

Readiness of F-16 Aircraft of the Indonesian Air Force in The Face of Regional Geopolitical Dynamics A Case Study of The Maintenance Depot 80

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ABSTRACT

The maintenance of F-16 fighter jets as strategic defense assets of the Indonesian Air Force (*TNI AU*) requires systems that adapt to technological advancements. *Depot Maintenance 80 (Depohar 80)*, as the main heavy maintenance unit, faces the challenge of enhancing its capabilities through digital transformation in the era of Society 5.0. The main issue in this study is the suboptimal implementation of digital technology to support F-16 operational readiness. This research aims to analyze the mechanics' competencies prior to digital transformation, identify the obstacles and challenges, and formulate strategies for digital maintenance implementation. A qualitative descriptive method was employed, utilizing literature review, interviews, and field observation. The findings reveal that human resource competencies in digital literacy need improvement, digital infrastructure is not yet fully established, and the integration of legacy systems with digital platforms still encounters technical challenges. It is concluded that digital transformation in *Depohar 80* can significantly improve the operational readiness of F-16 aircraft, provided it is supported by intensive training, improved infrastructure, and gradual implementation of AI- and IoT-based systems.

Keywords: *F-16 aircraft, Indonesian Air Force, regional geopolitical dynamics*

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INTRODUCTION

In the last five years, geopolitical conditions in the Indo-Pacific region have heated up due to the deterioration of relations between the two superpowers, namely the People's Republic of China (PRC) and the United States (US) (Bouri et al., 2023; Demiralay et al., 2024; Hoque et al., 2021; Melnik, 2024; Qin et al., 2020). Both seek to strengthen their positions, expand their influence, and prove themselves in various sectors to become the dominant power in the region. This conflict is described by Graham Allison in his work, *Destined for War*, as a meeting between traditional forces that seek to maintain the status quo as a superpower (US) and the PRC, which is described as a developing power (Allison, 2017). Meanwhile, Indonesia, located at the center of the Indo-Pacific region, has the potential to gain significant influence from the conflict between these two powers. As a middle-power country with various limitations in bargaining power, Indonesia needs to take strategic actions to prepare for worst-case scenarios, such as limited war. Moreover, the establishment of the AUKUS Pact has the potential to threaten Indonesia's sovereignty, as it risks further disrupting the regional security order (Priyandita and Herscovitch, 2021).

Indonesia's position in the geopolitical dynamics of the Indo-Pacific region necessitates awareness of these threats to its sovereignty, making it essential to implement more concrete balancing measures. One strategic step that must be taken is the modernization of defense equipment, especially in the air dimension, which is crucial for guarding Indonesia's airspace. Modernization is not only carried out through the procurement of new defense equipment but also by focusing on the maintenance of defense assets to support the readiness of the Air Force (*TNI AU*) in being more adaptive and responsive to various emerging situations.

Maintenance management is an aspect that cannot be overlooked in the defense sector, including air defense. Effective maintenance activities significantly affect operational readiness and success in carrying out national security and defense tasks. In the context of air defense, maintaining fighter aircraft is especially critical, particularly for the F-16 fighters. As one of the main fighter jets of the Indonesian Air Force (*TNI AU*), the F-16 has complex mechanical, avionics, and weaponry systems that require strict, technology-based maintenance procedures to ensure optimal performance. Maintenance on the F-16 not only focuses on mechanical components but also involves avionics and weaponry systems that continuously evolve with cutting-edge technology. The main challenge in maintaining this aircraft lies in the mechanics' competencies, which must be adaptive to rapid technological developments.

In the era of Society 5.0, technology use is inseparable from human life. Therefore, in fighter aircraft maintenance, digital transformation has become indispensable, especially for *Maintenance Depot 80 (Depohar 80)*, which has the responsibility for conducting heavy maintenance on the F-16 aircraft. In recent years, aircraft maintenance technology has evolved by adopting Artificial Intelligence (AI), the Internet of Things (IoT), and big data to support predictive maintenance systems.

Previous research by Bengtsson (2004) on Condition-Based Maintenance Systems highlighted the importance of prediction-based maintenance for complex equipment but lacked empirical aspects in the context of military aviation in developing countries such as Indonesia. Meanwhile, Brown (2018), in his research on Digital Maintenance Transformation in Military Aviation, examines the role of IoT and AI in maintenance systems but focuses only on the Western military context, ignoring the unique challenges faced by middle-power countries with limited digital infrastructure and literacy.

This study aims to fill this gap by analyzing the technical competence of *Depohar 80* personnel in adopting digital systems, identifying infrastructure and cultural obstacles to digital transformation, and formulating a strategy for AI- and IoT-based system implementation tailored to the needs of the Indonesian Air Force. Thus, this research not only contributes to the development of maintenance management theories in the digital age but also provides practical recommendations to improve the operational readiness of the F-16 aircraft in the face of regional geopolitical challenges.

As part of air defense modernization, the Indonesian Air Force must continue to adapt to technological developments to increase the effectiveness and efficiency of fighter aircraft maintenance. With a more sophisticated, digitally based maintenance system, it is hoped that the readiness of the F-16 aircraft can be maintained at an optimal level, supporting national air defense tasks more effectively. Therefore, this study aims to analyze how digital transformation can improve *Depohar 80*'s ability to support the operational readiness of F-16 aircraft, as well as identify challenges and solutions in applying digital technology to ensure the effectiveness and efficiency of fighter aircraft maintenance within the Indonesian Air Force.

This research provides both theoretical and practical benefits. Theoretically, it enriches the literature on defense equipment maintenance management by integrating digital transformation within a geopolitical context, complementing previous research gaps that focused mainly on developed countries. Practically, the findings are useful for the Indonesian Air Force in improving F-16 operational readiness through recommendations on digital training, infrastructure improvements, and AI/IoT system implementation. These findings can

also serve as a reference for the development of national defense policies and future research related to the modernization of military maintenance systems.

Based on these conditions, the main problem focus of this study is the insufficient enhancement of *Maintenance Depot 80*'s capabilities through digital transformation in the Society 5.0 era to support the readiness of *TNI AU*'s F-16 aircraft. To examine these issues more deeply, this study investigates how digitalization is applied in F-16 aircraft maintenance at *Depohar 80* amid regional geopolitical dynamics.

METHOD

This study used a descriptive qualitative approach with a case study method to describe and analyze the maintenance of F-16 aircraft at *Maintenance Depot 80* of the Indonesian Air Force, aiming to improve operational readiness. This approach was chosen because it focused on understanding the phenomenon of digital transformation and its role in enhancing maintenance organizational capabilities in a contextual manner.

Data analysis was carried out interactively following the model proposed by Miles, Huberman, and Saldana (2014), consisting of three main stages: data reduction, data presentation, and conclusion/verification. These stages were interconnected in a cyclical and dynamic process. To strengthen data validity, source triangulation was applied to ensure credibility and trustworthiness. According to Miles, Huberman, and Saldana (2014), qualitative analysis requires consistency in data coding, theme sorting, and in-depth interpretation of patterns emerging from the field.

The research steps included problem identification, preparation of research instruments, collection of primary and secondary data, thematic analysis, and preparation of the final report based on the synthesis of empirical data and theoretical studies.

RESULTS AND DISCUSSION

Regional Geopolitical Dynamics: Possible Occurrence of Air Battles.

The Southeast Asia and Indochina region is a strategic region that is a meeting point for various global geopolitical interests. This region is also known as the indo-pacific region which includes the Indian Ocean and Pacific Ocean, as well as mainland Asia, the Australian continent and parts of the United States. Its location on international trade routes, its wealth of natural resources, and its proximity to major powers such as China and the United States make the region vulnerable to political and security dynamics. In recent years, tensions in the region have increased, especially over territorial claims in the South China Sea, military modernization, and power competition between major powers. This situation raises concerns about the possibility of air combat as a manifestation of a wider conflict.

Geopolitics also has direct implications for the aspects of national defense and security. Countries with strategic positions and large natural resource potential often face external pressures, both in the form of open military threats and non-traditional infiltration, such as air espionage, airspace violations, and provocations of foreign powers in border zones. Therefore, military preparedness, especially air power, is a crucial component in maintaining sovereignty and national interests (Asbanu, 2018).

In the Indonesian context, Indonesia's geographical location in the international shipping lanes (SLOC), such as the Strait of Malacca, the Sunda Strait, and the Lombok Strait,

makes this country a key actor in the geopolitical dynamics of the region. In the Indo-Pacific region, Indonesia has emerged as a *middle power country*. According to researcher Ian Montratama, Indonesia's position as a middle power country is still very weak. In the sense that Indonesia only has a large population and territory, but it is not enough to say that it is a *middle power country*. This is because Indonesia does not have enough power to influence other countries as the meaning of power in the sense of middle power. He continued, the influence brought by Indonesia is inseparable from ASEAN by bringing an inclusive narrative of cooperation (Montratama 2021).

As is the case in the geopolitical perspective According to Griffiths, geopolitics is the study oriented to how geographical factors such as location, terrain, climate, population, and natural resources influence the political behavior of a country. The state cannot escape its geographical reality, and that position determines how it responds to threats and opportunities in the international order.

Considering the increasingly complex geopolitical dynamics in the Indo-Pacific region characterized by strategic competition between major powers, increased military activity in disputed areas, and the potential for conflict escalation that can occur at any time, Indonesia needs to take strategic steps to strengthen its military posture. This effort is not solely to show strength, but as a preventive measure in dealing with all forms of threats to the integrity and sovereignty of the state. In this case, air defense is a crucial sector that must be systematically strengthened, because Indonesia's vast and strategic airspace is vulnerable to violations by state and non-state actors. This strengthening can be realized through the modernization of the main tools of the weapon system (alutsista), increasing maintenance and logistics capacity, and the integration of advanced technology in the national air defense command and control system.

One of the main components in Indonesia's air defense system is the F-16 fighter, which has long been the backbone of the Indonesian Air Force's air power. F-16 aircraft play an important role in interception operations, air patrols, and force projections at the nation's air borders. However, the technical and tactical advantages of this aircraft can only be optimally utilized if supported by a reliable, efficient, and sustainable maintenance system. In the face of dynamic geopolitical challenges, F-16 maintenance should not be reactive, but rather adaptive and predictive, integrating digital technology and centralized information systems to detect potential technical glitches before they impact combat readiness. Without adequate maintenance support, the F-16's operational superiority would be eroded by time, service life, and high operational burden. On the contrary, with intelligent and planned maintenance management, Indonesia is not only able to maintain the readiness of the air fleet, but also strengthen its strategic position in the face of the region's ever-evolving geopolitical dynamics.

F-16 Aircraft Maintenance Readiness at Maintenance Depot 80

In Maintenance Management Theory according to Bengtsson (2004), maintenance systems are divided into two main approaches: preventive maintenance, which is carried out on a scheduled basis to prevent breakdown; and corrective maintenance, which is carried out after damage has occurred to restore the functionality of the appliance. In the context of F-16 aircraft with a high level of complexity, the ideal maintenance strategy is to prioritize predictive-based preventive maintenance, which can only be done effectively through the support of digital technology.

Based on data and facts in the field to date, it shows that the maintenance system at Depot 80 has mostly used a preventive approach, but the publications and documentation are still manual or paper-based which has many vulnerabilities. The maintenance process is often carried out after the damage has occurred, which causes relatively *high downtime*. This is due to the lack of optimal use of digital systems that support damage prediction or periodic maintenance needs. The aircraft condition monitoring system still relies on manual inspections and paper-based technician reports. Although the implementation of platforms such as *the Interactive Engine Technical Manual System (IETMS)* and *the Integrated Logistic Information and Automation System (ILIAS)* has been implemented, the implementation is still limited to the socialization stage and has not been fully integrated in the maintenance routine. In addition, there is no internal policy that comprehensively regulates the digitization of the maintenance process, including in the aspects of scheduling, reporting, and technical documentation.

In addition, the mechanical competence of the F-16 aircraft at Depohar 80 is still mostly focused on conventional technical aspects, such as mechanical, electrical, and understanding of manual systems. This is in accordance with the basic skills components mentioned in the theory, but does not include the *transformational competence* aspect, namely the ability to adapt to technological changes and digital-based work processes. Facts in the field show that technicians have become accustomed to working with printed procedures and have empirical experience in handling aircraft maintenance. However, when associated with the dimension of digital technology knowledge, significant limitations are found. Most mechanics are not used to using maintenance software such as IETMS or ERP (*Enterprise Resource Planning*) systems such as ILIAS, which actually require digital literacy and AI- and IoT-based data interpretation skills. This shows that even though technicians have good work experience and work attitudes, adaptive competencies to new systems are still not optimally developed. Thus, when compared to the standard of human resource competency theory, the condition before the digital transformation at Depohar 80 is still at the basic *competence level*, has not reached *the dynamic competence* needed to face changes in the Society 5.0 era. This gap then becomes an important basis for the need for intensive training programs, digital literacy coaching, and restructuring of the human resource development curriculum to match the demands of modern maintenance technology.

Technicians generally have a background in basic mechanical and electrical education and training, and are experienced in routine maintenance and *overhaul* processes using a manual procedure-based approach and experience working in the field. From field observations and internal technical reports, it was found that the mechanics were quite qualified in handling physical disturbances and mechanical damage to the aircraft. However, there are significant limitations in aspects of digital capabilities, such as the operation of data-based systems, the use of maintenance software, and the understanding of increasingly complex avionics systems based on digital integration. Training on the use of digital technology is also still limited and has not become the main competency standard in human resource development programs. In addition, communication and reporting of damage are still done manually, using paper forms or limited data entry, which results in the coordination process between divisions being slow and unresponsive to technical urgency.

Based on the above findings, it can be concluded that the mechanical competence of F-16 aircraft is still not adaptive to digital transformation and is still limited to conventional

technical skills and has not fully met the demands of the digital era. Unpreparedness in terms of technological literacy, mastery of maintenance software, and adaptation to AI and IoT-based systems shows that there is a gap between the actual competencies of technicians and the standards of human resource competencies needed in the Society 5.0 era. Therefore, improving digital-based competencies is an urgent need to ensure the readiness of Depohar 80 to support optimal and sustainable maintenance of F-16 aircraft.

Obstacles and challenges in implementing digital transformation in supporting F-16 aircraft maintenance.

One of the important aspects in supporting the success of digital transformation in the defense equipment maintenance environment is the competence of human resources (HR). These competencies include not only basic technical capabilities, but also the readiness of individuals to adopt and operate new technologies used in modern maintenance systems. In the context of aircraft technicians, these competencies include expertise in understanding digital systems, the ability to analyze technical data quickly, and adaptive attitudes to changes in work procedures. In theory, Yendrawati (2013) states that human resource competence is the capacity possessed by individuals, both personally and within the framework of the organization, to carry out certain functions or authorities effectively and efficiently to achieve common goals. Meanwhile, Sudiarti (2020) added that these competencies also involve a combination of knowledge, skills, and personality characteristics that directly affect a person's performance. In this case, increasing the competence of technicians at Depohar 80 is a requirement so that the digital transformation carried out can run well and provide maximum results in supporting the operational readiness of F-16 aircraft.

Theoretically, digital transformation is a process of fundamental change in the way an organization works through the use of digital technology. In the context of aircraft maintenance, digital transformation allows the use of technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and Big Data to improve the efficiency, effectiveness, and accuracy of technicians' work (Priyadi, Dewi, & Wulandari, 2023). In Society 5.0, technology not only supports, but becomes central to decision-making and overall system management, including in the maintenance process of fighter aircraft. Several technology platforms such as the Interactive Engine Technical Manual System (IETMS) from Pratt & Whitney (2012) and the Integrated Logistic Information and Automation System (ILIAS) described by Brown (2018) and Johnson & Martinez (2020), show how information and automation integration can accelerate, facilitate, and optimize the entire maintenance process digitally and centrally. Therefore, digital transformation theory emphasizes the importance of digital literacy, infrastructure readiness, and change management to create a system that is adaptive to technological developments.

The data and facts in the field show that in its implementation within the Maintenance Depot 80 (Depohar 80) of the Indonesian Air Force, the digital transformation process has not run optimally. Based on the results of observations and interviews, it was found that most of the maintenance processes are still carried out manually or semi-manually, especially in technical recording, reporting, and distribution of technical data between sections. Technologies such as IETMS and ILIAS have not been fully utilized due to limited network infrastructure, the availability of supporting devices, and the lack of full integration with legacy

systems. In addition, there are still many technical personnel who do not have adequate training or literacy to operate digital systems independently. Lack of technical assistance, limited budgets for the procurement and maintenance of digital devices, and resistance to change are also factors that slow down the digital transformation process.

When faced with the theoretical framework of digital transformation, it can be analyzed that data in the field shows that there is a significant gap between ideal conditions and real conditions. The theory emphasizes the importance of digital infrastructure and technological literacy as the main prerequisites for successful transformation, but in Depohar 80 there are still fundamental obstacles that hinder the implementation.

In the process of implementing digital transformation in the Depohar 80 environment, there are a number of obstacles that directly hinder the speed and effectiveness of implementation. First, inadequate digital infrastructure is the main obstacle. The limitations of the internal network, the availability of hardware that supports digital systems, and software that has not been fully integrated, cause the digitization process to run slowly and inefficiently. Second, most of the existing human resources (HR) have not received optimal training in the operation of technology-based systems, such as IoT, AI, and digital maintenance platforms. Third, manual systems that have been used for a long time are still not completely abandoned, so the integration process between old and new systems becomes slow and creates technical obstacles in data transition and work procedures. Fourth, the limited budget also affects the unit's ability to modernize equipment and conduct training intensively and sustainably.

In addition to these technical and structural obstacles, there are also a number of strategic challenges that must be faced in supporting the success of digital transformation. One of them is to build a digital work culture in the military environment that tends to be structural and conservative, so it requires a systematic and sustainable approach to change. The next challenge is to increase the confidence and readiness of technicians to move from manual to digital systems, which demands a change in thinking and new capabilities in software operation and data-driven decision-making. In addition, during the transition period, efforts are needed to maintain the continuity of the work system so that the operational readiness of the aircraft is not disrupted. This is important so that the new system does not reduce the unit's performance in maintaining the combat readiness of defense equipment. Another challenge is to build a solid partnership between internal parties (TNI AU) and external partners (technology providers or vendors), to ensure that the development and maintenance of digital systems such as IETMS and ILIAS can be carried out in a sustainable, reliable manner, and in accordance with operational needs in the field.

It can be concluded that the main obstacles and challenges in the implementation of digital transformation in the F-16 aircraft maintenance system at Depohar 80 lie in the aspect of human resource readiness and technological infrastructure. Although theoretically digital transformation offers high efficiency and an integrated work system, realization in the field still requires careful planning, continuous training, and institutional support to build a modern maintenance system that is adaptive to technological developments in the era of Society 5.0.

Strategy for Implementing Digitalization in F-16 Aircraft Maintenance Systems

If it is associated with maintenance management theory, then the analysis of digitalization strategies should play an important role in strengthening the preventive

maintenance aspect. Technologies such as IETMS and ILIAS can help technicians accurately schedule maintenance based on historical data analysis and actual machine conditions. But in reality, this approach has not been fully adopted. The digitalization strategy at Depohar 80 still does not touch the root of the problem in maintenance management, namely how to set the right maintenance interval and integrate technical reports into a central system that can be accessed across units.

To provide a clearer picture of the differences between traditional and modern approaches to F-16 aircraft maintenance systems, the following is presented a comparison matrix between manual and digital strategies based on five main aspects of maintenance. This matrix shows how digital strategies offer significant improvements in terms of efficiency, accuracy, and operational readiness through the use of information technology and automation.

Table 1. Manual vs Digital Strategy Comparison Matrix in F-16 Aircraft Maintenance

Aspects	Manual Strategy	Digital Strategy
Scheduling System	Static and technician experience-based	Based on historical data and actual conditions (predictive maintenance)
Condition Monitoring	Regular visual/manual inspections	Using sensors, IoT and digital dashboards in real-time
Reporting & Documentation	Manually recorded in paper form	Automatically recorded in digital systems such as IETMS and ILIAS
Response to Damage	Reactive, done after damage has occurred	Predictive, preventing damage before it happens
Operational Readiness	Vulnerable to <i>downtime</i> , not thoroughly monitored	Minimal downtime, aircraft conditions can be monitored continuously

Source: Maintenance Systems and Management, Ignatius Deradjad Pranowo (2019)

CONCLUSION

Based on the analysis of mechanical competencies, challenges, and implementation strategies for digitalizing F-16 maintenance at *Depohar 80*, it can be concluded that digital transformation significantly enhances the effectiveness and operational readiness of air defense systems. However, prior to digitalization, mechanical skills were largely conventional, with limited digital literacy to support AI, IoT, and Big Data-based maintenance. Obstacles included inadequate infrastructure, low digital capacity among personnel, reliance on manual processes, organizational resistance, weak collaboration with technology partners, and the need to maintain continuity during transition. Recommended strategies involve developing an integrated digital maintenance information system for real-time planning and reporting, improving technicians' digital skills, adopting predictive maintenance, integrating tools like IETMS and ILIAS into daily routines, reinforcing regulations to ensure digital documentation, and gradual implementation of modern systems. These efforts aim to maintain high F-16 operational readiness to support Indonesia's sovereignty amid regional geopolitical challenges. Theoretically, the study reinforces Maintenance Management Theory in the digital era by optimizing preventive maintenance to boost combat readiness; practically, it offers a strategic roadmap for *Depohar 80*'s digital transformation aligned with Society 5.0. Future research could explore the long-term impacts of digital transformation on maintenance efficiency and personnel adaptation, as well as the integration of emerging technologies like machine learning to further enhance predictive maintenance in military aviation.

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