The remaining inconveniences may arise from the remaining 20% of cases, such as staff shortages, improper recording of materials, incorrectly assigned uniform material index by the supply service personnel, any damages during storage and other unspecified causes.

Assessing the results of the conducted analysis, it can be concluded that errors in the storage process may have a negative impact on the functioning of the entire supply chain. Deliveries in the aviation-technical security of operated aircraft directly impact the safety of the system and the maintenance of continuous flight readiness.

The use of modern time-oriented strategies, such as Just in Time (JiT), Quick Response (QR), or Efficient Consumer Response (ECR), require smooth operation of supply chains. The use of logistics support systems is necessary to maintain the appropriate number of spare parts in warehouses. Properly functioning organizational, supervisory, forwarding and financial activities, supported by electronic support systems, enable the implementation and effective functioning of cost-effective maintenance strategies (Christopher and Peck, 2005).

5. Conclusions

The article attempted to cover an expansive subject area, interlinking space technologies with logistics security. That is why the theoretical foundation appears must be sufficiently robust to support the broad conclusions draw. The linkage between space technologies and their direct impact on aviation logistics security processes is attempt adequately explored and substantiated.

The aim of the publication was to discuss innovative technologies influencing the aviation-technical security process.

The research problem was formulated in the form of a question: What conditions made the space technologies an efficiency for air transport in security aspect?

To resolve specific research problems and confirm the hypothesis, the authors used a compensation of quantitative and qualitative analysis, moreover, SWOT and Pareto-Lorenz analysis were used. The authors' hypothesis was confirmed. It is confirmed that introducing modern secure information technologies into logistics is not just a trend but an urgent necessity.

The authors' aim that the results obtained from the conducted research and the presented considerations will constitute a starting point for further scientific research on the discussed subject.

The research problem has also been methodically addressed. Deliberations in solving the research problem related to the trends in the development of the technological environment for logistics have led to the formulation of the following conclusions:

• Research conducted among respondents regarding the integrity and readiness of the examined technologies showed that the highest readiness coefficient was obtained by the information system, with a readiness indicator of 94%. Similarly, in terms of the integrity coefficient, the information system also had the highest indicator, reaching 98%. Based on this data, it can be concluded that among the examined technologies, the information system is the most reliable. On the other hand, among the least reliable technologies are electronic security systems, with a readiness indicator of 78%. As for the integrity coefficient, mobile racks had the lowest indicator at 85%.

• Innovative technologies that have had the most impact on the development of the technological environment in logistics include ERP/SAP-type (All for One, 2024) information systems along with WMS for warehouse management, Electronic Data Interchange (EDI) systems, and RFID technology.

• The implementation of innovative solutions increasingly allows the adoption of time-oriented strategies such as Just in Time (JiT), Quick Response (QR), and Efficient Consumer Response (ECR). A wide spectrum of current, as well as continuously evolving modern technologies and intelligent solutions in the field of robotics and automation (Rada, 2020), has laid the foundation for the creation and development of modern logistic systems, particularly in the context of the Internet of Things (IoT).

A key factor influencing future logistic solutions will be the implementation of modern, often innovative, technical and technological solutions from various areas of economic activity. The wide spectrum of current, as well as continuously evolving, modern technologies, computer systems, communication systems, and intelligent solutions in the field of robotics and automation has laid the foundation for creating and developing modern logistic systems.

References:

All for One. 2024. Available at: https://www.all-for-one.pl/.

Ayers, J.B. 2002. Making Supply Chain Management Work: Design, Implementation, Partnership, Technology, and Profits. Boca Raton, FL: CRC Press.

Baijal, R. 2009. GPS: A military perspective, by Geospatial World, Department of Civil.

Christopher, M., Peck, H. 2005. Marketing Logistics. Warsaw, PWE.

Crandell, M. 2021. Examining the impact of Logistics on military strength. AFIT scholar.

Jafari, N., Azarian, M., Yu, H. 2022. Moving from Industry 4.0 to Industry 5.0: What Are the Implications for Smart Logistics? Logistics, 6(2), 26. Available at: https://www.mdpi.com/2305-6290/6/2/26.

MFiles. 2024. Pareto Diagram. Retrieved: https://mfiles.pl/pl/index.php/Diagram_Pareto.

Pervan, 2017. Military GNSS Applications: From GPS to Galileo and Beyond, Springer.

Rada, M. 2020. Industry 5.0 definition. Available at: https://michael-rada.medium.com/industry-5-0-definition-6a2f9922dc48.

Reddy, P.K., Pham, V.Q., Prabadevi, B., Deepa, N. 2021. Industry 5.0: A Survey on Enabling Technologies and Potential Applications. Available at: https://www.researchgate.net/publication/353555332_Industry_50_A_Survey_on_Enabling_Technologies_and_Potential_Applications.

RFID Polska. 2024. RFID Technology - What is it? Available at: https://www.rfidpolska.pl/technologia-rfid-co-to-jest/.

Rodrigue, J.P., Comtois, C., Slack, B. 2013. The Geography of Transport Systems. New York, Routledge.

Warehouse Program. 2018. Mobile Terminals in the Warehouse. Available at: https://www.programmagazyn.pl/terminale-mobilne-w-magazynie/.

Woźniak, K., Sołtysik, M. 2012. SWOT Analysis. Available at: https://mfiles.pl/pl/index.php/Analiza_SWOT.