

COMPETENCY DEVELOPMENT OF MILITARY AIRCRAFT MAINTENANCE PERSONNEL: TRAINING PHASES AND EFFECTIVENESS EVALUATION

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Abstract

In the aviation sector, which inherently involves a high level of risk, it is essential to implement a training system that is properly adapted to the specific requirements of personnel. A fundamental prerequisite for effective educational activities is the creation of favorable conditions for professional development. This issue represents a key factor in ensuring aviation safety. The present article focuses on analyzing the various stages of the training process for aircraft maintenance personnel.

Effective preparation and implementation of training involves several successive stages, each of which is based on insights and outcomes derived from the previous one. The broad thematic scope of the subject matter makes the process time-consuming and demanding in terms of organizational resources.

One of the main challenges that arises after training is the practical application of newly acquired knowledge and skills in day-to-day tasks. In the absence of adequate support from supervisors or the organization, trainees may struggle to integrate new work methods, which often results in a return to previously established habits.

Keywords: stages, training process, aircraft maintenance personnel, flight safety

ROZWÓJ KOMPETENCJI PERSONELU TECHNICZNEGO OBSŁUGUJĄCEGO WOJSKOWE STATKI POWIETRZNE: FAZY SZKOLENIA I OCENA EFEKTYWNOŚCI

Streszczenie

W sektorze lotnictwa, który z natury wiąże się z wysokim poziomem ryzyka, kluczowe jest wdrożenie systemu szkoleniowego odpowiednio dostosowanego do specyficznych wymagań personelu. Podstawowym warunkiem skutecznej działalności edukacyjnej jest stworzenie sprzyjających warunków do rozwoju zawodowego. Kwestia ta stanowi jeden z kluczowych czynników zapewniających bezpieczeństwo lotnicze. Niniejszy artykuł koncentruje się na analizie poszczególnych etapów procesu szkolenia personelu Służby Inżynierijno-Lotniczej (SIL).

Efektywne przygotowanie i realizacja szkolenia obejmuje kilka następujących po sobie etapów, z których każdy opiera się na wnioskach i wynikach uzyskanych na etapie poprzednim. Szeroki zakres tematyczny zagadnień sprawia, że proces ten jest czasochłonny i wymaga dużych nakładów organizacyjnych.

Jednym z głównych wyzwań pojawiających się po zakończeniu szkolenia jest praktyczne zastosowanie nowo zdobytej wiedzy i umiejętności w codziennych obowiązkach. W przypadku braku odpowiedniego wsparcia ze strony przełożonych lub instytucji, uczestnicy szkoleń mogą mieć trudności z wdrażaniem nowych metod pracy, co często prowadzi do powrotu do wcześniej utrwalonych nawyków.

Słowa kluczowe: etapy, proces szkolenia, personel służby inżynierijno-lotniczej, bezpieczeństwo lotów

1. Introduction

Establishing a supportive environment for personnel development serves as a foundational element within the broader context of training activities. According to widely accepted definitions, training is understood as a continuous process aimed at improving skills and acquiring new competencies, with the overarching goal of enhancing employee effectiveness, performance, and engagement in professional duties.

This article adopts an exploratory perspective and falls within the scope of security studies, incorporating aspects of technical sciences. Its primary objective is to examine the stages of the training process for aircraft maintenance personnel. To that end, the study focuses on selected methodological components, with the training of maintenance personnel constituting the core subject of investigation. The main research methods applied include a literature review, diagnostic survey, and generalization of findings. The source material consists of both monographs and scholarly articles.

The structure of the paper is divided into three interconnected sections. The first addresses organizational training processes by outlining general stages. The second details the specific sequence of aircraft maintenance personnel training. The third presents the outcomes of survey-based research conducted among aircraft maintenance staff. The study is supplemented with relevant tables and graphs to enhance clarity. Acknowledging the complexity of the topic, this work is intended as a contribution to further academic discussion. The author believes the paper will be of interest to aircraft maintenance professionals and enthusiasts in Poland.

2. Stages of training in an organization

The effective implementation of training programs requires a structured approach consisting of several stages, each building upon the insights gained in the previous one. Adhering to recognized standards and current knowledge is essential to ensure training effectiveness. In larger organizations, the training process is typically overseen by dedicated human resources departments. In smaller entities, however, training responsibilities often fall to the owner or direct supervisor. This poses potential risks, as these individuals may lack the expertise necessary to properly design, execute, or coordinate training initiatives. Insufficient knowledge in this area can result in poorly tailored training that fails to meet either individual or organizational needs and may rely on suboptimal methods that limit skill acquisition¹.

Designing and executing a successful training program involves several core activities: identifying training needs, defining objectives and content, selecting participants, developing an appropriate schedule, choosing suitable training locations, and appointing qualified instructors. These components must be cohesively managed to ensure the training's effectiveness and to facilitate meaningful evaluation². The training process can generally be broken down into four critical phases:

- identification of training needs,
- development of the training plan,
- execution of training sessions,
- evaluation of training outcomes³.

These stages occur in an environment conducive to learning, where training initiatives aim to meet both current and future needs of the organization and its employees. Figure 1 highlights the key interdependencies and contextual factors affecting this process, such as leadership culture, organizational values, management style, and structural configuration.

An enabling environment fosters interpersonal relationships based on trust, which helps avoid the pitfalls of overly rigid systems that can create bureaucratic, organizational, or communication barriers.

¹ U. Pauli, *Rola szkoleń pracowników w rozwoju małych i średnich przedsiębiorstw*, Uniwersytet Ekonomiczny, Kraków 2014, p. 132–136.

² D.L. Kirkpatrick, *Cztery poziomy oceny efektywności szkoleń*, Studio Emka, translation J. Teodorowicz, Warszawa 2001, p. 21–22.

³ A. Poczowski, *Zarządzanie zasobami ludzkimi*, PWE, Warszawa 2007, p. 284.



Fig. 1. Stages and cultural context of the training process

Source: U. Pauli, *Rola szkoleń pracowników...*, op. cit., p. 132–136.

The next step in the process involves a thorough assessment of current and strategic development requirements. This requires not only organizational analysis but also attention to employee expectations and aspirations, which help promote individual self-actualization. Training needs identification can occur at three levels: Organizational: recognizing gaps in competencies essential to achieving strategic goals. Team: analyzing needs among groups performing similar roles or within specific units. Individual: assessing how well an employee's current skills align with their role and career progression⁴. This process seeks to answer critical questions:

- In which areas should skills be improved?
- Who should participate in the training?
- What areas require priority in planned training efforts?
- What outcomes are expected by both the organization and the employees.

To address these questions effectively, data must be gathered from a variety of sources, including job descriptions, performance reviews, and qualification standards. Additional methods such as observations, surveys, and competency tests may also be employed⁵.

Following the assessment of training needs and the analysis of collected data, the next critical step involves the development of a comprehensive training plan. At this stage, it is essential to clearly define the learning objectives, which should be articulated as measurable and expected outcomes. Based on the specific competencies targeted for development, appropriate training methods must be selected and tailored to ensure optimal results⁶.

Individuals responsible for designing training programs should be capable of evaluating developmental areas from a broader strategic perspective. They must also recognize and differentiate between various instructional approaches, ensuring that the selected strategies align with the overarching goals of the organization and effectively support its long-term vision⁷.

In addition to selecting appropriate development methods, this stage of the training process should also include the following key elements:

- Clearly identifying the target group of participants – specifying who should take part in the training based on organizational needs and individual roles.

⁴ T. Boydell, M. Leary, *Identyfikacja potrzeb szkoleniowych*, translation L. Wójcik, Wolters Kluwer Polska, Kraków 2006, p. 23.

⁵ A. Andrzejczak, *Projektowanie i realizacja szkoleń*, PWE, Warszawa 2010, p. 99.

⁶ Ibidem.

⁷ U. Pauli, *Rola szkoleń pracowników...*, op. cit., p. 132–136.

- Analyzing potential influencing factors – recognizing internal and external conditions that may positively or negatively affect the effectiveness of the training.
- Determining the training budget – allocating financial resources necessary for the planning and execution of the program.
- Setting the location and scheduling the timeframe – choosing the most suitable venue and establishing realistic dates for implementation.
- Developing a detailed training schedule – outlining the structure, sequence, and duration of training modules.
- Defining evaluation methods – selecting tools and criteria to assess the quality and outcomes of the training initiative⁸.

Proper preparation is essential for successfully implementing the developed training plans and carrying out the program effectively. While the core activity at this stage is the actual delivery of the training sessions, it is equally important to verify all logistical aspects in advance—this includes the availability and readiness of training facilities, technical equipment, and instructional materials. A frequently overlooked, yet crucial component of this phase is ensuring that both the participants and their supervisors are adequately prepared. To support this, those responsible for training delivery should provide advance access to the following key information:

- a detailed training schedule that outlines all planned modules,
- a breakdown of the thematic blocks to be covered,
- a description of the skills to be developed, with particular emphasis on the intended learning outcomes (e.g., the knowledge and abilities expected upon completion),
- a list of recommended topics or issues for participants to review prior to the start of the training.

All of this information should be communicated in advance to both the training participants and their immediate supervisors. This approach ensures that managers are equipped to support their employees in applying newly acquired methods, integrating fresh knowledge into their daily routines, and reinforcing the desired behavioral changes. To fulfill this role effectively, supervisors need to understand which areas of development their subordinates will be focusing on. Providing such information before the training begins helps create a supportive learning environment and allows for clear definition of expectations. As a result, employees start the training mentally prepared for the topics and challenges they will encounter.

The final phase of the training process involves evaluating its outcomes. While several frameworks exist for assessing training effectiveness, one of the most commonly applied is the model developed by Donald Kirkpatrick. The primary goal at this stage is to determine the extent to which the intended learning objectives have been achieved. For this reason, evaluation criteria and methods should be established during the planning phase of the training.

Once the training process has been completed, organizational culture becomes a key reference point in determining how successfully the acquired knowledge and skills are implemented. At this stage, attention should be directed toward leadership style, openness to change, and the provision of resources necessary to support employees in adapting to new expectations. A major post-training challenge involves the application of newly gained competencies to real job responsibilities. If supervisors or the organization fail to provide sufficient support, employees may experience difficulties in adjusting their work habits and revert to previous, less effective behaviors. To mitigate this risk, managers should take an active role in encouraging the use of newly acquired skills, showing understanding for initial mistakes, and offering guidance in overcoming obstacles. These actions are essential to maximizing the long-term impact of training efforts and improving overall organizational performance⁹.

⁸ A. Pocztowski, *Zarządzanie...*, op. cit., p. 289.

⁹ U. Pauli, *Rola szkoleń pracowników...*, op. cit., p. 132–136.

3. The phased structure of the aircraft maintenance personnel training process

The primary institutions responsible for training maintenance personnel for the needs of the Armed Forces of the Republic of Poland include: the Military University of Technology, the Polish Air Force University, the Air and Engineering Training Center, and the Non-Commissioned Officers' School of the Air Force¹⁰. These institutions are tasked with educating highly qualified specialists for the Air Force, who will not only support a variety of aircraft types but also take on leadership roles in personnel management¹¹. To fulfill these responsibilities, all training facilities must be adequately equipped to meet contemporary standards and the evolving operational demands of the air forces¹². The training process for maintenance personnel is inherently time-intensive due to the breadth and complexity of the subject matter¹³.

Its overarching goal is to ensure the high reliability of aircraft systems while maintaining an acceptable level of flight safety throughout the training process¹⁴. At the same time, training must guarantee compliance with required aircraft readiness and operational availability rates – particularly in light of ongoing modernization efforts aimed at improving performance and operational effectiveness¹⁵. Training centers are mandated to continually enhance the competencies of maintenance specialists, whose core responsibilities include maintaining aircraft airworthiness, adhering to maintenance standards, and upholding safety regulations during operations¹⁶.

The training pathway for maintenance personnel is structured in distinct stages: initial orientation, fundamental aviation engineering instruction, type-specific training for designated aircraft platforms, hands-on operational practice, certification for additional qualifications, and ongoing professional development¹⁷. These stages are implemented according to officially approved training curricula designed specifically for aircraft maintenance personnel. A visual representation of this training algorithm is provided in Figure 2.

The personnel of the maintenance process should be equipped with advanced analytical thinking skills and effective communication competencies. Officers are expected to demonstrate situational awareness in complex operational environments, the ability to rapidly assess and adapt to changing circumstances, as well as a set of competencies aligned with the operational capabilities of modern air forces¹⁸.

Specifically, engineering officers are required to possess comprehensive knowledge in areas such as aircraft structures, thermodynamics, automation systems, and the technologies related to the operation of airborne platforms. Meanwhile, personnel directly responsible for the maintenance of aircraft must be proficient in identifying potential malfunctions and symptoms of abnormal system behavior, enabling them to conduct accurate diagnostics and make informed decisions regarding corrective actions.

¹⁰ Military pilot training – D. Bogusz, *Szkolenie selekcyjne kandydatów na pilotów wojskowych w Siłach Zbrojnych Rzeczypospolitej Polskiej*, LAW, Dęblin 2020.

¹¹ D. Bogusz, *Selekcja i szkolenie lotnicze pilotów wojskowych w Wielkiej Brytanii*, LAW, Dęblin 2021.

¹² M. Sztobryn, *Wpływ wytycznych (procedur, instrukcji, list kontrolnych) na pracę personelu służby inżynieryjno-lotniczej w procesie obsługi samolotów szkolno-treningowych. Wybrane problemy bezpieczeństwa*, De Securitate Et Defensione. O Bezpieczeństwie i Obronności, 10(1) 2024, p. 206–219; M. Sztobryn, *Procedures in the process of operating military aircraft. Selected aspects of aviation safety*, "Scientific Journal of Safety and Logistics" 2(1), Warszawa 2024.

¹³ M. Sztobryn, *Wybrane procedury bezpieczeństwa eksploatacji samolotu M-346 „Bielik”*, "Studia Społeczne" 2023, no. 1(40).

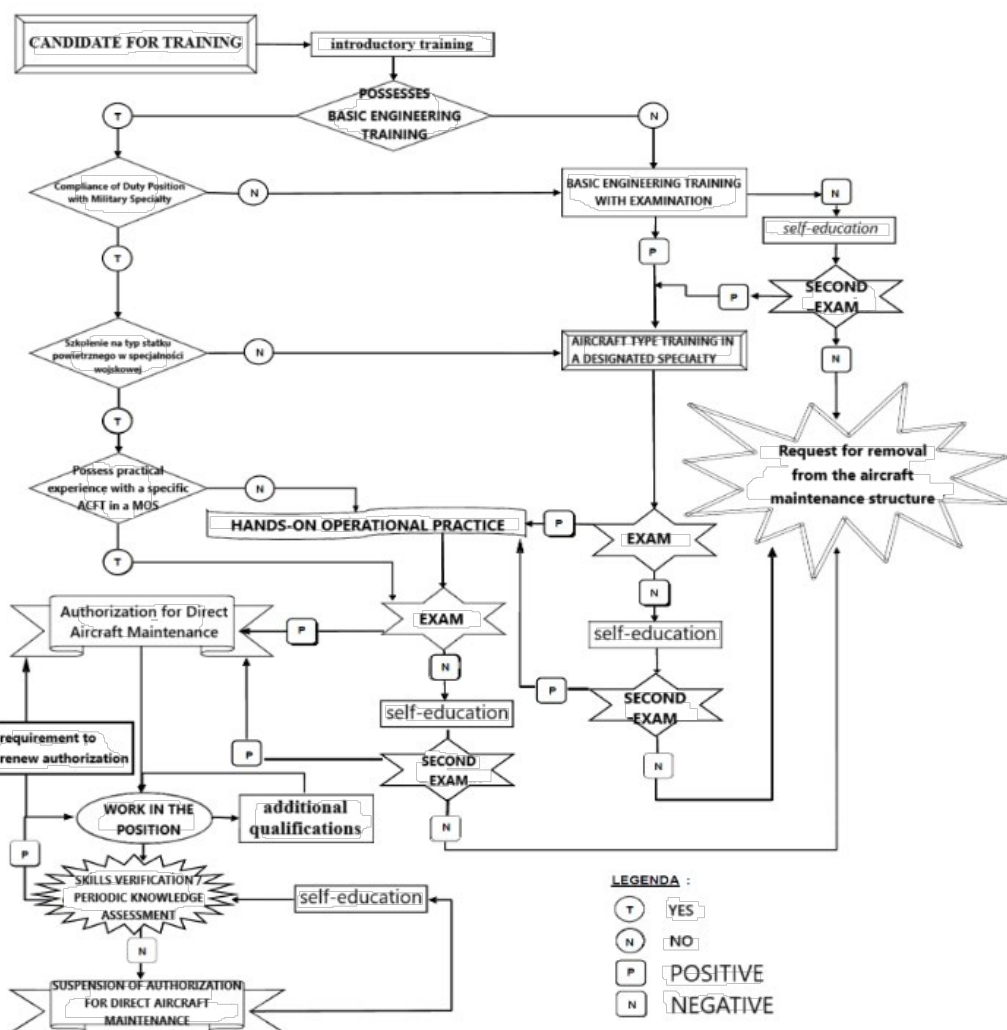
¹⁴ M. Sztobryn, *Proces szkolenia specjalistycznego personelu SIL samolotów wojskowych. Zarys problematyki*, "Przegląd Naukowo-Metodyczny, Edukacja dla Bezpieczeństwa" R. XVII, WSB Poznań 4/2024 (65), p. 55–65.

¹⁵ M. Sztobryn, *Realizacja procesu eksploatacji samolotów w bazie szkolenia lotniczego. Wybrane aspekty bezpieczeństwa*, LAW, Dęblin 2024; M. Sztobryn, *Współpraca personelu procesu eksploatacji samolotów w bazie lotniczej jako element zapewnienia bezpieczeństwa lotów*, [in:] *Prakseologia w naukach o bezpieczeństwie. Postawy proobronne służb mundurowych*, red. J. Wolejszo, Wydawnictwo Naukowe Uniwersytetu Kaliskiego im. Prezydenta Stanisława Wojciechowskiego, Kalisz 2024, p. 57–75.

¹⁶ M. Sztobryn, *Analiza przygotowania personelu SIL do obsługi samolotów M-346. Wybrane aspekty bezpieczeństwa*, "Scientific Journal of Safety and Logistics" 1(1), Warszawa 2023.

¹⁷ M. Sztobryn, *Szkolenie i kształcenie personelu procesu utrzymania samolotów jako konieczny element bezpiecznej realizacji operacji lotniczych*, "Studia Społeczne" 2024, no. 2(45), p. 45–59; MON, *Instrukcja szkolenia i upoważniania specjalistów służby inżynieryjno-lotniczej do bezpośredniej obsługi sprzętu lotniczego w lotnictwie SZ RP*, Inspektorat Wsparcia Sił Zbrojnych, Warszawa 2017.

¹⁸ J. Hanson, A. Beauregard, D. Rudd, *Air Power at the Turn of the Millennium*, Canadian Institute of Strategic Studies, Toronto 1999, p. 66–68.



Source: MON, *Instrukcja szkolenia i upoważniania specjalistów służby inżynierijno-lotniczej do bezpośredniej obsługi sprzętu lotniczego w lotnictwie SZ RP*, Inspektorat Wsparcia Sił Zbrojnych, Warszawa 2017.

The overarching objective of the aircraft maintenance personnel training system is the development of intellectually and analytically capable professionals who consistently engage in critical thinking and pursue continuous professional improvement. Desired characteristics of maintenance specialists include emotional composure, adaptability, and cognitive openness – traits particularly valuable within the rigid and hierarchical framework of military structures¹⁹.

4. Surveys of military aircraft maintenance personnel

The conclusions presented below were developed based on the results of a survey conducted among the maintenance personnel of the 41st Air Training Base. One of the challenges encountered during the data collection process was the need to carefully schedule the survey dates so as not to interfere with ongoing

¹⁹ B. Horn, B. Bentley, *Forced to Change – Crisis and Reform in the Canadian Armed Forces*, Dundurn, Toronto 2015, p. 82–83.

flight training activities. The assessment of training effectiveness should be largely based on the subjective evaluations of its participants, which were collected using a standardized questionnaire.

A total of 131 specialists participated in the study. Following a review of the formal correctness of the completed questionnaires, four were deemed unreliable and excluded from further analysis. Consequently, 127 correctly completed questionnaires were qualified for statistical processing.

The conducted research focused on identifying factors related to the structure and dynamics of the training paradigm for military aircraft maintenance personnel, beginning with an analysis of the frequency of training sessions.

Table 1 presents the percentage distribution of staff opinions regarding the frequency of training aimed at improving professional qualifications, categorized by years of service. The overall data indicate a relatively high level of satisfaction, with nearly 70% of respondents expressing a positive assessment. However, approximately 30% of the personnel reported partial dissatisfaction with the current number of training opportunities. The highest level of dissatisfaction was observed among individuals with 11 to 20 years of service, while the lowest was noted among employees with the longest professional experience.

Table 1. Assessment of the number of training courses improving the qualifications of aircraft maintenance staff at the air base, depending on the length of service

	very bad	bad	sometimes bad, sometimes good	good	very good
Under 5 years	0.0%	2.3%	3.1%	12.2%	6.1%
5-10 years	0.0%	2.3%	6.1%	9.2%	1.5%
11-20 years	2.3%	6.9%	7.6%	23.7%	6.1%
Over 20 years	0.0%	0.0%	0.8%	8.4%	1.5%

Source: own study.

The assessment of the effectiveness of aircraft maintenance personnel training aims to provide an in-depth analysis of the training process and to determine its impact on the operation of aircraft. When comparing the perceived importance of individual training components for the proper operation of aircraft (Table 2), no statistically significant differences were observed. This indicates that, in the opinion of the respondents, each evaluated element was considered equally important for ensuring correct aircraft operation.

Table 2. Assessment of the necessity of individual training stages for the proper operation of aircraft, depending on the length of service

Carried out before starting work in a job position within the aircraft maintenance staff structure

	To a very small extent	To a small extent	To a medium extent	To a large extent	To a very large extent
Under 5 years	1.5%	1.5%	3.1%	5.4%	12.3%
5-10 years	0.0%	0.8%	5.4%	7.7%	5.4%
11-20 years	0.8%	2.3%	12.3%	25.4%	6.2%
Over 20 years	0.0%	0.0%	1.5%	6.2%	2.3%

Implemented before the introduction of new aviation equipment into the aviation unit, e.g. new types of weapons, advanced systems

	To a very small extent	To a small extent	To a medium extent	To a large extent	To a very large extent
Under 5 years	0.8%	1.5%	2.3%	9.2%	9.9%
5-10 years	0.0%	0.8%	3.1%	6.1%	9.2%
11-20 years	0.0%	0.8%	12.2%	17.6%	16.0%
Over 20 years	0.0%	0.0%	2.3%	3.1%	5.3%

Cyclically carried out at the air base

	To a very small extent	To a small extent	To a medium extent	To a large extent	To a very large extent
Under 5 years	0.8%	0.8%	5.4%	8.5%	7.7%
5-10 years	0.0%	0.8%	3.8%	8.5%	6.2%
11-20 years	0.0%	2.3%	10.0%	23.8%	10.8%
Over 20 years	0.0%	0.0%	0.8%	6.9%	3.1%

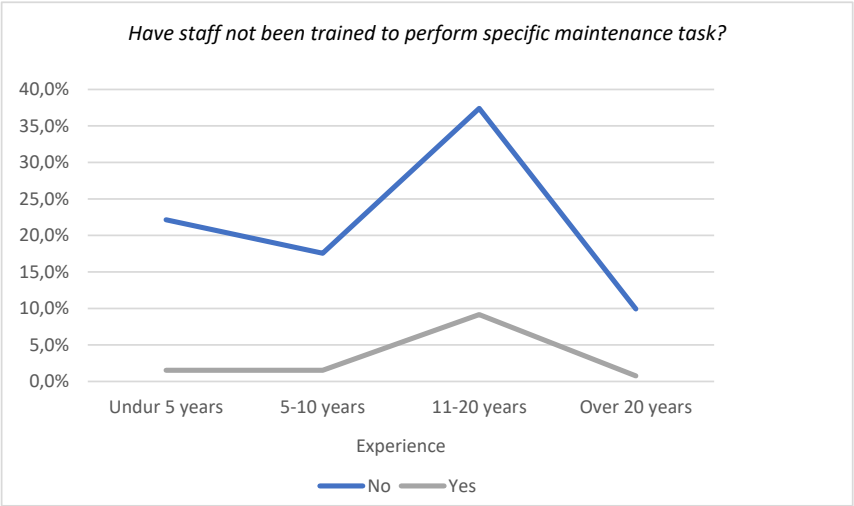
Source: own study.

According to the respondents, training is particularly crucial when aircraft maintenance personnel begin working with newly introduced aircraft equipment in a military unit. A significant portion of the staff from the 41st Air Training Base, involved in aircraft maintenance, emphasized the necessity of such training. In this regard, factory-based training at the aircraft manufacturer remains a key phase, as experts highlight that it offers the most in-depth knowledge and allows trainees to benefit from the experience of personnel already familiar with the specific aircraft type.

Until now, the training model for aircraft maintenance personnel has followed a traditional structure comprising theoretical coursework and hands-on practice with actual aircraft. The practical stage is aimed at developing specific skills necessary for performing repairs, maintenance, and component replacements, with a defining feature being its implementation during real-time operational conditions. However, within aviation units, a noticeable challenge has emerged: full-time specialists are tasked not only with the daily servicing of aircraft but also with conducting training sessions and supervising new ground support staff.

Regarding the difficulties associated with the stages that prepare personnel for hands-on maintenance tasks (see Chart 2), the majority of aircraft maintenance staff did not report significant issues. Most of the positive responses came from individuals with 11 to 20 years of professional experience.

Chart 1. Opinions of aircraft maintenance personnel on the stages of training for performing maintenance tasks, depending on the length of service



Source: own study.

In the conducted study, respondents were given the opportunity to evaluate the theoretical aspects covered during various stages of training (see Chart 2). The analysis revealed that the vast majority rated the scope of knowledge acquired through the training process positively. The most favorable opinions were expressed by personnel with a medium length of service. However, it is important to note that the mandatory implementation of theoretical training components is not always directly reflected in the practical procedures related to aircraft maintenance.

Chart 2. Aircraft maintenance personnel opinions on theoretical training stages by length of service



Source: own study.

The majority of surveyed aircraft maintenance personnel assessed the current training system as good or rather good. However, approximately one-third expressed critical or negative opinions. Importantly, nearly 80% of respondents indicated the need for targeted changes in the structure and content of aircraft maintenance personnel training programs. These critical voices, regardless of respondents' length of service, highlight the presence of systemic deficiencies within the existing educational model.

From an expert perspective, a key recommendation emerged regarding the acquisition of new aircraft types for the Polish Armed Forces. Specifically, experts emphasized that procurement contracts should mandatorily include provisions for the development of corresponding educational infrastructure. The rationale behind this is clear: essential practical skills, such as performing wheel replacement or conducting standard maintenance procedures, cannot be effectively acquired through theoretical instruction alone, such as reading technical manuals or procedural documentation.

Instead, practical learning requires direct access to physical components, subsystems, and equipment in a controlled training environment. The lack of such resources may hinder the development of critical competencies and ultimately affect operational readiness. Experts stressed that certain mechanical elements should be physically available in training centers to ensure hands-on experience. This approach is not novel; similar technical training bases were historically maintained in institutions located in Zamość and Oleśnica. Furthermore, experts acknowledged that the Engineering and Aviation Training Center is equipped with some technical infrastructure; however, its current capacity does not comprehensively support training for all aircraft types currently in service with the Polish Armed Forces. This disparity underscores the need for strategic investment in training logistics and the expansion of technical facilities, ensuring alignment between operational needs and personnel preparation.

Ultimately, integrating didactic resources with aircraft procurement strategies should be viewed not as an auxiliary measure but as a fundamental element of force modernization, contributing directly to flight safety, system reliability, and the long-term efficiency of aircraft maintenance operations.

When military decision-makers authorize the operational use of aircraft, they must be assured that such utilization will be conducted safely. A critical factor in ensuring this safety is the technical servicing of the aircraft, which is carried out by the aircraft maintenance personnel who have undergone a multi-stage training process.

In conclusion, the effective utilization of the training capabilities of air bases is closely dependent on the proper implementation of each stage within the training process for aircraft maintenance personnel. Based on the conducted analysis, several general conclusions can be drawn:

- Each phase of the training program enables aircraft maintenance personnel to acquire competencies necessary for independently identifying and resolving technical issues. Moreover, the training equips them with the ability to respond effectively to atypical situations and to perform diagnostic tasks under dynamic operational conditions.
- The rapid technological advancement of modern aircraft has significantly increased the expectations placed on the personnel responsible for their maintenance. Aircraft maintenance personnel constitute an essential component of the military aviation system. Their qualifications, technical expertise, and operational experience are critical to maintaining high standards of operational safety at every stage of task execution.

Therefore, it may be concluded that the principal objective of this article has been successfully achieved – namely, the presentation of research findings concerning the stages of the training process for engineering and aviation support personnel. Given the importance of this subject matter, it is advisable to continue monitoring and developing training systems in this field.

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