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**ENHANCING TENTERA UDARA DIRAJA MALAYSIA (TUDM) LOGISTICS
PERFORMANCE THROUGH INVENTORY, ENGINEERING AND INTEGRATED
LOGISTICS SUPPORT**



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MASTER OF SCIENCE (TRANSPORTATION AND LOGISTICS

MANAGEMENT)

UNIVERSITI UTARA MALAYSIA

JANUARY 2026

**ENHANCING TENTERA UDARA DIRAJA MALAYSIA (TUDM) LOGISTICS
PERFORMANCE THROUGH INVENTORY, ENGINEERING AND INTEGRATED
LOGISTICS SUPPORT**



Thesis submitted to
College of Business,
Universiti Utara Malaysia,
in fulfilment of the requirement for the Master of Science in
Transportation and Logistics Management



Kolej Perniagaan
(College of Business)
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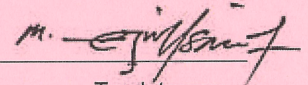
: **Enhancing Tentera Udara DiRaja Malaysia (TUDM) Logistics Performance Through Inventory, Engineering and Integrated Logistics Support**

Program Pengajian
(Programme of Study)

: **Master of Science (Transportation & Logistics Management)**

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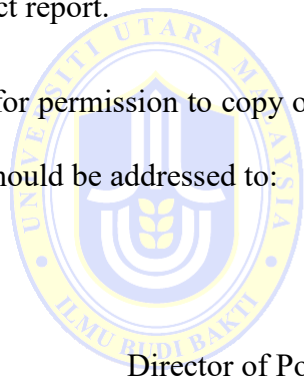
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Abstrak

Kajian ini mengkaji hubungan antara Pengurusan Inventori Cepak (EIM), Sokongan Kejuruteraan yang Diperbaiki (IES), dan Pengurusan Sokongan Logistik Bersepadu (ILS) dan pengaruh kolektifnya terhadap prestasi logistik (LP) dalam Tentera Udara Diraja Malaysia (TUDM). Bagi mengekalkan tahap kesediaan pesawat yang tinggi kekal sebagai cabaran berterusan untuk tentera udara, terutamanya dalam persekitaran yang dicirikan oleh platform penuaan, keperluan penyelenggaraan yang kompleks dan kekangan rantaian bekalan. Menggunakan reka bentuk penyelidikan kuantitatif, data telah dikumpul daripada kakitangan TUDM yang terlibat dalam fungsi logistik, kejuruteraan dan penyelenggaraan. Analisis statistik deskriptif dan inferensi digunakan untuk menilai kekuatan dan hala tuju hubungan antara pembolehubah kajian.

Penemuan ini mendedahkan bahawa pengurusan inventori yang cekap dapat meningkatkan prestasi logistik dengan ketara dengan mengurangkan kekurangan alat ganti dan kelewatan penyelenggaraan. Sokongan kejuruteraan yang lebih baik didapati mempengaruhi secara positif masa pemulihan penyelenggaraan, kebolehpercayaan sistem dan ketersediaan pesawat. Tambahan pula, pengurusan ILS menunjukkan kesan integratif yang amat kuat dengan menjajarkan aktiviti inventori, kejuruteraan dan penyelenggaraan merentasi kitaran hayat pesawat. Secara kolektif, keputusan menyokong Teori Sistem dengan mengesahkan bahawa prestasi logistik dapat dioptimumkan apabila subsistem yang saling bergantung beroperasi dalam cara yang diselaraskan dan bersepadu. Penyelidikan ini menyumbang bukti empirikal kepada literatur logistik pertahanan Angkatan Tentera Malaysia (ATM) dan memberikan pandangan praktikal untuk mengukuhkan perancangan logistik dipacu data dinamik, penyelarasan kejuruteraan dan strategi sokongan kitaran hayat dalam TUDM serta mengesyorkan cadangan yang paling berdaya maju untuk isu ini dalam meningkatkan prestasi logistik TUDM.

Kata kunci: *Pengurusan Inventori yang Cepak, Sokongan Kejuruteraan yang Diperbaiki, Sokongan Logistik Bersepadu, Prestasi Logistik, Keselamatan dan kedaulatan negara.*

Abstract

This study examines the relationship between Efficient Inventory Management (EIM), Improved Engineering Support (IES) and Integrated Logistics Support Management (ILS) and their collective influence on Logistics Performance (LP) in the Tentera Udara DiRaja Malaysia (TUDM). Maintaining a high level of aircraft readiness remains a continuing challenge for the air force, especially in an environment characterized by aging platforms, complex maintenance requirements, and supply chain constraints. Using a quantitative research design, data were collected from TUDM personnel involved in logistics, engineering, and maintenance functions. Descriptive and inferential statistical analyses were used to assess the strength and direction of the relationships between the study variables.

The findings reveal that EIM can significantly improve logistics performance by reducing spare parts shortages and maintenance delays. IES was found to positively influence maintenance turnaround time, system reliability and aircraft availability. Furthermore, ILS management demonstrated a very strong integrative effect by aligning inventory, engineering and maintenance activities across the aircraft life cycle. Collectively, the results support Systems Theory by confirming that logistics performance can be optimized when interdependent subsystems operate in a coordinated and integrated manner. This research contributes empirical evidence to the Angkatan Tentera Malaysia (ATM) defense logistics literature and provides practical insights to strengthen dynamic data-driven logistics planning, engineering coordination and life cycle support strategies in the TUDM as well as recommending the most viable proposals for this issue in improving TUDM logistics performance.

Keywords: *Efficient Inventory Management, Improved Engineering Support, Integrated Logistics Support, Logistics Performance, Security and National Sovereignty.*

ACKNOWLEDGEMENT

I would like to express my deepest gratitude to my supervisor, Associate Prof Dr Mohd Azril bin Ismail CMILT, for his invaluable guidance, insightful comments, and unwavering support throughout the duration of this research. His expertise and encouragement have played a vital role in shaping this paper.

I am also very grateful to all the lecturers and colleagues at Universiti Utara Malaysia who have shared their knowledge, provided feedback, and offered their assistance whenever needed. Your friendship and intellectual exchange have enriched my research experience.

In addition, I would like to express my deepest gratitude to my research respondents from the Ministry of Defence, the Tentera Udara DiRaja Malaysia for giving me a valuable opportunity to further my knowledge pursuit and also to those who have directly or indirectly supported me in ensuring that my work was completed.

Finally, I would like to express my deepest gratitude to my family and wife for their love, as well as my comrades who have always been there to provide support, strength, understanding and inspiration to move forward, as well as their endless patience throughout this journey. Their support is a source of continuous strength and motivation. This research would not have been possible without the contributions and support of these individuals and institutions. Thank you all sincerely.

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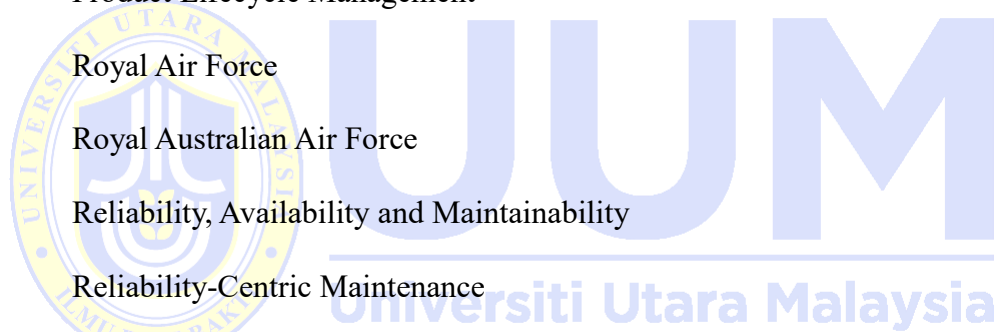
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LIST OF ABBREVIATIONS

| | |
|---------|--|
| AI | Artificial Intelligence |
| ASD | Aerospace/defense |
| AOG | Aircraft on the Ground |
| ATM | Angkatan Tentera Malaysia |
| ATSC | Aerospace Technology Systems Corporation |
| AVE | Average Variance Extracted |
| BI | Business Intelligence |
| CAPP 55 | Capability Development Plan 2055 |
| CLS | Contractor Logistics Support |
| CR | Composite Reliability |
| DMU | Depoh Materiel Utama |
| DWP | Defence White Paper |
| EFA | Exploratory Factor Analysis |
| EIM | Efficient Inventory Management |
| FKU | Flait Khas Udara |
| ICMS | Integrated Computer Management System |
| IES | Improved Engineering Support |
| IoT | Internet of Things |
| ILS | Integrated Logistics Support |
| KPIs | Keys Performance Indicators |
| LSA | Logistics Support Analysis |
| MATRA | Materiel Udara |

| | |
|--------|---|
| MC | Mission-Capable |
| MINDEF | Ministry of Defence |
| MK AB | Markas Angkatan Bersama |
| MTBF | Mean Time Between Failures |
| MRO | Maintenance, Repair, and Overhaul |
| MSCL | Military Supply Chain Logistics |
| OAP | Optimization of Aircraft Performance |
| OEM | Original Equipment Manufacturers |
| PdM | Predictive Maintenance |
| PLM | Product Lifecycle Management |
| RAF | Royal Air Force |
| RAAF | Royal Australian Air Force |
| RAM | Reliability, Availability and Maintainability |
| RCM | Reliability-Centric Maintenance |
| RFID | Radio Frequency Identification |
| SPSS | Statistical Package for the Social Sciences |
| TAT | Turnaround Time |
| TUDM | Tentera Udara DiRaja Malaysia |
| USAF | United States Air Force |



CHAPTER ONE

INTRODUCTION

1.0 Overview of TUDM

Malaysia is a nation that deploys security and military assets and is ranked 42nd in terms of military strength as assessed in the (Index Global Firepower) GFP 2025 list. This ranking makes Malaysia the seventh strongest military in Southeast Asia. This rating is influenced by a number of factors, including geography, logistical capability, financial status, and the quantity of military personnel.

The Royal Malayan Air Force (Tentera Udara DiRaja Persekutuan), now known as the Tentera Udara DiRaja Malaysia (TUDM), was established on 2 June 1958 (TUDM, 2020). The Air Force, means "The part of the Armed Forces that fights in the air", and for that it requires aircraft that can fly and are capable of training and operations. The readiness of the TUDM for training and operations must be maintained at a high level and it acts as a deterrent to any possible threat to the country. Although it is a difficult task, the best efforts are being made in all areas of sound logistical management to maintain the TUDM and ensure its relevance in defending the sovereignty of our Nation.

The Kertas Putih Pertahanan (KPP) or Defence White Paper outlines a comprehensive strategy to change the Angkatan Tentera Malaysia (ATM) into a future force with five key attributes: unity, interoperability, technology, the capacity to function concurrently in two regions, and mission-orientedness. With a defensive posture, this future force is capable of responding to any danger to the country's defense because it is cohesive, agile, and focused. The participation of

the entire government and populace in maintaining the nation's internal integrity strengthens this endeavor even more (KPP, 2020).

The ATM Forces as the national defense force, it is bound to guarantee the stability, peace and sovereignty of the Malaysian nation from any external threats and intimidation whether in the air, sea or land. Another important task of the TUDM is to support government authorities in administering domestic threats to the country. To ensure that responsibilities are always maintained, especially threats from the air, the TUDM as one of the ATM branches must always be ready and prepared. The TUDM, which firmly adheres to the vision of "Superior Air Power" and the mission of "Defending the Sovereignty and Integrity of the Nation and Its Interests through the Effective Use of Air Power", will continue to ensure the safety and security of the country, especially to ensure political, economic and national prosperity stability to bring Malaysia towards a developed nation. Thus, as an organization that has existed for the past 67 years (1958 - 2025), the RMAF has gone through various developments in human development, organizational structure, and defense equipment in line with the outlined concept Capability Development Plan 2055 (CAPP 55).

Capability Development Plan 2055 emphasises the need for modern, sustainable and mission-ready defence assets, which directly emphasises the importance of a robust logistics support system. It also has the potential to be a key driver in the transformation of readiness at the strategic level. Efficient inventory management ensures timely availability of spare parts, engineering support strengthens maintenance response, and Integrated Logistics Support (ILS) maintains the readiness and capability of TUDM assets. It will impact on efficient spare parts and support management, efficient maintenance cost management, operations and training (CAPP 55, 2021).

When these elements operate cohesively, they increase aircraft availability, reduce operational downtime, and strengthen long-term force readiness. Therefore, aligning logistics transformation with capability development priorities ensures that the future TUDM platform remains reliable, supportable, and strategically resilient for TUDM asset readiness, focus on operations, and operational outcomes (CAPP 55, 2021).

Logistics elements are seen as one of the most important enablers in ensuring operational readiness and sustainability in the TUDM. Logistical support for modern assets requires the use of advanced logistics management approaches and techniques (Magee, et al., 1985). Despite having qualified, trained and experienced logistics personnel, the TUDM Logistics Division has always struggled to provide support. This is mainly due to the constraints of aircraft management and maintenance. The TUDM to carry out all the tasks and roles that have been entrusted.

The overall goal and role of the TUDM is to maintain and protect the interests of the country by preparing and mobilizing its forces that are always ready and capable of projecting the strength of air power (TUDM, 2020). The TUDM must be responsible for carrying out the following tasks as one of the defense components of the ATM, the TUDM is responsible for carrying out the following tasks:

- a. Maintain control of sovereign airspace during peacetime and prevent enemy aggression. This will involve offensive air strikes, defensive counter-air and defensive suppressive operations.
- b. The use of force against any threat on the surface, whether on land or in the air. This would involve strategic strikes, maritime operations and strikes.
- c. Increasing the strength of the TUDM to enhance its superior air and ground force capabilities, which will involve aerial refueling operations and missions, air and ground

transport missions, surveillance and reconnaissance, electronic countermeasures and air warfare rescue operations.

d. The resilience of the force to successfully carry out operations will involve base defense, efficient and rapid logistical assistance, and basic support to provide essential services to the TUDM organization and staff.

The term "Integrated Logistics Support" describes a management strategy that ensures the availability, functionality, and operability of military assets, particularly aircraft, and maintainable throughout their life cycle (Shukla et al., 2014). ILS encompasses everything from initial design and acquisition to maintenance, military upgrades, and ILS maintenance is essential. ensuring that aircraft can be serviced, tested, and repaired efficiently and reliably, ensuring mission readiness at all times.

Globally, ILS has become an established approach in the military and defense industry to optimize the performance, cost-effectiveness and operational continuity of assets. However, while ILS principles have been widely implemented in leading air forces such as the United Kingdom, Australia, and the United States, empirical research looking at the quantitative relationship between ILS components and aircraft performance in the context of the TUDM are still lacking. Existing research in Malaysia tends to focus on defense procurement, supply chain challenges, or general maintenance efficiency, but few studies have statistically examined how efficient inventory management, engineering support and ILS collectively influence the optimization of aircraft readiness performance. This gap highlights the urgent need to provide empirical evidence on how these interconnected systems can contribute to the enhancement of the TUDM overall operational and mission capabilities.

In recent years, the geopolitical landscape has witnessed significant changes, with emerging security threats requiring more agile and responsive military forces. Military organizations around the world have recognized the need to adapt to these evolving challenges, and resource management, inventory management, engineering support based on ILS management are essential to achieving the strategic and tactical objectives of a mission and operation. Furthermore, the complexity of modern military missions and operations requires the seamless integration of air capabilities. Resource efficiency is a critical component in the overall effectiveness of improving the performance levels of TUDM operational aircraft, and it often determines the success of joint operations.

Resource efficiency is a key component in the overall effectiveness of improving the performance level of the TUDM operational aircraft, and it often determines the success of joint operations. Current and future operations by the ATM will continue to be carried out in the context of joint operations, under the command and control of the Markas Angkatan Bersama (MK AB). The concept of joint operations is the integration of troops and the merging of assets of all three ATM Services, which are assigned under the command of MK AB such as Ops Daulat, Ops Sempadan, Ops Pasir and others. Future conflicts are hybrid and multi-dimensional in nature that require the mobilization of joint forces in all domains to win the conflict. This will encompass all stages of the military process; from research to acquisition to operational execution; regardless of single or multiple domain activities. This joint force concept is very important to achieve maximum synergy of the ATM group (KPP, 2020).

Maintaining the mission and operational readiness of its diversified fleet of aircraft presents the TUDM with difficult and important problems. To guarantee the long-term viability, capability, and efficacy of the TUDM aircraft, an efficient inventory management plan and engineering

support based on ILS management are crucial. This paper outlines a strategic framework for managing the logistics of the TUDM aircraft from acquisition to retirement, focusing on a holistic, data-driven and collaborative approach. By integrating all elements of logistics, including maintenance planning, supply chain management, technical data and training, the TUDM can optimise resource allocation, minimise downtime and extend the service life of its aircraft. The proposed strategy emphasises the importance of an aircraft performance improvement perspective, early and ongoing engagement with Original Equipment Manufacturers (OEMs) and suppliers, and leveraging modern technology to achieve a more efficient and resilient logistics support system (Emma, L, 2025).

1.1 Background of the Study

The operational performance of the air force is highly dependent on the efficiency and reliability of its aircraft fleet. The operational effectiveness and readiness of a military air force depends not only on sophisticated aircraft and skilled personnel but critically on the logistics and support systems that sustain those assets (Lambert, 2020). For the TUDM, maintaining high aircraft performance is not just a matter of advanced technology or pilot capabilities but is rooted in the strength of its logistics and maintenance systems.

In military aviation, the variables represent inventory management, engineering support, and ILS management represent the backbone of operational readiness. When these systems function effectively, aircraft availability, mission success rates, and maintenance turnaround times can be significantly optimized. Conversely, inefficiencies in these areas often result in extended aircraft downtime, higher operating costs, and reduced mission capabilities, all of which directly affect the nation's defense readiness. In modern air forces, inventory management, engineering

support, and ILS practices serve as critical pillars in maintaining aircraft availability, reliability, and mission readiness. (Vaskić, L., & Paetzold, K., 2021).

The past TUDM largely relied on traditional maintenance practices, fragmented inventory processes, and limited integration between logistical elements, which often constrained readiness and responsiveness (Syed Mustapa, et al., 2020). Manual inventory management can compromise the availability of spare parts and at the same time this situation has disrupted the operational readiness of the TUDM. After the establishment of the TUDM for 74 years, modern TUDM Operations have emphasized efficient inventory management, a stronger engineering support framework, and structured ILS to maintain technologically advanced aircraft systems. These developments reflect a shift towards capability-based planning and increased national sustainment capacity, aligning logistics transformation with the priorities of sustainable strategic defense modernization (Ab Rahman, 2021).

In light of contemporary air defense operations due to aging platforms, complicated maintenance requirements, and disturbances in the worldwide supply chain, the TUDM is facing more and more difficulties in maintaining the availability and dependability of its fleet of aircraft in the context of contemporary air defense operations. Due to aging platforms, complicated maintenance needs, and disruptions in the worldwide supply chain, the TUDM is finding it more difficult to maintain the preparedness and dependability of its fleet of aircraft. Purchasing delays for replacement parts, inadequate engineering coordination and inadequate integration between logistics support systems can result in Aircraft on the Ground (AOG) incidents, limiting the readiness and sustainability of the fleet. Efficient inventory management guarantees that critical components are available when required, while enhanced engineering support increases the technical capacity to maintain and repair aircraft promptly. Both aspects are further strengthened

by the implementation of ILS a comprehensive management framework that coordinates maintenance, supply, engineering and logistics activities throughout the aircraft life cycle.

Effective inventory control can minimize downtime by always ensure critical components and spare parts are available when needed and avoid mission delays caused by procurement shortages or bottlenecks (Zhu, et al., 2022). Failure or inefficiency in inventory control can lead to Aircraft on the Ground situations where the aircraft becomes inoperable while awaiting parts or overall repairs, thereby degrading overall performance and availability.

In parallel, engineering support is essential to play its role in ensuring the technical reliability and maintainability of military aircraft. An effective engineering system facilitates fault diagnosis, corrective and preventive maintenance, component modifications, and life cycle monitoring. Strong engineering capabilities reduce maintenance Turnaround Time (TAT) and increase Mean Time Between Failures (MTBF), directly improving the performance and sustainability of the aircraft fleet.

This study contributes to the scholarly conversation on military logistics and systems management from a theoretical standpoint by offering a quantitative analysis of the relationship between logistics efficiency, engineering performance and operational outcomes. It advances our understanding of integrated systems engineering, military operations research, and aerospace logistics management, offering insights into how different logistical factors interact to optimise performance in a complex defence environment. The findings are expected to enrich existing logistics integration models by contextualising them within the unique operational and organisational structure of the TUDM.

In practical terms, defence planners, policymakers and TUDM management can benefit from this valuable research. By identifying the logistics and engineering factors that most strongly influence aircraft performance, this study offers an evidence-based framework for improving resource allocation decision-making, maintenance planning and system integration. Understanding the relationship between EIM, IES and ILS provides significant benefits to defence planners, policymakers and the TUDM. For planners, it supports evidence-based capability development, resource prioritisation, increased asset availability and cost savings. Policymakers benefit from clearer justification for investment, better sustainment strategies and stronger governance of life-cycle costs that can have long-term impacts (Mont, O., & Bleischwitz, R., 2007).

For the TUDM, integrated logistics enables higher aircraft availability, reduced turnaround times, improved maintenance reliability and long-term operational sustainability. Collectively, these advantages can be applied to all three ATM services and can implement this study for all ATM assets. It will also strengthen the nation's defense readiness and ensure that modern air power capabilities are effectively supported throughout their service life.

By identifying the logistics and engineering factors that most strongly influence aircraft performance, this study offers a framework based on evidence to enhance resource allocation decision-making, maintenance planning, and system integration. Improving the efficiency of these processes can lead to shorter maintenance cycles, higher aircraft availability, and better cost-effectiveness in sustaining air operations (Kabashkin, et al., (2024). Ultimately, the results will support the TUDM strategic goal of achieving mission readiness and operational excellence through data-driven and systems-oriented logistics management and engineering support functions.


Reinforcing these two elements is ILS, a systematic management method designed to integrate logistics, maintenance, and supply functions across the entire life cycle of a weapons structure (Vaskic & Paetzold, 2019). Under the ILS framework, supportability, maintainability, reliability, and supply chain integration are planned and managed from the design stage through in-service operations (Shukla, et al., 2014). In aerospace and defense sectors, the implementation of ILS has been shown to enhance operational reliability, reduce life-cycle costs, and strengthen mission readiness by aligning technical, logistics, and engineering functions into a cohesive system (Vaskic & Paetzold, 2019).

However, despite the proven success of ILS in advanced military systems globally, empirical studies examining the quantitative relationship between EIM, IES and ILS implementation remain scarce, particularly in Southeast Asia. Regarding the TUDM, maintaining high aircraft performance continues to present challenges such as supply chain delays, engineering coordination gaps, and fragmented logistics management. The Ministry of Defence Malaysia's (2020), KPP emphasizes how crucial it is to change the armed forces into an integrated defense system that is supported by efficient logistics and engineering infrastructures. It explicitly calls for modernization of support systems and enhanced cooperation between military and industry partners to sustain readiness (KPP, 2020).

The National Defense Policy (NDP, 2019), One of the strategic focus areas is to develop the local defense sector as a catalyst for the economy, reducing foreign dependence. It emphasizes the importance of transforming the armed forces into an integrated defense system supported by efficient logistics and engineering infrastructure. The policy emphasizes the development of autonomous defense capabilities to reduce dependence on foreign suppliers, especially in Maintenance, Repair and Overhaul (MRO) operations. It explicitly calls for the modernisation of

support systems and increased collaboration between the military and industry partners to maintain readiness (Batau, et al., 2020).

Malaysian organizations such as AIROD Sdn. Bhd., Zetro Aerospace and Defence Sdn Bhd., and Aerospace Technology Systems Corporation (ATSC) exemplify national efforts to strengthen local Maintenance, Repair, and Overhaul and technical support for the TUDM aircraft fleet. Yet, the efficiency of these support systems depends on the degree of integration between inventory control, engineering operations, and ILS management. Studies of Malaysia's defense logistics ecosystem reveal persistent issues such as limited integration, unclear role delineation, and resource constraints that reduce operational effectiveness (Ab Rahman, 2021; Abdullah, 2022).



From an academic perspective, this study introduces a quantitative relationship

framework to fill a significant gap in the literature to examine the interaction between EIM, IES and ILS management as determinants of aircraft performance optimization in the TUDM. While international studies have acknowledged these variables individually, few have empirically tested their interrelationship in a Malaysian military setting. The study will therefore contribute to the development of defense logistics theory, particularly within the fields of integrated systems management, aerospace logistics, and military logistics performance (Loska, et al., 2025).

Practically speaking, the results will provide defense planners and TUDM decision-makers with evidence-based insights to enhance aircraft maintenance policies, improve coordination between engineering and logistics divisions, and develop integrated life-cycle support strategies. Identifying which factor most strongly influences aircraft performance will

allow the TUDM to improve readiness rates, reduce downtime, and optimize operational efficiency, aligning with Malaysia's broader defense modernization objectives.

In conclusion, by analyzing the relationship between ILS management, engineering support improvements, and inventory management effectiveness as factors influencing logistics performance in the TUDM, this study also fills a significant gap. This study advances scientific understanding by bridging the gap between academic theory and real-world applications. It also offers practical recommendations to enhance Malaysia's air defense capabilities through effective integration of logistics and engineering systems to strengthen the TUDM capabilities.

1.2 Problem Statement

The operational readiness of an air force is fundamentally determined by the reliability and availability of its aircraft fleet (Lambert, 2020). Within the TUDM, ensuring high levels of logistics performance has become increasingly challenging due to the complexity of maintaining aging aircraft, fluctuating operational demands, and constraints in logistics and engineering resources (MINDEF, 2020). The TUDM maintenance, repair, and overhaul ecosystem supported by entities such as AIROD Sdn. Bhd. and the ATSC has faced persistent issues including supply chain delays, resource limitations, and gaps in technical integration. These inefficiencies often lead to Aircraft on Ground incidents and reduced fleet availability, undermining mission readiness and operational effectiveness.

The timely availability of spare parts, critical components and consumables critical for aircraft maintenance is an important factor in effective inventory management (Shukla, et al., 2014). However, within Malaysia's defense logistics framework, inventory management continues to face challenges such as limited automation, inadequate demand forecasting, and bureaucratic

procurement processes (Abdullah, 2022). These inefficiencies often result in extended maintenance cycles, high operating costs, and reduced aircraft utilization rates. Similarly, the engineering support function, which ensures that technical systems are serviceable and airworthy, encounters difficulties in manpower specialization, diagnostic capability, and coordination with logistics units (Ab Rahman, 2021). Weak engineering-to-logistics alignment further contributes to delays in maintenance turnaround time and limits the capacity to sustain mission readiness.

To address these systemic issues, many defense organizations globally have adopted Integrated Logistics Support as a complete life-cycle management framework to optimize operational performance (Vaskic & Paetzold, 2019). ILS integrates key components such as inventory, maintenance, and engineering functions to ensure reliability, maintainability, and cost-efficiency across the system life cycle (Shukla, et al., 2014). Nevertheless, despite ILS being incorporated conceptually within Malaysia's defense modernization strategy, empirical validation of its impact on operational performance within the TUDM remains limited (MINDEF, 2020).

The National Defence Policy and the KPP both emphasize the importance of enhancing logistics efficiency and achieving self-reliance in defense support capabilities. Yet, reports and academic assessments indicate persistent structural weaknesses such as unclear delineation of logistics roles, fragmented data management, and underdeveloped integration between engineering and inventory systems (Ab Rahman, 2021; Abdullah, 2022). These issues highlight the ongoing disconnect between policy aspirations and operational implementation, underscoring the need for empirical evidence on how logistics and engineering functions interact to effect logistics performance within the TUDM.

From a theoretical stance, existing research on defense logistics and ILS management in Malaysia remains predominantly descriptive and policy-based, with few quantitative studies

testing causal or correlational relationships among key logistics variables (Abdullah, 2022). There is thus a significant research gap concerning how EIM, IES and ILS management collectively influence logistics performance in a Malaysian military aviation context. Without such evidence, decision-making within the TUDM continues to rely on experience-based approaches rather than data-driven analysis, limiting opportunities for predictive maintenance, life-cycle optimization, and integrated logistics planning (Lambert, 2020).

Despite ongoing modernization, the TUDM continues to face logistical challenges arising from inefficient inventory practices, limited engineering support capacity, and a poorly adapted ILS structure. These weaknesses can lead to risks of longer maintenance downtime, inefficient maintenance, high life cycle costs, lower aircraft availability, and higher operating costs. (Ab Rahman, 2021). From a practical perspective, the absence of an empirical model linking these operational variables hinders the TUDM ability to prioritize investments and optimize resource allocation.

Limited quantitative evidence remains a critical gap in understanding how EIM, IES and ILS collectively influence logistics performance in the TUDM. Despite a large body of descriptive literature, quantitative validation of the relationship between logistics efficiency, engineering reliability, and performance outcomes remains underdeveloped, particularly in Southeast Asian defense organizations (Ab Rahman, 2021). Much of the existing knowledge is conceptual or policy-driven, with insufficient empirical validation to measure its direct and interactive impact on system readiness, cost-efficiency, and reliability. Therefore, strengthening quantitative research is essential to validate claims and support informed decision-making in the military logistics environment (Blanchard, 2004).

Inconsistent logistics performance measurements arise when different indicators, reporting standards, and evaluation frameworks are used across the domains of EIM, IES and ILS, leading to inconsistent assessments of readiness and effectiveness. Previous research may have encountered a lack of standardized metrics (MC rates, TAT, MTBF, AOG duration), hindering cross-study comparisons (U.S. GAO, 2022). Such variability complicates benchmarking, obscures true levels of capability, and undermines evidence-based decision-making in military logistics environments.

Therefore, this study aims to conduct research how the logistics performance of the TUDM is influenced by EIM, IES and ILS management. Using quantitative analysis methods, this research aims to identify the most influential determinants of logistics performance and to provide actionable insights to strengthen the TUDM logistics and engineering systems. In summary, the study will bridge the empirical gap in defense logistics research and contribute both academically by developing quantitative evidence on logistics performance relationships and practically, by guiding the TUDM in achieving enhanced operational readiness through logistics performance optimization.

1.3 Research Objectives

The primary objective of this study is to examine how the logistical performance of the TUDM is impacted by EIM, IES and ILS management. The research objectives are:

- a. To determine the relationship between EIM and Logistics Performance.
- b. To determine the relationship between IES and Logistics Performance.
- c. To determine the relationship between ILS management and Logistics Performance.
- d. To determine the relationship between EIM and IES.

- e. To determine the relationship between IES and ILS management.
- f. To determine the relationship between EIS and ILS management.

1.4 Research Questions

- a. What is the relationship between EIM and Logistics Performance in the TUDM?
- b. What is the relationship between IES and Logistics Performance in the TUDM?
- c. What is the relationship between ILS management and Logistics Performance in the TUDM?
- d. What is the relationship between EIM and IES in the TUDM?
- e. What is the relationship between IES and ILS management in the TUDM?
- f. What is the relationship between EIM and ILS management in the TUDM?

1.5 Scope of the Study

This study focuses on the relationship between efficient inventory management, effective engineering support to TUDM aircraft with emphasis on system-based inventory management such as Sistem Pengurusan Komputer Bersepadu (SPKB). This research will focus on analyzing current inventory management practices, predicting maintenance needs and reducing aircraft downtime, to identify challenges and inefficiencies (Alomar, I., & Nikita, D., 2025). The target population of this study consists of TUDM officers and personnel, inventory managers, operations supervisors and logistics professionals, especially those directly involved in TUDM inventory management. This includes personnel responsible for managing or overseeing the accuracy of inventory and tracking systems, such as SPKB. The effectiveness and efficiency of ILS management in TUDM will also be examined in relation to contemporary technologies, including

cloud computing, inventory management systems, radio frequency identification (RFID), artificial intelligence (AI), the Internet of Things (IoT), and predictive maintenance systems.

Since the inventory management and engineering support of the TUDM aircraft involves the collection and analysis of a large amount of data, this study aims to collect aircraft inventory data that will increase the awareness of inventory managers and operators at the Depoh Materiel Utama (DMU), Materiel Udara (MATRA), Flait Khas Udara (FKU), Engineering Branch and Materiel Branch regarding attitudes towards safety and security issues. Basically, the authority for the approval of inventory management, procurement and repair of aircraft spare parts is under the supervision of the Markas Pemerintahan Bantuan Udara (MPBU). Decision Policy for TUDM aircraft and the process in aircraft maintenance management also involves the concerns of the MPBU, Engineering Branch and external contractors.

The scope of this study aims to contribute basic knowledge in assisting the TUDM actual inventory management and engineering support based on ILS management from practitioners who face challenges every day, thus increasing the validity, relevance and applicability of the study findings. The combination of these elements is believed to be able to improve the readiness of TUDM aircraft. EIM is a symbol of systematic control of spare parts availability, stock accuracy, and planning for replenishment of depleted stocks and supporting the implementation of timely maintenance. IES can improve maintenance reliability through structured maintenance planning, effective technical expertise, and configuration control. It can help reduce aircraft downtime and maintain optimal levels of readiness. Meanwhile, ILS aligns inventory management, engineering, documentation and life cycle management to ensure that aircraft systems remain supportable and cost-effective throughout their operational life (Eski, S., & Özaslan, İ. H., 2022).

This approach will ensure inventory management, demand forecasting, supply chain optimization, and the availability of needed spare parts at the right time, while controlling costs and ensuring mission readiness. The combination of these variables can impact logistics performance by strengthening readiness, ensuring aircraft can continue to operate with minimal disruption, and ensuring resource efficiency in a military aviation environment.

1.6 Limitation of the Study

This study has several problems that could compromise the accuracy and reliability of the findings. First, when utilizing stratified random sampling, there is a possibility that the sample selected may not be fully representative of the greater population. Officers and personnel of the TUDM are involved in inventory management and engineering divisions. This may result in biased findings that fail to capture the diversity of experiences across different ranks and units within the TUDM. Second, data collection errors are some of the potential limitations caused by the reliance on self-reported questionnaires. Respondents may misunderstand questions, provide inconsistent answers, or lack attention to detail, which may affect the validity and reliability of the data collected.

Additionally, constraints may limit the depth and thoroughness of data collection and analysis, potentially leading to hasty conclusions or overlooking details that could otherwise enrich the study's insights. Finally, non-response bias is a concern, as low response rates or response patterns dominated by certain groups, such as senior officers, may skew the results. This would prevent the findings from accurately reflecting the views of all officers and personnel in the TUDM inventory management and engineering divisions, thus impacting the generalizability of the study's conclusions.

The focus of this study is to investigate issues related to EIM, IES and ILS management to improve the performance and usability of TUDM aircraft and enhance the national defense capability to maintain Malaysia's sovereignty. It should be fully monitored by MPBU as the headquarters responsible for inventory management, procurement and repair of TUDM aircraft with the motto "So They Fly". As a result, the information available from this source may be limited. In addition, given the time constraints of this research, there may be some aspects that lack thorough analysis, which can be explored in future studies on similar topics.

1.7 Significance of the Study

The significance of the study is to determine the relationship between the variables of EIM, IES and ILS on Logistics Performance. It will also emphasize the importance of strategic readiness by proposing a comprehensive ILS management system plan for inventory management and engineering support. This roadmap serves as a proactive measure against potential operational disruptions, providing the TUDM with a structured approach to aircraft inventory management, maintenance scheduling and financial resource allocation. Such strategic foresight is essential in maintaining continuous training and operational readiness and availability amidst the rapidly evolving security scenario (Sandu N., 2024).

From a variety of theoretical, practical and policy perspectives, this study is important for the TUDM in broader strategic considerations and has direct implications. First, this study focuses on inventory control and engineering support for TUDM aircraft while addressing critical issues. It aims to support the TUDM missions and operations by improving effectiveness and efficiency based on ILS management. By identifying and reducing inefficiencies in inventory management and engineering support, maintenance practices and technology integration, this study can

contribute to improving aircraft performance and producing a more elite, agile and responsive TUDM team that is capable of effectively addressing dynamic security challenges in the future.

Second, the optimization of inventory management practices and ILS based engineering support proposed in this research is in line with the budgetary constraints faced by the TUDM organization. (Lopes R. M., 1986). Through efficient inventory management strategies, proactive maintenance and the incorporation of modern technology, the TUDM can achieve cost savings and ensure responsible resource allocation. These financial savings are important to maintain the TUDM capabilities while managing limited resources.

A key strategy in modern aerospace operations is the involvement of ILS, which ensures that complex systems are operational, sustainable and cost-effective over time. The key elements of ILS ensure that the TUDM can operate and maintain aerospace systems with minimal waste of resources. This paper also provides a deeper understanding of inventory management and ILS and its role in enabling proactive engineering support strategies to optimize aircraft performance benefits.

The aim of this study is also to analyze the current role of TUDM facilities in inventory management and engineering support and propose improvements that can improve the life performance and sustainability of aircraft in the TUDM logistics ecosystem. Comparative analysis of international best practices provides valuable insights that can be applied to military organizations worldwide (Okromtchedlishvili I., 2024). By sharing successful lessons and strategies, this research contributes to a collaborative approach in inventory management and engineering support that is enhanced based on ILS management to logistics performance optimize, foster advancements in military logistics and enhance national security on a broader scale.

1.8 Chapter Summary

Chapter one lays the foundation for the study by examining the weaknesses in the relationship between EIM, IES and ILS management towards improving the logistics performance of TUDM and how these shortcomings affect the operational readiness and national security. It highlights the challenges posed by budgetary constraints, complex processes and evolving security demands, emphasizing the need for efficient inventory management practices and good engineering support. This study aims to analyze the key process factors, workforce, leadership, relationships and resource allocation that influence the efficiency of aircraft inventory management and preservation (Gallego-García, et al., 2021). Focusing on the unique context of the TUDM, this chapter highlights the importance of optimizing resources to improve transparency, accountability and effectiveness in aircraft inventory management and engineering support based on ILS management. It also outlines the study objectives, framework and methodology, providing a roadmap to understand how targeted reforms can improve ILS management practices to aircraft performance optimise of TUDM and contribute to the defense preparedness of Malaysia.

1.9 The Organisation of the Study

This research organized into five chapters, each structured to align with established academic conventions in postgraduate research and to ensure a logical flow of information. According to recent studies in logistics and operations management, structured chapter development enhances coherence and reader comprehension in empirical research (Noor & Hamzah, 2023; Tan & Ibrahim, 2022). The first chapter provides an overview of TUDM, background of the study, highlights problem statement section, scope of the study, limitations of the study and provides its significance. The second chapter includes a literature review conducted on the relationship between EIM, IES and ILS on the logistics performance of the TUDM, research framework and

the theoretical framework. Meanwhile, chapter three provides details on the methodology; the quantitative research methodology was taken through an online survey conducted with TUDM personnel working in the fields of logistics and engineering to obtain their experiences and opinions on the advantages and challenges of inventory management, engineering support and ILS in the TUDM. Chapter four discusses the analysis that was carried out based on the data obtained during the survey. Finally, chapter five discusses the findings, recommendations, directions for future research, implications, limitations, and finally conclusions. This structure reflects best practices in postgraduate research reporting (Noor & Hamzah, 2023).



CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The literature review in the same field of research as the current study is the main topic of this chapter. It will also discuss the definition and conceptual variables, hypothesis development, theoretical framework and basic theories (Varpio, et al., 2020). Inventory management, enhanced engineering support based on effective ILS management and its implementation are crucial in ensuring the improvement of TUDM logistics performance to successfully carry out all missions and operational activities.

The goal of integrated logistics support is to guarantee the availability and preparedness of aircraft systems, particularly in the context of military aviation like the (Shukla, et al., 2014). ILS includes a number of logistical components, such as life cycle support, supply chain management, and maintenance, all of which are intended to maximize operational effectiveness and lower expenses.

2.1 Definition of Logistics Performance

Logistics performance describes an organization's capacity to effectively plan, control, and execute logistics activities in support of operational objectives. In terms of the TUDM, logistics performance is assessed by the capability of the logistics system to ensure the continuous availability of aircraft, spare parts, ground support equipment, and technical services required to sustain air operations (Shukla, et al., 2014). High logistics performance directly impacts mission readiness, number of operations, overall aircraft reliability.

In the context of the TUDM, logistics performance is typically measured by indicators such as aircraft availability rates, maintenance turnaround times, supply responsiveness, cost efficiency and supportability throughout the system life cycle. Good logistics performance ensures that maintenance and operations units get the resources they need on time, in the right quantities and at a reasonable cost (Gattorna, et al., 1991). This is particularly important given the complexity, high value and long lead times associated with TUDM aviation assets.

Furthermore, logistics performance in the TUDM is not limited to efficiency alone but also encompasses effectiveness and sustainability. It illustrates the logistics company's capacity to consistently maintain operations amid changing and dynamic operational tempos while complying with safety, airworthiness and regulatory requirements. As a result, strong logistics performance is essential to maintain long-term airpower capabilities and meet national defense objectives as well as safeguarding airspace sovereignty (MINDEF, 2019).

2.2 Definition of Inventory Management

The methodical process of supervising and regulating purchasing, storing, and using components and completed commodities utilized by a company in its activities is known as inventory management. Inventory management, which focuses on maintaining the right quantity of items on hand at the right time, is another essential part of supply chain management. To guarantee that the correct products are accessible in the right number, at the right time, and at the right cost, it entails maintaining ideal stock levels, thereby balancing the competing goals of customer service and operational efficiency (Jean G., 2024). Effective inventory management purposes to reduce the expenses related to surplus inventory while optimizing sales and at the same time preventing stockouts.

2.3 Definition of Engineering Support

Human engineering, manufacturing, Reliability, Availability, and Maintainability (RAM), standards, interoperability, survivability, vulnerability, and the configuration management process, test and evaluation, testability, and airworthiness are all included in this engineering support (Blanchard, B. S., 1999). The Concept and Acquisition stages of a project offer the best chance to impact the system design for supportability. Engineering support is implemented through both the Logistics Support Analysis (LSA) and Systems Engineering processes (Knox, J. A., & Thede, T. N., 1983). The goal of engineering support is to emphasize the scope of performance in the design process and recognize the need for logistical provisioning requirements to influence system design requirements and the design process. Engineering support has been defined as the process, practice, profession, and application of scientific knowledge. However, if engineering is an application of scientific knowledge, there is an implicit assertion that it is impossible to make calculations with precise engineering knowledge.

Engineering support is a factor that encompasses all the considerations needed to ensure design integrity throughout the life cycle of a material system. The main role of engineering support is to emphasize the scope of performance in the design process and recognize the need for logistical provisioning requirements to influence system design requirements and the design process (CSKL, 2009).

2.4 Definition of Integrated Logistics Support

ILS is a structured management approach designed to ensure that complex systems are efficiently supported throughout their entire life cycle, from asset or system acquisition to disposal. According to the Defense Acquisition University (DAU), ILS focuses on the planning and execution of the

logistics processes required to support a system from concept to retirement (Hagan G. J., 2001). It will integrate elements such as maintenance planning, supply support, technical documentation, workforce considerations, and training to ensure system readiness, reliability, and sustainability. The fundamental principle of ILS is to design supportability into the system from the earliest stages rather than reactively addressing logistics needs after deployment. This proactive integration will help minimize disruption to operations while ensuring the availability of mission-critical assets in demanding environments such as military aviation operations (Blanchard, 2004).

The importance of ILS is crucial in military organizations as it directly affects operational readiness, cost efficiency and overall logistics performance. Effective implementation of ILS will reduce life cycle costs, improve maintenance effectiveness, increase spare parts availability, and strengthen system reliability, contributing to continued mission and operational capabilities. For the TUDM, ILS supports fleet availability, timely maintenance recovery, and optimal resource utilization, thereby enabling the TUDM to ensure operational continuity and strategic readiness. Furthermore, by incorporating logistics considerations into engineering and operational decision-making, ILS can foster long-term sustainability and structural performance improvements in a dynamic defense logistics system (Hardt H., 2017).

2.5 Integrated Logistics Support & Systems Engineering

Integrated Logistics Support, based on systems engineering principles, provides an organizing logic for life cycle support (maintenance planning, provisioning, technical data, training) that is often embedded in systems engineering and Product Lifecycle Management (PLM) toolchains for aerospace/defense systems. Empirical papers and reviews since 2019 show that ILS maturity is associated with improved sustainment outcomes and cost control to improve reliability, readiness,

and capability, thereby reducing operational challenges in military environments (Ivanov et al, 2024).

According U.S. Government Accountability Office (2022) Reliability-Centric Maintenance and Predictive Maintenance are engineering-based approaches that ensure systems function reliably under operational stress (U.S. GAO, 2022). These frameworks extend ILS principles into the maintenance domain by integrating diagnostics, sensors, and data analytics to predict component failures. However, Mustafa M. A. S. (2025) find inconsistent implementation of PdM programs across aircraft fleets, citing inadequate data analytics capabilities as a challenge reflected in many developing defense organizations (Mustafa M. A. S., 2025).

Dynamic capability in the military supply chain refers to the ability to sense operational demand, integrate logistics resources, and reconfigure inventory, engineering, and ILS processes to maintain logistics readiness and performance in an evolving defense environment (MINDEF, 2020). The 2025 Synthesis argues that MSCL performance depends on tracking and reconfiguring capabilities, e.g., agile parts sourcing, rapid MRO capacity adjustments under supply shocks. This lens explains the rationale for integrating inventory and engineering to improve readiness under fluctuations (Kelka H., 2024).

According to government and defense studies, predictive analytics can improve mission and operational capabilities and reduce downtime. Reliability-centric and predictive maintenance will emphasize condition-based assessments, proactive fault detection, and optimized maintenance scheduling to maintain asset availability while reducing downtime and life-cycle costs. However, because many projects lack reliable performance indicators, inconsistent real-world benefits have been demonstrated to date. This approach can improve inventory accuracy, engineering effectiveness, and ILS integration to strengthen logistics performance (Blanchard, 2004).

2.6 TUDM Scenario

One of the branches of the Angkatan Tentera Malaysia for air combat is the TUDM and was established in 1957, now the TUDM has developed into a modern and technologically advanced air force, in line with the main goal of protecting the sovereignty of Malaysian airspace and providing air support to the country's defense and security needs during peace and war. The overall role of the TUDM is to help prepare, operate and mobilize an air force that is always ready and capable of projecting superior air power to preserve and safeguard the interests of national sovereignty with strong air power.

The role and responsibility of the TUDM is to defend and protect Malaysian airspace from external threats and maintain air superiority. The TUDM also provides air support to the Malaysian Army and Royal Malaysian Navy in conducting joint exercises and operations such as Ops Daulat, Ops Benteng, Ops Sempadan, Ops Belasah and other operations. In addition, the TUDM also provides air support for humanitarian aid and disaster relief operations such as Ops Murni, Ops Pyramid, Ops Haiyan and other operations directed by the Majlis Keselamatan Negara (MKN). Search and rescue operations are also carried out by the TUDM for civilians and military personnel.

In the TUDM, Capability development plan (2025), it calls for implementing efficient inventory management and sustainable support system management to maintain asset readiness. Quantitative work in the TUDM shows that procurement efficiency is a measurable determinant of support performance, with resource and relationship factors clearly demonstrating that data-driven logistics improvements can be implemented in the TUDM environment.

In conducting aviation operations, the TUDM faces several challenges that need to be addressed to successfully conduct various TUDM operations. The most important challenge is financial constraints which are often the main obstacle to the acquisition of new assets, maintenance, and technology upgrades. The TUDM also faces challenges in acquiring modern combat aircraft, air defense systems, and new platforms (such as unmanned aerial vehicles/UAVs) which are expensive to face today's cyber warfare competition. In addition, the lack of technology to integrate new technologies and ensure combat capabilities are always relevant to the development of global air defense (Bernama, 2025). Furthermore, core challenges relate to maintaining high aircraft availability while managing aging platforms, limited spare parts access and complex maintenance demands.

Security threats are also a challenge for the TUDM as it needs to be constantly prepared to deal with security threats in the region including territorial disputes and terrorism. The TUDM also faces Limited Resources such as budget constraints, which can limit its ability to modernize and upgrade its fleet. These factors contribute to prolonged turnaround times, increased maintenance burdens and cost pressures, especially when the logistics structure is not fully integrated across engineering, inventory and life cycle support systems (Blanchard, 2004).

In addition, the TUDM also faces evolving logistical and operational challenges as it moves towards a modern and technologically advanced airpower capability. Reliance on external maintenance providers and international Original Equipment Manufacturers introduces coordination issues, technical dependencies and potential delays in support responsiveness. Capacity constraints, skills availability, and the need to strengthen indigenous technical expertise also pose ongoing concerns in sustaining advanced aircraft systems. At a strategic level, aligning logistics modernization with capability development objectives requires stronger data-driven

planning, enhanced governance of ILS and continued investment in a systems engineering-based approach to supportability (Ab Rahman, 2021). Addressing these challenges is essential to improving logistics performance, ensuring operational resilience, and supporting the TUDM long-term readiness ambitions. In addressing these challenges, the TUDM needs to ensure consistent supply reliability while managing budgetary constraints that will further complicate the TUDM fleet sustainability and readiness planning (Bernama, 2025).

In the face of the challenges of this modern and sophisticated world, the TUDM is undergoing a modernization effort to improve its operational preparedness and skills. The purchase of modern aircraft, such as the Airbus A400M and Sukhoi Su-30MKM, is part of this endeavor. The TUDM has also been upgrading and modernizing its existing fleet, including the F/A-18D Hornet and C-130 Hercules. In addition, the TUDM is investing in training and development programs for its officers and personnel to enhance their skills and capabilities at all times.

The significance of EIM is examined in this case study, IES and ILS Management to enhance the capability and performance of the TUDM aircraft readiness. EIM, IES and ILS management are essential elements for the readiness and effectiveness of the TUDM operations. These factors can impact the availability and reliability of aircraft, as well as the safety of personnel. By adopting efficient inventory management practices, the TUDM can ensure that the right parts and materials are available when needed, reducing downtime and increasing aircraft availability. Improved engineering support can enhance the capacity of TUDM to sustain and repair its aircraft, while ILS management can ensure that the logistics support functions are integrated and effective.

The TUDM is a force that plays a critical role in maintaining the sovereignty of Malaysian airspace and providing aviation support to the nation's defense and security needs. The TUDM

noble efforts in modernization and investment in EIM, IES, and ILS management can enhance its operational readiness and effectiveness while also upholding the national mandate that has been entrusted to it.

2.7 Research Gaps

Several integrated models (Malaysia) have been conducted and most local studies are policy/descriptive; very few test the combined model of inventory efficiency, engineering support, ILS on quantitative performance outcomes in military aviation. This study addresses a significant gap in the domestic academic and professional literature on military logistics performance. While previous Malaysian research has often been descriptive or focused on a single logistics function, this investigation provides empirical, quantitative evidence for the synergy model. Specifically, it tests the impact of a combination of EIM, IES and ILS management on measurable performance outcomes in the unique context of the TUDM. As a result, it goes beyond policy discussions to offer a validated framework that can guide evidence-based resource allocation and strategic planning for defence logistics modernisation (Sokri A., 2014).

Causality and measurement are an international assessment stating that Predictive Maintenance (PdM) used within a Reliability-Centered Maintenance (RCM) (PdM/RCM) programs often lack standard performance metrics, making it difficult to attribute readiness improvements and this gap reflects Malaysia's need for rigorous KPIs (e.g., AOG hours, MTBF, MC rates). Context-specific evidence has demonstrated that there is little TUDM-specific evidence measuring how improvements in inventory and engineering coordination (e.g., TAT, spares fill rates) translate into mission and operational capability rates under the ILS framework.

2.8 Implications of this Study

By considering EIM, IES and ILS Management as distinct Independent Variables with direct impact on Logistics Performance. Using Key Performance Indicators (KPIs) as objectives where possible using mission capability rate, AOG time, TAT, MTBF, sortie completion rate addresses the metric gaps highlighted by recent surveillance reports.

This study will demonstrate that the synergistic integration of efficient inventory management, improved engineering support and ILS management are critical determinants of improved logistics performance in the TUDM. The main implication is that leadership in the TUDM must prioritize integrated systems rather than improving isolated functions. In particular, modernizing the inventory system with data analytics for inventory management demand forecasting, while simultaneously coordinating it with predictive maintenance schedules from engineering support units, and can be organized under an integrated logistics support framework to reduce aircraft downtime (Richey et al., 2022).

To realize these logistics performance improvements, personnel across logistics, engineering, and operations command require cross-functional training to foster interoperability and a shared understanding of the combined ILS philosophy (Blanchard, 2004). These people-centric implications are as important as technology investments. As a result, this study provides a validated model for policymakers to support holistic logistics transformation, ensuring that capital allocation for new assets is supported by robust integrated sustainment systems to maximize fleet availability and mission readiness (TUDM, 2021).

The literature on defense logistics, particularly in the context of air force operations, underscores the strategic importance of logistics integration, inventory efficiency, and engineering

support reliability in maintaining aircraft readiness. Despite widespread recognition of these variables, empirical studies remain fragmented, with limited quantitative evidence particularly in the context of Southeast Asian military aviation. The following section critically analyzes key theories, empirical findings, and methodological gaps from both international and Malaysian perspectives to situate this study within the existing scholarship.

2.9 Empirical Discussion

Empirical analysis reveals that optimizing inventory management in the TUDM directly improves fleet availability. Research shows that implementing demand forecasting models and selective inventory categorization can reduce stockouts of critical aviation parts by up to 30%, thereby reducing aircraft ground time (Atakari C., 2025). At the same time, advancing engineering and maintenance practices are empirically linked to improved logistics outcomes. Studies show that the use of predictive maintenance technologies, informed by real-time aircraft health monitoring data, can reduce unscheduled repairs by 20%, streamlining spare parts logistics (Mustafa, M. A. S., 2025). Furthermore, the integration of these domains through a robust Integrated Logistics Support framework is critical. Evidence confirms that ILS, when used from the asset acquisition phase, ensuring supportability considerations are embedded in the design, can result in reductions in life cycle costs. Ultimately, the synergistic application of these three pillars of inventory accuracy, engineering innovation and ILS integration forms an empirically validated strategy to significantly improve the operational readiness and logistics efficiency of the TUDM.

EIM has a proven positive relationship with operational readiness and cost efficiency (Shukla et al, 2014). Inadequate forecasting and procurement inefficiencies contribute to long Aircraft on the Ground periods and low Mission-Capable (MC) rates (U.S. GAO, 2022). Studies in commercial aviation (Setiawan, et al., 2025) also highlight that optimized inventory systems

reduce turnaround time. However, Malaysian defense logistics research remains descriptive, often lacking measurable performance metrics (Abdullah, 2022).

Engineering support directly impacts the speed and reliability of maintenance. Research in the global MRO sector shows that a shortage of skilled engineers and limited repair facilities lead to increased TAT and reduced MTBF. In the Malaysian defence context, similar challenges are evident, as reliance on external maintenance providers may introduce coordination complexity and delays in technical decision-making. This is because the TUDM reliance on external contractors (e.g., AIROD, ATSC) sometimes causes coordination delays. While these organizations enhance national self-reliance, studies have found that capacity constraints and continued reliance on original equipment manufacturers (OEMs) can impact support responsiveness and technical depth (Ab Rahman, 2021).

This engineering challenge is closely related to inventory efficiency and the ILS structure, where spare parts availability, maintenance planning, configuration control and supportability engineering must work together to maintain aircraft readiness. Ineffective alignment between engineering support and inventory systems can lead to stock shortages, delayed repairs and fragmented logistics outcomes, while an integrated ILS framework improves forecast accuracy, reliability assurance and system sustainability throughout the life cycle (Blanchard, 2004). Therefore, strengthening this three-dimensional integration is essential to maintaining the TUDM logistics performance.

The ILS literature focuses on the notion that integrating logistics and engineering functions significantly improves sustainment outcomes (Vaskic & Paetzold, 2019). However, empirical testing of ILS frameworks in developing countries is still limited. The Ministry of Defence Malaysia's (2020), KPP advocates for a unified logistics management system in Malaysia,

although it offers few information on its effectiveness. This highlights the need for operational research to assess whether ILS maturity translates into measurable performance gains in the TUDM (KPP, 2020).

2.10 Contextual Gap in Malaysian Studies

Malaysian military logistics research has focused more on procurement policies than operational logistics performance (Abdullah, 2022). A clear contextual gap exists in Malaysian defense logistics research, as limited empirical studies specifically examine how EIM, IES and ILS influence TUDM logistics performance. Therefore, the specific contributions of logistics and engineering integration to TUDM readiness have yet to be empirically explored. Most of the available evidence is derived from broader international frameworks rather than local military settings.

2.11 Theoretical Integration Deficiency

The literature rarely bridges system-based ILS with dynamic capability and reliability-centered maintenance, limiting theoretical coherence in explaining performance optimization. The logistics literature frequently addresses ILS as a systems-based framework that focuses on life-cycle maintenance, but it rarely integrates dynamic capability theory or reliability-centered maintenance perspectives. This theoretical separation limits the depth of explanation of how logistics systems adapt to uncertainty and performance fluctuations (Blanchard, 2004). As a result, ILS is often conceptualized as a static coordination mechanism rather than a capability that evolves in response to operational and environmental changes.

The lack of theoretical coherence becomes apparent when EIM, IES and ILS management are examined independently. Without integration, explanations of logistics performance fail to

capture the interdependencies between parts availability, maintenance decision-making, and reliability outcomes. Dynamic capability theory suggests that performance optimization emerges from the ongoing alignment of resources, efficiencies, and processes, reinforcing the need for a unified framework that embeds EIM and IES within an adaptive ILS structure. Lack of theoretical integration can occur when logistics frameworks do not integrate EIM, IES, and ILS management, limiting explanations of logistics performance.

2.12 Research Framework

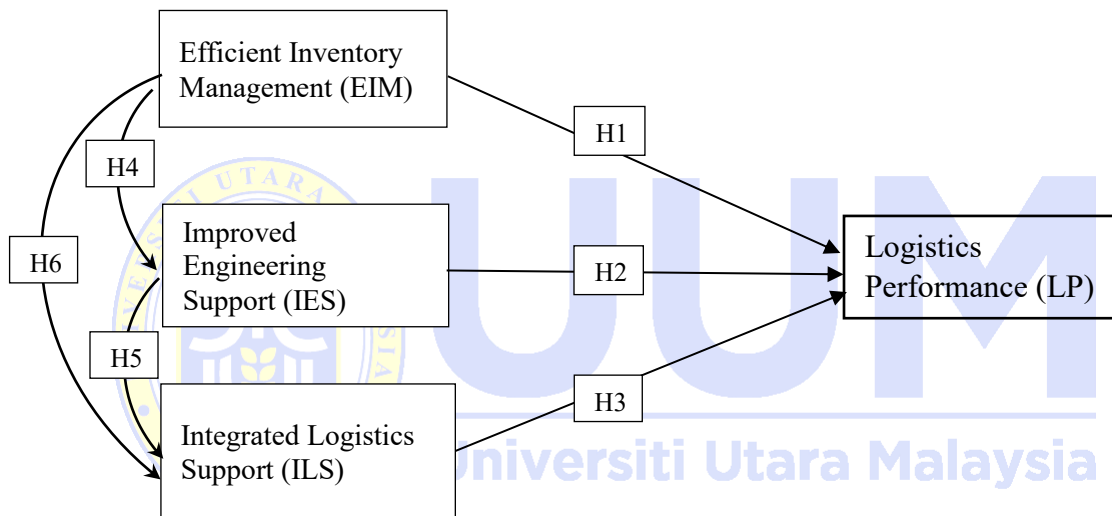


Figure 2.1: Research Framework

The theoretical underpinning that shows the connections between important study variables is a conceptual framework (Sekaran & Bougie, 2020). In this research, the framework integrates principles from Integrated Logistics Support Theory, Dynamic Capabilities Theory, and Reliability-Centered Maintenance to explain how logistics and engineering systems collectively influence logistics performance in the TUDM.

The arrow explanations indicate a direct positive relationship between each independent variable (EIM, IES, ILS) and the dependent variable (LP) as well as independent variable

relationships between EIM and IES, IES and ILS, and EIM and ILS. The model assumes that improvements in any one area can improve aircraft performance; however, the combined integration of all three factors under the ILS environment is expected to yield the highest operational benefits. The framework also emphasizes the principles of EIM, IES and ILS Management to Optimize TUDM logistics performance.

The ILS management approach offers significant advantages to enhance the administration of TUDM aircraft inventory and can improve the quality of TUDM aircraft, especially for complex and high-value assets such as military aircraft. By shifting the focus to efficient inventory management, it is possible to improve the repairability status of TUDM aircraft. ILS management can provide a more strategic and cost-effective approach and platform.

Apart from that, this framework explains that EIM, IES and ILS Management are three interrelated independent factors that directly affect the study's dependent variable, Logistics Performance.

2.13 Research Hypothesis Development

The proposed variables will represent an integrated logistics perspective where logistics performance is influenced by engineering support (IES), efficient inventory management (EIM) and integrated logistics support management (ILS). According to previous research, engineering support has improved maintenance reliability and technical decision-making, while efficient inventory planning improves the availability of supplies, spare parts, systems and operational responsiveness. Both of these factors directly affect performance outcomes (Shukla, et al., 2014). To maximize performance, ILS management also offers a coordination structure that synchronizes resources, procedures and life cycle maintenance initiatives (Blanchard, 2004).

Systems and dynamic capacity theory, emphasizing cross-functional integration and adaptive coordination, is the basis for the interaction between EIM, IES, and ILS management. According to empirical research, engineering skills enable mature ILS practices, which strengthen logistics performance through systemic alignment, and inventory effectiveness to improve engineering efficiency (Vaskic & Paetzold, 2019). Therefore, this hypothesis explains that EIM Management, IES and ILS are three independent and interrelated factors that directly influence the dependent variable of the study, Logistics Performance. The following are the variables related to the hypotheses regarding eim, ies and ils obtained from the literature:

- a. H₁. EIM is significant to Logistics Performance.
- b. H₂. IES is significant to Logistics Performance.
- c. H₃. ILS management is significant to Logistics Performance.
- d. H₄. EIM is significant to IES.
- e. H₅. IES is significant to ILS management.
- f. H₆. EIM is significant to ILS management.

2.13.1 Efficient Inventory Management and Logistic Performance

There is a direct variable relationship between efficient inventory management and logistics performance, particularly in military aviation where quick response and preparedness are critical. Optimisation of inventory systems plays a key role in ensuring that air forces can maintain operational capability while minimizing costs. This analysis explores the synergy between inventory management and logistics performance, outlines its implications for the TUDM, and highlights the importance of this relationship for logistics and engineering personnel.

Effective inventory management involves strategic oversight of stock levels, facilitating streamlined logistics operations such as timely and accurate supply distribution, which is essential

for maintaining fleet readiness. The literature demonstrates how military organizations can maximize resource usage, shorten cycle times, and enhance overall operational efficiency with well-integrated inventory management systems (Al-Momani, et al., 2020). For example, Almomani et al. emphasize that customized inventory management systems in military aviation can significantly improve aircraft operational availability and usability (Al-Momani, et al., 2020). Such systems not only minimize costs by reducing excess inventory but Additionally, make sure that essential materials and spare parts are accessible when needed, thus supporting continuous operational and maintenance activities.

Logistics performance, defined by timely delivery and management of supplies, has always been linked to inventory control practices. EIM allows the air force to respond promptly to logistics demands, which is essential during peacetime and conflict scenarios (Krivonosova, 2024). Research by Krivonosova shows that in aviation logistics, unique challenges including security concerns and rapid transportation requirements require highly advanced inventory strategies to maintain competitiveness and operational efficiency (Krivonosova, 2024). Additionally, automated system components and algorithmic decision-making improve logistics processes, leading to improved performance indicators such as delivery reliability and budget efficiency (Huang L., 2025). These advances are particularly relevant to air force logistics personnel, who must ensure that each logistics component is aligned with strategic operational goals without unnecessary delays or complications.

In the context of the TUDM, the relationship between inventory management and logistics performance becomes even more critical due to the complexity of the military supply chain. The

logistical requirements of air force operations demand careful and well-planned planning and execution, especially regarding aircraft maintenance and repair. As Perez J, (2023) noted, maintaining military weapons systems involves not only logistics management but also engineering oversight, indicating that coordination between these two areas is paramount. Logistics personnel require accurate inventory data to effectively plan maintenance schedules and ensure that all required parts are available for rapid deployment (Al-Momani, et al., 2020: As Perez J., 2023).

In conclusion, the relationship between EIM and logistics performance is critical to the integrity and readiness of air force operations. This relationship enhances the capacity of logistics and engineering personnel to efficiently support tactical operations, demonstrating the importance of adopting advanced management systems and methodologies. By fostering an operational readiness environment through effective inventory strategies, the TUDM can better navigate the challenges of modern warfare and maintain their defense and operational capabilities more robustly.

Based on the explanation regarding efficient inventory management and logistics performance, the researcher proposes Hypothesis 1 (H1) as follows:

H1: *EIM is positively significant to Logistics Performance in the TUDM.*

2.13.2 Improved Engineering Support and Logistic Performance

IES is a fundamental driver of improved logistics performance in the TUDM. Engineering support encompasses activities such as airworthiness management, maintenance engineering, technical analysis and configuration control, all of which are essential to ensuring the reliability and safety of aircraft systems. Within the TUDM organization, effective engineering support enables timely

fault diagnosis, optimized maintenance planning, and informed decision making, thereby reducing unscheduled maintenance and operational disruptions.

In this context, metrics like aircraft availability are used to gauge logistics success, mission completion rates, recovery times and cost-effectiveness. Strong engineering support can directly contribute to these outcomes by ensuring that maintenance actions are technically sound, standardized and aligned with the original equipment manufacturer's specifications and in accordance with military regulations (Caporossi M. S., 2025).

Accurate technical data and engineering oversight can also improve spare parts forecasting and maintenance scheduling, which increases supply chain responsiveness. Supply Chain Management and logistics provides the latest practical tools and approaches to managing human resources, assets, and support processes (Christopher M., 2016). This approach enables the TUDM to maintain a high level of operational readiness, optimize resource utilization, and ensure continuity of logistical support to strengthen the nation's air defense capabilities (Christopher M., 2016).

The integration of engineering support with logistics functions has strengthened coordination between maintenance units, supply organizations, and operational commanders. This alignment allows the TUDM to maximize aircraft serviceability while controlling life cycle costs to a minimum. Furthermore, IES long-term fleet sustainability by identifying reliability trends and informing capability enhancements and modernization programs (Smoliarov V., 2024).

The airplane maintenance department is responsible for carrying out all maintenance tasks in compliance with the guidelines established by the company and the aircraft manufacturer. The goal is to have dependable, safe, and airworthy aircraft. In order to guarantee dependability, which

translates into aircraft availability, the aircraft maintenance department performs maintenance and preventive maintenance. (Kinnison, et al., 2013).

Overall, the synergy between IES and logistics performance enhances operational readiness, optimizes resource utilization, and ensures the sustainability of the TUDM air power. This integrated approach is essential to reduce aircraft downtime, improve serviceability, and maintain effective air operations in a resource-constrained and technologically complex defense environment.

Based on the explanation regarding IES and logistics performance, the researcher proposes Hypothesis 2 (H2) as follows:

H2: *IES is positively significant to Logistics Performance in the TUDM.*

2.13.3 Integrated Logistics Support Management and Logistic Performance

Improving logistics performance in the TUDM is largely dependent on ILS management. ILS is a methodical approach to management that incorporates all aspects of logistics throughout a military system's whole life cycle, including facilities, training, technical documentation, maintenance planning, supply support, and reliability management. In the context of the TUDM, this integration ensures that aircraft and support systems are maintained efficiently and effectively from acquisition through operational service to disposal.

Logistics performance in the TUDM is typically reflected in aircraft availability, mission readiness, recovery time and cost effectiveness. Effective ILS management can directly contribute to these performance indicators by ensuring that logistics planning is embedded early in the system design and procurement phases (Caplice, et al., 1995). This proactive approach reduces

maintenance risk, increases spare parts availability and aligns maintenance resources with current operational requirements.

Furthermore, ILS management improves coordination between engineering, maintenance and supply organizations, reducing duplication of effort and improving decision-making. Standardized processes and accurate technical data enable better forecasting, reducing downtime and supporting consistent maintenance outcomes (Daily J., & Peterson, J., 2016).

Research by Frager, A (1986), has been described in his book as an expert guide to using Integrated Logistics Support for acquisition and procurement planning in the development of new products or assets. (Frager, A et al, 1986). As a result, the TUDM can achieve higher service rates while optimizing limited defense resources.

Overall, the integration of ILS management improves the TUDM logistics performance by strengthening operational readiness, supporting the long-term sustainability of airpower capabilities, reducing downtime, optimizing resource utilization, ensuring sustainable airpower and effective mission accomplishment in line with meeting national defense objectives.

Based on the explanation regarding ILS Management and logistics performance, the researcher proposes Hypothesis 3 (H3) as follows:

H3: *ILS management is positively significant to Logistics Performance in the TUDM.*

2.13.4 Efficient Inventory Management and Improved Engineering Support

EIM and IES are essential elements to maintain operational readiness and effectiveness in the air force context (Nor-Qurratu'aini, 2025). Inventory control guarantees that consumables, ground support equipment, and essential aircraft parts are available in the appropriate amounts at the

appropriate times. The TUDM can lower store management expenses like storage, prevent obsolescence, and maintain high aircraft service rates by eliminating surplus stock and preventing shortages.

IES can complement inventory management by providing technical and analytical expertise in maintenance planning, fault diagnosis, and system reliability. It is also effective in ensuring that aircraft systems can be maintained to established standards, reducing unscheduled downtime, and extending the life cycle of assets. Logistics engineering, which applies scientific advancements in the field of logistics and enhances continuous operating capabilities, is another way that engineering management is mirrored in logistics (Adeniran, et al., 2024).

The interaction between EIM and IES will strengthen mission readiness, support sustainable fleet operations and maximize the distribution of resource. The use of this integrated approach, enables the TUDM to maintain high aircraft availability, improve logistical efficiency, and ensure long-term airpower sustainability, ensuring that the sovereignty of the country's airspace is always protected (MINDEF, 2019).

Completing all maintenance duties in accordance with the category of aircraft and operating requirements is the responsibility of the aircraft maintenance section. Ensuring airworthy, dependable, and safe aircraft is the aim. In order to guarantee dependability, which translates into aircraft availability, the aircraft maintenance sector also offers maintenance and preventative maintenance (Quinlan, et al., 2013).

In conclusion, EIM combined with IES can enable the TUDM to maintain optimal aircraft availability for operational readiness. The Defence White Paper has outlined the government's

main objectives and efforts to defend the integrity, sovereignty, and security of the country. the shared national goal of establishing a secure, independent, and wealthy Malaysia.

Based on the explanation regarding EIM and IES, the researcher proposes Hypothesis 4 (H4) as follows:

H4: *EIM is positively significant to IES in the TUDM.*

2.13.5 Improved Engineering Support and Integrated Logistics Support Management

The air force's operational effectiveness is greatly aided by the combination of IES and ILS management. Engineering support can ensure that aircraft systems, ground support equipment and associated infrastructure are maintained to stringent airworthiness and safety standards (Kritzinger D., 2016). Effective engineering support increases system reliability, reduces technical failures, and ensures compliance with regulatory and operational requirements essential for continued air operations.

ILS Management has complemented engineering support by providing a structured life-cycle-based framework that integrates configuration management, training, technical documentation and data, supplier support, and maintenance preparation and reliability analysis. In the context of the TUDM, ILS ensures that engineering activities are fully aligned with structured logistics planning from the acquisition phase through operational service and eventual disposal (Kirkpatrick et al, 2007). This integration can minimize sustainment risk and improve decision-making related to fleet availability and modernization.

The synergy between IES and ILS Management enhances the operational readiness of the TUDM by ensuring reliable aircraft systems, increasing aircraft serviceability and safety throughout their lifecycle. The integration of these elements can streamline logistics and

engineering maintenance activities by reducing unscheduled maintenance and reducing aircraft downtime.

In conclusion, this integrated approach will enable the TUDM, strengthen mission readiness, ensure airpower sustainability and maintain long-term airpower capabilities to achieve the TUDM mission and its sustainment capabilities in a dynamic defense landscape (MINDEF, 2019).

Based on the explanation regarding IES and ILS management, the researcher proposes Hypothesis 5 (H5) as follows:

H5: *IES is positively significant to ILS management in the RMAF.*

2.13.6 Efficient Inventory Management and Integrated Logistics Support Management

The air force's operational preparedness and sustainability depend heavily on EIM and ILS management. As a technology-intensive military organization, the TUDM relies on the continuous availability of aircraft, ground support equipment, and critical spare parts. EIM will ensure that these resources are always available when needed, while minimizing overstocking, obsolescence, and high holding costs associated with aviation components.

ILS management can complement inventory management by adopting a holistic, life-cycle-oriented approach. In the TUDM, ILS integrates logistical components for a system or asset, including training, technical documentation, supply support, maintenance preparation, and reliability managing. The integration of inventory management within the ILS framework enables the TUDM to increase aircraft service rates, reduce downtime and optimise defence expenditure (Alomar, et al., 2025).

By aligning logistics planning with operational objectives, the TUDM will strengthen mission readiness, aircraft availability requirements and support sustainable airpower capabilities in an increasingly complex security environment. In line with the introduction of the NDP (2010) and the KPP (2020) by the Malaysian government, especially in driving the national defense industry towards achieving the principle of self-reliance and preserving the prosperity, peace and sovereignty of the country. (Abdullah, et al., 2023).

In summary, the TUDM operational readiness depends on the link between EIM and ILS management. Inventory efficiency ensures the timely availability of critical assets, while ILS integrates logistics activities across the system lifecycle, reducing downtime, increasing aircraft usability and optimising national defence resources.

Based on the explanation regarding EIM and ILS management, the researcher proposes Hypothesis 6 (H6) as follows:

H6: *EIM is positively significant to ILS management in the TUDM.*

2.14 Underpinning Theory

ILS Theory. ILS provides a structural foundation for integrating logistics, maintenance, and supply functions across the defense system lifecycle (Vaskic & Paetzold, 2019). It emphasizes supportability, maintainability, and reliability as determinants of mission and operational readiness and performance.

This ILS theory emphasizes life cycle supportability, systematic integration of logistics elements, and proactive planning to ensure sustained operational readiness and capability. The foundation of this theory is directly aligned with the constructs of EIM, IES and LP. EIM supports the objectives of ILS by ensuring spare parts availability, reducing delays, and strengthening

sustainment reliability. IES improves maintenance effectiveness, configuration control, and technical readiness, which are the foundation of the ILS principles. Collectively, these constructs contribute to improved LP to enhance readiness, and the strategic capabilities of TUDM aviation.

2.14.1 General System Theory

The results of this investigation closely align with systems theory. Systems Theory posits that an organization functions as an interconnected system where subsystems must operate cohesively to achieve optimal performance (Bertalanffy, 1968). In the context of the Tentera Udara DiRaja Malaysia, EIM, IES and ILS represent interdependent subsystems within a broader logistics system. The results show that when these elements are strategically integrated, logistics performance improves through enhanced aircraft availability, reduced maintenance delays and improved operational reliability, thereby improving the TUDM logistics performance. Conversely, inefficiencies in any subsystem disrupt the balance of the system and weaken overall performance. This confirms that logistics optimization in military aviation requires a holistic and systems-oriented management approach rather than fragmented functional improvements.

2.14.2 Conceptual Grounding: GST as a Systems-Level Lens for Logistics

According to GST, complex systems are made up of interdependent pieces whose interactions result in emergent features that cannot be reduced to individual components. In logistics, this implies that inventory, engineering, and logistical processes cannot be optimally managed in isolation if overall performance is the objective (Mellat-Parast, et al., 2014). The literature on logistics theory emphasizes an integrative view of inventory, transportation, and information flows as a coherent system rather than discrete functions (Mentzer, et al., 2004). This systemic framing

underpins the argument that EIM, IES, and ILS must be coordinated to achieve superior LP, particularly in the high-stakes, time-critical environment of air force operations.

An explicit systems-analytic perspective in defense logistics recognizes that military sustainment requires alignment between logistics management and engineering activities to maintain warfighting readiness, highlighting the necessity of cross-functional coordination and data fidelity across the supply chain. These ideas resonate with GST's emphasis on feedback loops, interdependencies, and holistic performance metrics rather than siloed functional optimization.

2.14.3 Efficient Inventory Management within GST: Its Role, Mechanisms, and Implications for LP

EIM, within a GST framework, is not merely a stock-control problem but a node that stabilizes the entire logistics network by balancing availability, lead times, and total cost of ownership. Efficient storage, classification, and replenishment policies reduce stockouts and obsolescence, thereby improving fleet readiness and maintenance throughput a direct reflection of improved LP in air force contexts (Al-Momani, et al., 2020). The class-based and systematic storage literatures emphasize that proper inventory control yields higher productivity and easier identification, reinforcing General Performance (GP) improvements when integrated with other logistics activities.

In air forces, the impact of EIM on the serviceability and availability of aircraft spares is critical, tailored inventory systems can improve aircraft fleet serviceability and readiness while containing costs, illustrating how EIM contributes to readiness as a core LP metric (Al-Momani, et al., 2020). Moreover, reliability-centered and predictive maintenance perspectives imply that EIM data informs maintenance planning, reducing downtime and enabling faster mission turnaround.

GST suggests feedback from maintenance outcomes to inventory policies: failure data, remaining useful life estimates, and predictive maintenance results should dynamically adjust reorder points, safety stock levels, and obsolescence mitigation. This aligns with the literature on data-driven failure time estimation and maintenance optimization, where inventory decisions are linked to component reliability and lifecycle costs (Ma, et al., 2020). The integration of Business Intelligence (BI) and analytics in inventory decision support further strengthens LP via improved decision quality (Grabińska & Ziora, 2019).

2.14.4 Improved Engineering Support within GST: The Engineering–Logistics Interface

IES embodies the engineering staff's role in sustaining weapon systems, requiring close coordination with logistics to ensure tools, parts, and technical publications are available to support maintenance actions. The interdependence between logistics management and engineering effort is explicit in defense contexts, where engineering oversight is essential to keeping inventory current and ensuring weapon-system readiness. This supports a GST claim that system performance emerges from aligned engineering and logistics subsystems, not from the isolated optimization of either domain.

Reliability and maintainability research illustrate that engineering teams must use precise material data and coordinated processes to identify and mitigate underperforming items, driving improvements in LP through better maintenance execution and fewer unplanned failures. The literature on predictive maintenance and remaining useful life further demonstrates how engineering insights, when coupled with inventory data, reduce downtime and enhance mission-capable rates, a core metric of LP.

The governance of engineering support through structured decision tools and performance reporting reinforces GST's emphasis on cross-functional visibility and feedback loops. Maintenance performance reporting systems and decision-support models demonstrate how engineering and logistics information systems jointly influence operational outcomes and resource efficiency (Pintelon & Puyvelde, 1997).

2.14.5 Integrated Logistics Support within GST: Enabling end-to-end Performance

ILS represents an integrated approach to sustaining weapon systems throughout their lifecycle, combining supply, maintenance, engineering, and support knowledge into a coherent framework. The literature on logistics theory identifies the need to integrate procurement, inventory, warehousing, and transportation management to deliver reliable service levels in line with GST's emphasis on system-wide integration for performance gains Shageeva, (2023). In air forces, ILS is critical because rapid deployment, security considerations, and high-risk environments demand an end-to-end, visibility-enabled logistics process (Krivonosova, 2024). Radio Frequency Identification (RFID) and other traceability technologies in aerospace logistics illustrate how ILS benefits from real-time visibility, enabling more accurate inventory control, maintenance forecasting, and disposition planning. This aligns with GST's call for interdependent components that share timely information to drive coherent system performance.

The literature on digitalized supply chain capabilities shows how integrated technologies (e.g., digital twins, data analytics) enhance coordination across logistics, engineering, and inventory functions, thereby improving LP via better information flow and proactive maintenance planning. In air forces, such integrated capabilities underpin readiness by reducing uncertainty and enabling faster decision-making (Andrés, et al., 2024).

2.14.6 Interactions among EIM, IES, and ILS: A GST-informed Synthesis of LP in Air Forces

The triad operates through reinforcing feedback loops: EIM reduces stockouts and stabilizes maintenance workflows; ILS ensures end-to-end continuity of supply and maintenance activities; IES provides the technical integrity and performance data to drive informed inventory and maintenance decisions. Under GST, the combined effect is a system with higher resilience, greater availability, and more predictable maintenance cycles, all contributing to enhanced LP metrics such as aircraft availability, maintenance turnaround time, and operational readiness (Shageeva, 2023).

The literature on maintenance optimization and data-driven failure prediction supports the argument that predictive insights from engineering data should feed inventory and logistics decisions, creating a closed-loop that minimizes downtime and total lifecycle costs. This is a classic GST principle: subsystems align through shared information and joint optimization to improve global performance.

Studies on resilience in logistics contexts imply that GST-based integration of EIM, IES, and ILS also contributes to organizational resilience an important consideration for air forces facing dynamic and uncertain threat environments. The redundancy and adaptability afforded by integrated systems enhance LP under disruptive scenarios.

2.14.7 Implications for Air Forces Logistic and Engineering Staff

For logistics staff: GST-informed integration of EIM and ILS implies adopting end-to-end visibility, accurate demand forecasting, and synchronized replenishment with maintenance schedules. Logistics officers should champion data fusion across inventory systems, transport

management, and maintenance planning to reduce stockouts and ensure timely availability of parts, ultimately improving mission readiness (Al-Momani, et al., 2020).

For engineering staff; GST underscores the necessity of embedding engineering data into inventory policies and logistics planning. Engineering teams should participate in integrated decision processes, employing predictive maintenance insights to guide stocking policies and repair capabilities, thereby lowering downtime and extending weapon system life.

For leadership and governance; Implementing GST-informed ILS requires cross-functional governance, investment in interoperable information systems, and adoption of analytics-driven decision support. Leadership should emphasize system-wide performance metrics beyond isolated KPIs, ensuring that operational decisions reflect interdependencies among EIM, IES, and ILS (Grabińska & Ziora, 2019).

2.15 Why General System Theory (GST) Is the Most Suitable Theoretical Lens (Based on the Figure

General Systems Theory (GST), considered the bearer of systems thinking in logistics, offers a holistic lens for interpreting military logistics as an interconnected adaptive system rather than a linear chain. The theory emphasizes feedback, interdependence, and coordination across strategic, operational, and tactical levels, allowing for the modeling of logistics as a dynamic network influenced by factors such as supply or spare parts fluctuations and operational tempo (Choi, et al., 2001; Holweg & Pil, 2007; Rutner, et al., 2012; Craig, et al., 2012). Advocates have argued that the evolution of the GST concept from a static system structure to adaptive behavior allows for better analysis of readiness, agility, and resilience in military logistics, particularly by integrating inputs from the information, material, and financial domains. However, critics have

argued that the abstract nature of GST makes it difficult to translate into direct performance measures, challenging its operational relevance without a tailored framework (Dörnhöfer et al., 2016).

The evolution of GST into complex adaptive systems (CAS) and a structure-inspired perspective introduces a nuanced debate around control versus emergence in military settings. While proponents of CAS highlight self-organization and decentralized responsiveness, critics argue that military logistics often rely on hierarchical command structures, creating friction between centralized planning and distributed adaptability (Choi, et al., 2001). Furthermore, while this structuring theory enriches GST by considering the interactions between technology and human actors (Lewis & Suchan, 2003), practical applications have been constrained by cybersecurity risks, data governance issues, and interoperability challenges in a digitally transforming defense environment (Huo, 2012; Serôdio, et al., 2012). Nevertheless, middle-distance theory offers a pragmatic bridge, integrating the systemic view of GST with empirical reality, although its generalizability across various military contexts remains debated to this day (Stank, et al., 2017).

In application, GST supports the design of integrated logistics systems where the synchronization of acquisition, maintenance, transportation and command ensures operational and mission effectiveness (Dörnhöfer, et al., 2016). It promotes alignment between information and material flows, enables timely responses to uncertainty, and encourages a maturity model and continuous improvement cycle for long-term resilience (Feitosa, et al., 2021; Varadejsatitwong, et al., 2022). However, challenges persist in operationalizing GST-based strategies, particularly in measuring systemic interactions and embedding them into performance metrics. Thus, while GST offers a solid conceptual foundation for military logistics, it requires contextual adaptation,

empirical validation and integration with digital and organizational realities to realize its full potential in improving readiness and performance across military supply chains.

Figure 2.2 provides an analysis of the underlying theories referenced in documents related to logistics performance in the military, highlighting both the number of documents and the percentage published between 2024–2025 compared to before 2024. The most referenced theory is Game Theory, which is present in 4 documents, with 25% of them published in the last two years. Agency Theory also shows recent interest, with 33% of its documents published between 2024–2025. Interestingly, Implementation Theory and Institutional Theory show 100% publication rates in 2024–2025, suggesting that these theories are emerging or gaining rapid traction in current military logistics research. Technology Acceptance Theory, Foundational Theory and Information Processing Theory all show balanced or equal attention in both periods, with 50% of their documents appearing in the most recent two years, indicating continued academic interest. On the other hand, a large number of theories, such as Signal Theory, Validity Theory, Systems Theory, etc., do not show any recent publications, suggesting either a declining interest or a specific relevance in current military logistics performance research. Nevertheless, the authors consider that GST is more suitable for this study as it offers a strong conceptual foundation for military logistics, requiring contextual adaptation, empirical validation of the combination of EIM, IES and IL. Overall, the figures suggest a shift towards a practical, implementation-focused and institutional perspective in the recent literature, while some classical theories maintain a stable but less dominant presence.

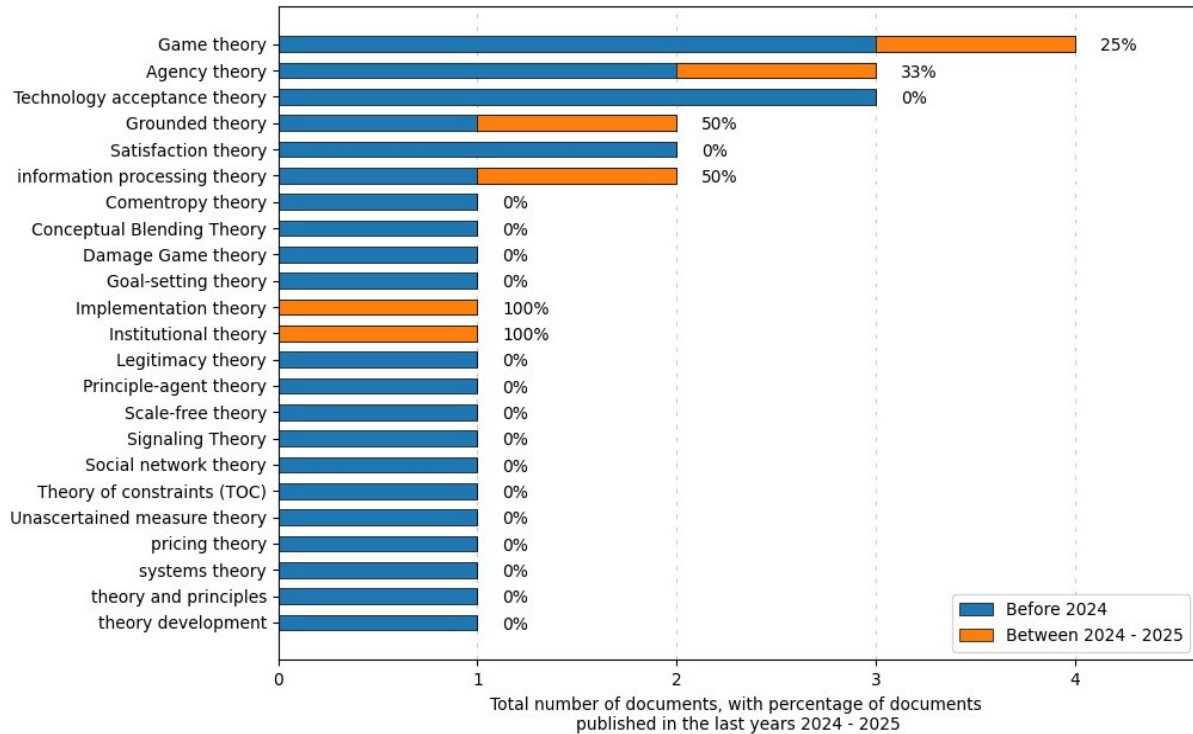


Figure 2.2: Various Theories Applied in Logistics Literature

GST remains a highly relevant theoretical framework for analyzing military logistics systems, despite the absence of recent publications from 2024 to 2025. GST’s comprehensive and integrative approach aligns well with the complex and interdependent nature of military logistics, as highlighted in various studies. For example, Peltz et al., have emphasized the need for an integrated Department of Defense supply chain, which requires the holistic perspective provided by GST (Peltz, et al., 2012). Lindskog also discusses the importance of systems thinking in logistics management, reinforcing the idea that a broad theoretical lens is essential for understanding complex and dynamic logistics networks (Lindskog, 2012). Furthermore, Chen and Unewisse illustrate how a systems approach can effectively address the complexity inherent in military operations, emphasizing the limitations of narrower theories such as agency or game theory. (Chen & Unewisse, 2016). Brick’s conceptual framework for defense logistics also

supports the notion that a systems-oriented perspective is essential for strategic management in defense logistics (Brick, 2019). Therefore, the ability of GST to encapsulate the diverse dynamics of military logistics makes it a superior choice for analysis compared to more focused theories. (Andrejić, et al., 2010).

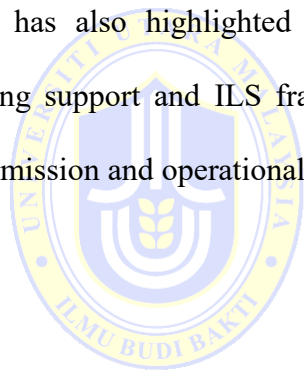
GST improves TUDM logistics performance by conceptualizing inventory management, engineering and integrated logistics support as interconnected subsystems within a broader and relevant logistics framework. This approach fosters coordination and feedback loops, which are essential for system-wide optimization, thereby ensuring efficiency, reliability and readiness across all support functions. The integration of Performance-Based Logistics (PBL) strategies, as highlighted in contemporary military logistics, emphasizes the need for streamlined processes that prioritize support at the point of impact, ultimately improving combat readiness and military operational capabilities (Griffin, 2008; Lindsay & Matyi, 2012). Furthermore, the application of this systems approach enables the identification of logistics needs and the development of tools that enhance military logistics planning, addressing both potential challenges and opening up opportunities for transformation (Lis & Jałowiec, 2015). Centralizing logistics information systems is also important, as it enhances command and control, enabling timely capability assessment and proactive problem identification (Burghard, 2012).

2.16 Chapter Summary

The integration of inventory management, enhanced engineering support and together with ILS management efficiency can improve the logistics performance of the TUDM aircraft availability. There is extensive interaction between these elements, especially on complex and highly technical systems. Many responsibilities in various elements will be shared across functional and technical expertise boundaries. The implementation of the complete ILS concept requires comprehensive

and extensive collaboration and with various logistics, engineering and project operations teams within the TUDM organization to enhance the level of mission readiness and operations in the region.

In this chapter, a dynamic exploration of various aspects of efficiency and cost effectiveness in inventory management, engineering support based on ILS can consider operational challenges, technology deployment and performance evaluation as key factors influencing these outcomes. Operational challenges encompass a broad spectrum of issues, from logistics management, aircraft maintenance to regulatory compliance, all of which can significantly impact the efficiency and cost effectiveness of operating TUDM aircraft. This literature has also highlighted the importance of modernizing the inventory management, engineering support and ILS frameworks through predictive maintenance and digital tools to maintain mission and operational availability and readiness



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CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter describes the study's methodology, which uses components of effective inventory management, improved engineering logistical support, and ILS management to maximize the readiness performance of the TUDM aircraft. Research design, demographic and sample selection, questionnaire preparation, data collection techniques, reliability testing, and statistical analysis are all included in the process.

This study design offers a thorough blueprint for how the investigation will be carried out in order to meet the goals and verify the theories presented in the earlier chapters. In this study, the design is structured to examine the relationship between logistics and engineering variables (Efficient Inventory Management, Improved Engineering Support, and ILS Management) and their collective influence on logistics performance of TUDM.

3.1 Research Approach

This study will use a quantitative research approach, which is appropriate when the purpose is to test the relationship between the targeted variables through measurable data and statistical analysis (Creswell, 2018) using the Statistical Package for Social Sciences (SPSS) Version 27.0. Quantitative research is characterized by objectivity, precision, and repeatability, allowing researchers to evaluate theoretical propositions using numerical evidence. A quantitative technique is suitable in this investigation for the following reasons:

- a. The variables of Efficient Inventory Management, Improved Engineering Support, ILS Management, and Logistics Performance can be measured numerically through

structured survey instruments and performance indicators (e.g., mission capability rate, AOG duration, MTBF and TAT).

- b. The study aimed to establish statistical relationships (correlations and effects) from interpretive meanings, in line with the positivist paradigm.
- c. Quantitative data offers evidence-based suggestions for operational and policy decision-making and enables findings to be generalized to the larger TUDM population.

In order to investigate the direction and strength of the association between the variables found in this study, a correlation quantitative design was selected. A qualitative analysis approach was used in this research. Purposive sampling, which is a non-random sampling method, was used for qualitative samples because the researcher chose to survey officers and members of the TUDM on the topic of the study. This sampling method is limited to a certain category of individuals who can provide information. They get the required details either because they are the only ones who have it or because they meet the researcher's criteria. Theoretical or idea sampling is a form of purposive sampling where individuals are selected so that they can lead to the development or exploration of new theories or certain concepts in theory (Morse et al, 2019). Respondents were selected as those who deal closely with and are involved in inventory and ILS management in the TUDM.

3.2 Research Design

This study used a quantitative research design and is very suitable for assessing the influence of various independent variables on the dependent variable across the sample population that was surveyed. This design allows for objective measurement and statistical testing of hypotheses. Quantitative research is appropriate for this study because it helps in understanding the relationship

between efficiency in inventory management, engineering support and ILS management statistically linked to performance. There are two designs in this study, namely:

- a. Correlational Design. This design determines the extent to which two or more variables are associated without manipulating them (Sekaran & Bougie, 2016). It is appropriate because the study investigated how efficiency in inventory management, engineering support, and ILS management are statistically associated with aircraft performance.
- b. Explanatory Design. The explanatory component seeks to determine the causal impact of how much changes in the independent variables (EIM, IES, and ILS) account for changes in the dependent variable (LP). Each independent variable's predictive potential will be evaluated using multiple regression analysis.

3.3 Population and Sampling

The population studied consisted of all officers and personnel of the TUDM from various logistics and engineering specialties and responsible for inventory management, engineering support and ILS management in the force. Within this diverse population, Air Bases in Peninsular Malaysia were selected as the study sample area. This sample will include personnel directly or indirectly involved in inventory management, engineering support and ILS management. Each sample should ensure a comprehensive understanding of the challenges and dynamics associated with logistics and engineering management in the TUDM.

Selecting the appropriate population and sample is essential to accurately assess the relationship between efficient inventory management, engineering support, and ILS in shaping TUDM logistics performance. Focusing on TUDM logistics practitioners, maintenance personnel, planners, engineers, and supply management officers ensures that data is collected from

individuals directly involved in inventory control, maintenance implementation, and ILS coordination. Their operational experience provides authentic insights into the readiness challenges, resource constraints, process supportability, and practical effectiveness of current logistics systems (Blanchard, 2004). Sampling this knowledgeable group enhances the reliability, relevance, and applicability of findings to real-world military contexts.

Personnel involved in this management are SMEs to understand their roles, responsibilities, and challenges in related management. Operational procedures, including logistics processes, engineering processes, and decision-making ILS framework to identify respective areas for improvement and optimization in TUDM logistics performance practices. In addition, carefully defined samples enhance generalizability within the TUDM environment while supporting evidence-based decision-making, policy refinement, and capability development. Such targeted sampling strengthens empirical understanding of logistics dynamics, supports strategic planning, and contributes to maintaining operational readiness, cost efficiency, and improved life cycle performance of TUDM assets (Ab Rahman, 2021).

3.3.1 Population

The target population consists of TUDM personnel directly involved in logistics, maintenance and engineering activities including officers and technicians stationed at major air bases such as Pangkalan Udara (PU) Subang, PU Gong Kedak, PU Kuantan, PU Butterworth and Kolej Tentera Udara (KTU). The total number of staffs involved in logistics and engineering management at the 5 bases is 239 people. These individuals represent the operational units responsible for aircraft maintenance and readiness.

3.3.2 Sampling Technique

For this research, the random selection sampling technique was used. Random sampling is a type of sampling technique in which respondents are selected intentionally based on specific characteristics related to the research problem (Etikan, et al., 2022). This method is suitable when researchers need to collect views from individuals who are knowledgeable and experienced in the fields of logistics and engineering and are directly involved in the phenomenon being studied.

In this research, the sampling was chosen to ensure that only eligible respondents were those directly involved in inventory management, engineering and ILS. These respondents would be more likely to provide meaningful, accurate and experience-based answers.

3.3.3 Instrument Administration

The questionnaire that will be utilized to operationalize the identified study variables will be covered in this section. The less researched variables, such as EIM, IES, ILS, and LP, were measured in this study using instruments from a variety of sources. This study has carried out a reliability test to evaluate the instrument's dependability. Additionally, this study has carried out content validity to make sure that every respondent from the TUDM can comprehend the questions on the questionnaire.

3.3.4 Sample Size

Cochran's formula will be used to calculate the sample size based on the analysis of Krejcie and Morgan (1970), the sample size ensures sufficient statistical power (usually $n \geq 148$), from a total of 239 respondents. The basis of calculation for this analysis is 95% is the confidence level, the margin of error is $\pm 5\%$ and the population proportion (P) is equal to $= 0.5$. A balanced sample increases the validity of regression and correlation analysis. A study sample refers to a subset of

individuals selected from a research population, intended to represent the entire group for the purpose of data collection and analysis (Sekaran U., & Bougie R., 2016).

3.4 Data Collection Methods

In this study, it focuses on optimizing inventory management, engineering support and ILS management in the TUDM. A combination of online data collection methods will be used to gather comprehensive insights into various aspects of TUDM logistics practices and performance challenges.

3.4.1 Primary Data

A standardized questionnaire with Likert Rating scale items will be used to gather data (e.g., 1 = Strongly Disagree to 5 = Strongly Agree). The instrument will measure according to the section:

- a. Inventory management efficiency.
- b. Engineering support quality.
- c. ILS management integration.
- d. Perceived and operational indicators of logistics performance.

3.4.2 Questionnaire Preparation

A structured questionnaire will be used as the instrument for collecting primary data for the purpose of this study. It was designed to obtain quantitative data from TUDM personnel and their experience in inventory management, engineering support and ILS formation. The questionnaire was constructed to ensure clarity, relevance, and consistency with the research objectives and hypotheses for the logistics performance level indicators. This survey will be conducted electronically or physically (via secure channels) to ensure confidentiality and compliance with defense data policies.

3.4.3 Supporting Data

Supporting data can be obtained from TUDM maintenance records, Defense White Paper reports, and AIROD/ATSC operational statistics, serving to triangulate and validate self-reported measures. This survey will form the primary method of data collection, enabling the systematic collection of quantitative data from personnel involved in the logistics management of the TUDM. The survey will be distributed among a representative sample of personnel, using a questionnaire developed according to the outlined structured questionnaire approach. The researcher will be able to effectively gather standardized data from a big number of participants thanks to the survey, providing valuable insights into inventory management practices, engineering and ILS support, perceptions and attitudes.

3.5 Measurement of Variables

This section outlines how each variable in the research framework is operationally defined and measured using structured questionnaire items. Measurements are in line with the goals and assumptions of the study and are based on proven indicators from earlier research. This section's main focus is on respondents' perceptions of Logistics Performance efficiency which includes 5 parts; EIM, IES, and ILS Management in the TUDM among the Materiel Branch and the Engineering Branch. Respondents' perceptions are measured on a 5-point scale (Nemoto, et al., 2022) as follows:

- a. 1 = Strongly disagree
- b. 2 = Disagree
- c. 3 = Neutral

d. 4 = Agree

e. 5 = Strongly Agree

Descriptive data of perception scores are displayed and examined independently of each required component using 5-point scale, starting with the EIM, IES variables and ending with ILS Management.

3.6 Data Analysis Techniques

Data analysis in this study uses quantitative methods as the data analysis process and involves studying how EIM, IES and ILS collectively influence the logistics performance of the TUDM through statistical testing, factor validation, and relationship modeling to ensure reliable evidence-based findings that support ongoing readiness, availability, and decision-making. The data collected will be analyzed to interpret the respondents' responses to achieve the study objectives (Rea, et al., 2014).

All quantitative data collected will be analyzed using the Statistical Package for the Social Sciences (SPSS) to test the research hypotheses. The use of the software also helps in measuring the reliability of the data collected in this research. Cronbach's Alpha test will be conducted for that purpose. Cronbach's Alpha is a widely used measure of internal consistency reliability, especially in research surveys, where it assesses the extent to which a set of questionnaire items consistently measure the same construct.

SPSS is a widely used analytical software for managing and analyzing quantitative research data. It supports normality test, linearity, descriptive statistics, reliability tests, correlation, regression, and multivariate analysis, allowing researchers to assess relationships between variables with statistical precision. SPSS is highly valued in social science and management research for its user-

friendly interface, robust data validation functions, and reproducible output, which increases the accuracy of analysis and transparency of research (Pallant, 2020; Field, 2018). The SPSS software version will be used to analyze the gathered data 27. Statistical procedures and analysis techniques will include:

- a. This Reliability and Validity Test will use Cronbach's Alpha, Composite Reliability (CR) and Average Variance Extracted (AVE).
- b. Descriptive Analysis to summarize demographic and operational characteristics.
- c. To find connections between variables, use correlation analysis.
- d. Goodness-of-fit and model validation tests to confirm theoretical alignment.

3.7 Missing data

Missing data may occur when respondents fail to complete survey items relevant to this study. This has the potential to bias the results and weaken statistical validity. Proper handling, such as screening, imputation or case exclusion, is essential to maintain analytical reliability and ensure accurate interpretation of the TUDM logistics performance relationship. The results of data screening for the study's demographic indicators demonstrated that all six items of rank, age, education, position, expertise and length of service were recorded from 155 valid responses without missing data. This confirms the complete data set and strengthens the credibility of subsequent statistical tests. The absence of incomplete cases increases robustness, supports unbiased interpretation, and provides a reliable empirical basis for the study's analytical procedures and is consistent with established quantitative research quality standards.

3.8 Reliability and Validity

The primary goal of reliability analysis is to determine the consistency and dependability of variables. It is employed to ascertain whether a set of variables are compatible (Sekaran & Bougie, 2016). In this study, the correlation between the elements was evaluated and verified using Cronbach's Alpha. The internal consistency of the items in the instrument being evaluated is higher when the alpha is nearer 1.00. The interpretation of Cronbach's Alpha is displayed in Table 3.10.

Table 3.1: Cronbach's Alpha Interpretation

| Interpretation | Cronbach's Alpha |
|----------------|------------------|
| Excellent | > .90 to 1.0 |
| Good | > .80 to .89 |
| Acceptable | > .70 to .79 |
| Questionable | > .60 to .69 |
| Poor | > .5 to .59 |
| Unacceptable | < .5 |

3.9 Chapter Summary

This research provides important support for previous findings in the field of inventory control and introduces a new perspective on inventory management and engineering support. Additionally, this study will look at how ILS, engineering support, and inventory management methods and procedures affect supply chain performance. The results will assist organizations in assessing the performance level of TUDM aircraft and serve as a guide to improve their performance by implementing effective inventory management and ILS practices. This research is expected to address the knowledge gap in inventory management, engineering support and ILS management,

particularly on strategies to logistics performance that can help organizations achieve excellence and achieve the TUDM missions and operations to defend the sovereignty of Malaysian airspace. In conclusion, this study adopts a quantitative, correlational, and to evaluate the relationship between engineering management variables and logistics empirically, use an explanatory research approach and aircraft performance in the TUDM. This design ensures scientific rigor, reliability, and applicability for defense operations and logistics management improvements.



CHAPTER FOUR

DATA ANALYSIS

4.0 Introduction

In military aviation, inventory management, engineering support, and ILS management represent the backbone of operational readiness. When these systems function effectively, aircraft availability, mission success rates, and maintenance turnaround times can be significantly optimized. Conversely, inefficiencies in these areas often result in extended aircraft downtime, higher operating costs, and reduced mission capabilities, all of which directly affect the nation's defense readiness. In modern air forces, EIM, IES and ILS practices serve as critical pillars in maintaining aircraft availability, reliability, and mission readiness (Shukla, et al., 2014). The purpose of the study was to analyze the relationship between EIM, IES and ILS in influencing logistics performance in the TUDM.

The researcher can utilize a variety of software in this chapter to analyze the data that has been gathered, making it the most crucial part of the thesis. The findings and analysis of the information gathered from 155 TUDM employees engaged in engineering, maintenance, and logistics activities are also presented in this chapter. According to the objectives and hypotheses of the study, the results are arranged topically. The impact of EIM, IES, ILS management on the logistics performance of the TUDM was quantitatively assessed using IBM SPSS Version 27.

Descriptive, reliability and validity have been implemented by the researcher in the chapter to interpret all the data and information effectively. The relationship between the study's independent and dependent variables is discussed below. Mean, median, mode, and Std. Deviation values of these variables are discussed in the chapter systematically. It helps the researcher to improve the

quality of the study and analyze all the collected data properly. Future researchers will benefit through the thesis by knowing about the increasing relationship between EIM, IES, and ILS Management to improve the logistics performance of the TUDM.

4.1 Reliability Test and Validity Test

Table 4.1 indicates strong reliability and validity for all constructs used in the study. Efficient Inventory Management ($\alpha = 0.970$), Improved Engineering Support ($\alpha = 0.912$), Integrated Logistics Support ($\alpha = 0.936$), and Logistics Performance ($\alpha = 0.974$) exceed the widely accepted 0.70 threshold, demonstrating internal consistency and stable measurement. With $N = 155$, the instrument shows robust psychometric adequacy for empirical analysis, supporting credible interpretation of relationships between logistics capabilities and performance outcomes. These coefficients suggest minimized measurement error and reinforce the suitability of the instrument for academic and practical logistics research (Cronbach L. J., 1951). Therefore, the survey framework is methodologically sound and suitable for future replication studies in similar organizational contexts (Nunnally et al, 1994).

If the study is exploratory, the lowest allowable Cronbach's alpha value is 0.60, while the lower limit is 0.70 (Hair, et al., 2010). According to a different perspective on the size of the Cronbach's alpha coefficient, a value of 0.60 is still appropriate (moderate) (Hair, et al., 2003). Overall, each instrument's Cronbach's alpha coefficient is adequate, as seen in the table below (> 0.60). Although the alpha value is low, the value is still acceptable (Hair et al., 2003; Tabachnick and Fidell, 2007).

Table 4.1: Internal Consistency Reliability test result for each variable

| Research Instrument | No. of Items | N | Cronbach Alpha |
|---------------------------------------|---------------------|----------|-----------------------|
| Efficient Inventory Management | 20 | 155 | 0.970 |
| Improved Engineering Support | 7 | | 0.912 |
| Integrated Logistics Support | 6 | | 0.936 |
| Logistics Performance | 17 | | 0.974 |

4.2 Data Screening

Table 4.2 reports the results of data screening for the study’s demographic indicators. All six items of rank, age, education, position, expertise and length of service recorded from 155 valid responses with no missing data, confirming the complete data set and strengthening the credibility of subsequent statistical tests. The absence of incomplete cases increases robustness, supports unbiased interpretation, and provides a reliable empirical basis for the study’s analytical procedures and is consistent with established quantitative research quality standards (Hair, J. F. et al., 2019).

To make sure the numerical code was adequate for the value of each variable under study, data screening was done (Tabachnick & Fidell, 2007). During the data entry procedure, data may be entered wrongly. As a result, the variables' distribution might not be normal (Coakes & Steed, 2003). No missing data was discovered during this investigation. This study tested the data for homoscedasticity, normality, linearity, and probable outliers in order to screen the data.

Table 4.2: Data Screening

| | | Rank | Age Group | Level of Education | Designation | Expertise in RMAF | Year of Served |
|---|----------------|------|-----------|--------------------|-------------|-------------------|----------------|
| N | Valid | 155 | 155 | 155 | 155 | 155 | 155 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 |

4.3 Normality

Normality tests were conducted for four logistics performance variables (Logistics Performance, Efficient Inventory Management, Improved Engineering Support, Integrated Logistics Support) using skewness and kurtosis statistics. Data were collected from 155 respondents (N = 155) using a 5-point Likert Rating scale (1.00–5.00). The statistical software used is analysis to calculate the shape of the distribution and descriptive statistics. The test results were normal and descriptive statistics were displayed at Table 4.3. All variables exhibited high mean scores (M = 4.14 to 4.18) with moderate standard deviations (SD = 0.68 to 0.74). Skewness values ranged from -1.788 to -2.432, indicating significant negative skewness. Kurtosis values ranged from 5.172 to 8.185, indicating a leptokurtic distribution that differs from a normal curve in that it has heavier tails and sharper peaks. The skewness and kurtosis standard errors are 0.195 and 0.387, respectively. Given that the absolute values of skewness and kurtosis exceed the recommended thresholds of 2 and 7, respectively (Byrne, 2016; Curran et al., 1996), the data for all constructs deviate significantly from a normal distribution.

Table 4.3: Results of skewness and Kurtosis for Normality Test

| Variables | N | Skewness | Std. Error of Skewness | Kurtosis | Std. Error of Kurtosis |
|---|----------|-----------------|-------------------------------|-----------------|-------------------------------|
| Logistic Performance Efficient Inventory Management Improved Engineering Support Integrated Logistic Support | 155 | -1.788 | 0.195 | 5.596 | 0.387 |
| | 155 | -2.432 | 0.195 | 8.185 | 0.387 |
| | 155 | -1.768 | 0.195 | 5.172 | 0.387 |
| | 155 | -1.924 | 0.195 | 6.163 | 0.387 |

4.4 Linearity

The linearity and normality of the Logistic Performance variable were visually assessed using the Quantile-Quantile (Q-Q) Normal Plot. The observed data quantities and the quantities predicted by a normal distribution were compared using this graphical method. The data were obtained from the same sample of 155 respondents described in the previous analysis.

Figure 4.1 below shows the Normal Q-Q Plot for Logistic Performance. Systematic departures of the data points from the diagonal reference line were visible upon investigation, which represents a perfect normal distribution. Specifically, the plot shows a clear concave curve, indicating negative skewness. This pattern is consistent with the significant negative skewness statistic (-1.788) reported in Table 4.3. Points at the upper end of the distribution fall below the line, while points at the lower end deviate above it, confirming the leptokurtic, negatively skewed distribution that was identified numerically. Such a pattern indicates that the assumption of univariate normality is violated for this construct (Field, 2018; Pallant, 2020), supporting the results of previous statistical tests. Multivariate analysis always assumes that variables are linearly

related to each other (Zikmund, 2003). The linearity between the independent and dependent variables was studied using scatter plots. According to Tabachnick and Fidell (2007), scatter plots showed that the relationship between variables should be along a straight line. Figure 4 shows the actual scatter plots for each variable. In addition, the normal probability plot of the standard regression residuals of the dependent variable shows that this distribution is reasonably normal.

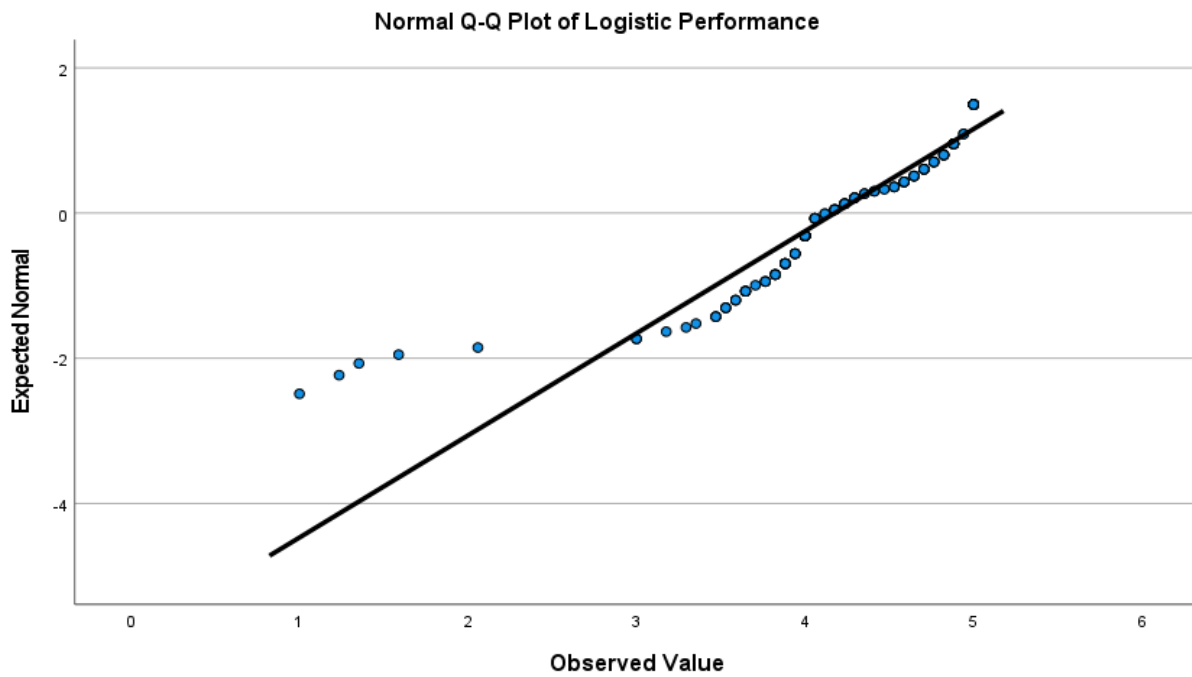


Figure 4.1: Normal Probability Plot of Regression Standardized

4.5 Logistics Performance Histogram

The univariate distribution of the Logistic Performance variable was examined graphically using a histogram with an overlapping normal curve. This visual tool complements the numerical normality test by displaying the frequency distribution of scores from a sample of 155 respondents. The histogram for Logistic Performance is presented in Figure 4.2. The score distribution shows a significant negative skew, with a high concentration of responses at the upper end of the scale

(towards 5.00) and a rapid decrease in frequency towards lower scores. The overlapping normal curve, which represents a theoretical Gaussian distribution, clearly does not align with the observed data bars. The bulk of the data is shifted to the right, and the left tail is truncated, confirming the significant negative skew statistic (-1.788) reported previously. This visual evidence reinforces the conclusion that the variable violates the normality assumption, as the observed distribution is asymmetric and peaked (leptokurtic) compared to a normal benchmark (Tabachnick & Fidell, 2019; Warner, 2021).

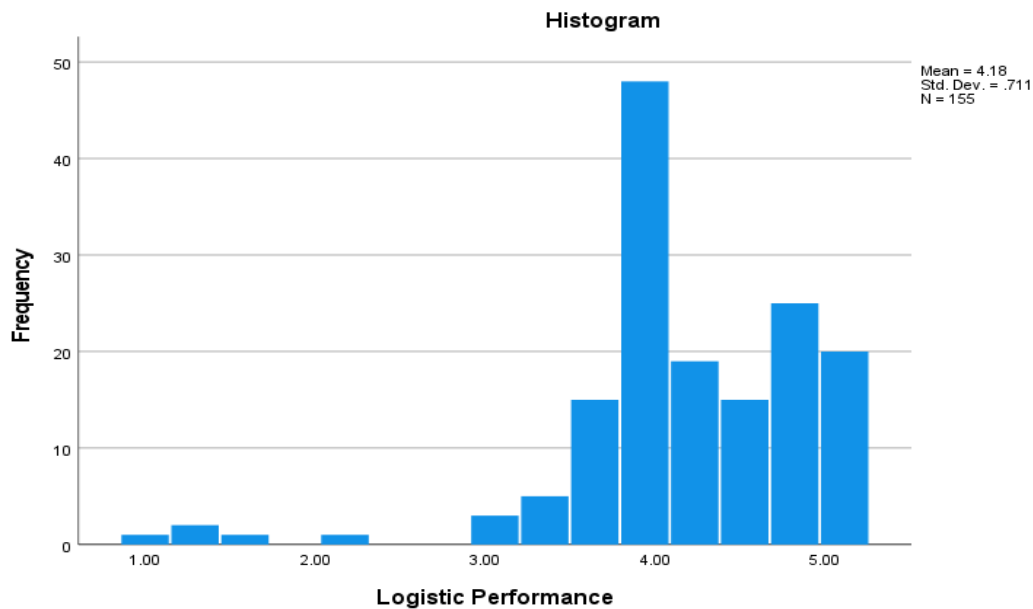


Figure 4.2: Logistic Performance Histogram

4.5.1 Efficient Inventory Management Histogram

The Efficient Inventory Management Histogram in Figure 4.3, depicts the overall distribution pattern of respondents' perceptions of logistics effectiveness within the TUDM. The visual output shows a generally acceptable spread of scores (M = 4.14), indicating that most responses clustered in the mid to higher performance range, with no extreme distortion or overconcentration at the lower end (Hair, et al., 2022). The SD value = 0.676, reflecting a relatively stable perception of

capabilities in efficient inventory management, while still showing variability that requires analytical examination. The histogram provides an important initial assessment of normality, supporting subsequent inferential analysis to assess the association between EIM, IES and ILS management (Field, 2018).

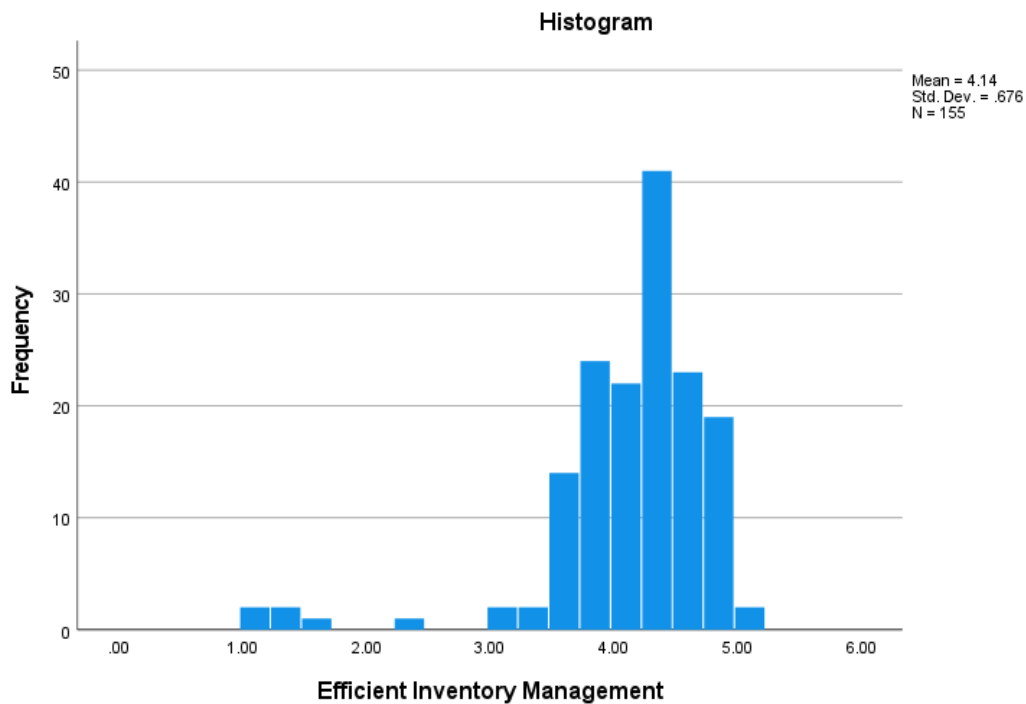


Figure 4.3: Efficient Inventory Management Histogram

4.5.2 Improved Engineering Support Histogram

The Improved Engineering Support Histogram provides a visual representation of respondents' (N = 155) perceptions of the effectiveness of logistics management in the TUDM. The distribution pattern indicates that most responses are in the moderate to higher performance range, reflecting a generally positive assessment of engineering support capabilities while still showing natural variation among respondents with values of $M = 4.11$ and $SD = 0.742$ at Figure 4.4 (Field, 2018). The absence of extreme skewness indicates that perceptions are reasonably balanced, supporting

the assumption of normality that is acceptable for subsequent statistical testing. This pattern indicates that engineering support functions, particularly those influenced by EIM, IES and ILS activities, are considered to be functioning at a satisfactory level, although further improvement is still needed. The histogram therefore serves as an important exploratory tool to confirm the suitability of the data before further inferential analysis to obtain efficient logistics performance (Hair, et al., 2022).

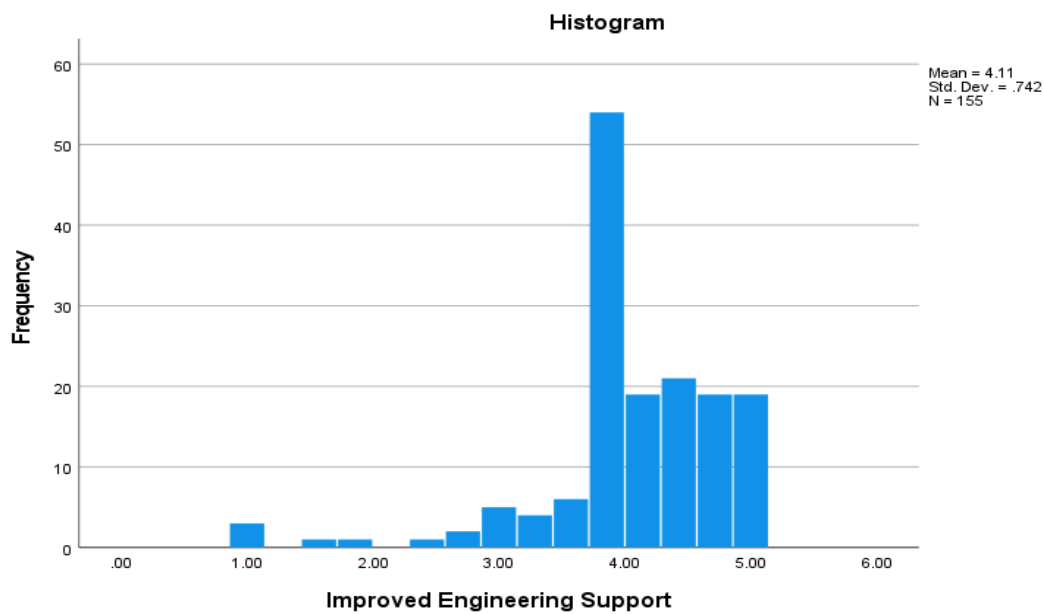


Figure 4.4: Improved Engineering Support Histogram

4.5.3 Integrated Logistics Support Histogram

The Integrated Logistics Support Histogram at Figure 4.5, reflects the overall distribution of perceptions of TUDM personnel regarding the effectiveness of logistics performance. With $M = 4.18$ and $SD = 0.727$, this graphical pattern indicates that most responses are concentrated in the moderate to higher performance range, reflecting a generally favorable assessment of the

contribution of ILS to logistics readiness. The distribution does not show significant skewness, suggesting relatively balanced perceptions across respondents and supporting a reasonable assumption of normality for subsequent statistical analyses. This pattern implies that ILS mechanisms including support planning, documentation, maintenance integration, and life cycle maintenance are functioning at an acceptable standard, although the observed variations suggest scope for continued improvement. As an initial diagnostic tool, this histogram reinforces the reliability of the data prior to inferential assessment of its relationship to inventory efficiency and engineering support (Field, 2018; Hair, et al., 2022).

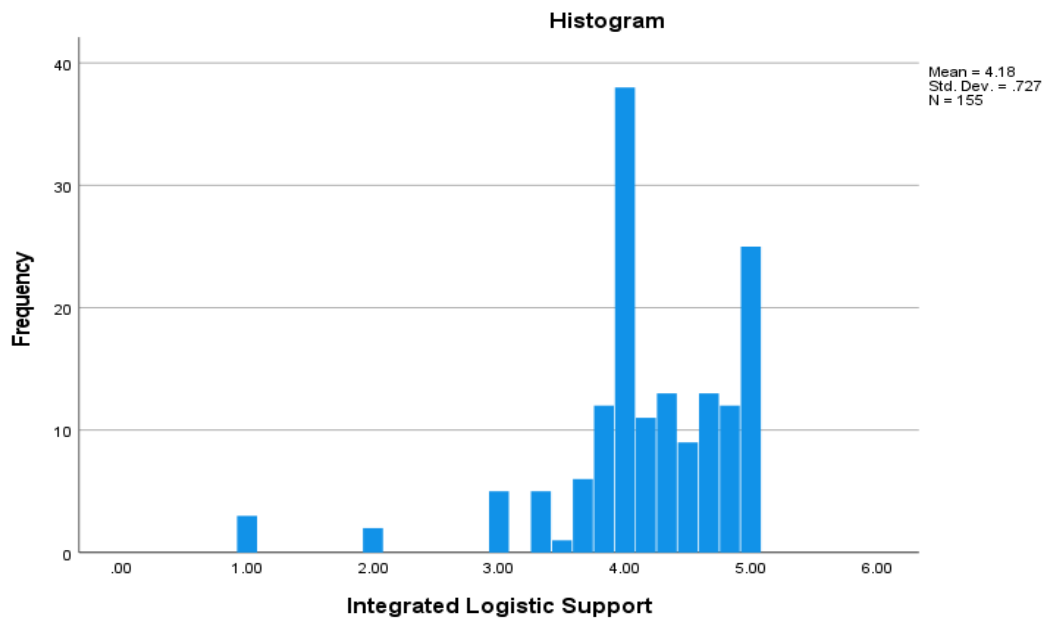


Figure 4.5: Integrated Logistics Support Histogram

4.6 Profile of Respondents

The demographic profile of TUDM respondents is described in this section. This section’s goal is to present comprehensive demographic data about the study participants. This data contains their age, rank, and educational attainment, job title, trade/field and years of experience in the TUDM.

Questionnaires were distributed to 155 randomly selected from all TUDM Bases. This study focuses on the relationship between TUDM logistics performance and effective inventory management, improved engineering support, and ILS management. The respondents' profiles and their job characteristics are revealed through descriptive statistics of their background data from Sections A, B and C of the questionnaire study. The following subsections will provide a detailed explanation of the profile of the respondents who participated in this survey.

4.6.1 Rank

Considering the outcome from the table 4.4, analysis of the respondents' rank profile demonstrates a predominantly mid-level composition. Majors constituted the largest proportion (21.3%), followed by Sergeants (19.4%) and Corporals (16.1%). Senior non-commissioned roles, including Flight Sergeants (12.9%) and Warrant Officers (8.4%), reflect substantial operational leadership presence. Officer representation was further indicated by Captains (6.5%), Lieutenants (8.4%), and Lieutenant Colonels (7.1%). Overall, the distribution of 155 participants illustrates balanced engagement across hierarchical levels, supporting credible insights into organizational dynamics and decision structures (Bryman, 2016).

Table 4.4: Respondents by rank

| | | Frequency | Percent | Valid Percent |
|-------|-----------------------------------|------------------|----------------|----------------------|
| Valid | Corporal | 25 | 16.1 | 16.1 |
| | Sergeant | 30 | 19.4 | 19.4 |
| | F/ Sergeant | 20 | 12.9 | 12.9 |
| | Warren Officer | 13 | 8.4 | 8.4 |
| | Lieutenant/ 2nd | 13 | 8.4 | 8.4 |
| | Lieutenant | 10 | 6.5 | 6.5 |
| | Captain | 33 | 21.3 | 21.3 |
| | Major | 11 | 7.1 | 7.1 |
| | Lt Colonel | | | |
| | Total | 155 | 100.0 | 100.0 |

4.6.2 Age of Group

Analysis of respondents' age (Figure 4.5) distribution shows that the study primarily involved mature participants. Individuals aged 31-40 formed the majority at 56.8 percent, indicating strong participation from mid-career personnel. Younger respondents aged 21-30 represented 16.1 percent, while 27.1 percent were 41 years and above, reflecting inclusion of experienced members. The pattern suggests that perceptions captured are shaped largely by individuals with considerable exposure, thereby strengthening the credibility of findings. Such demographic balance supports dependable empirical outcomes in organizational research (Creswell, 2018) and enhances the representativeness of the study sample overall for policy relevance and evidence-based interpretation in this context.

Table 4.5: Respondents by age of group

| | | Frequency | Percent | Valid Percent |
|-------|--------------------|------------------|----------------|----------------------|
| Valid | 21-30 | 25 | 16.1 | 16.1 |
| | 31-40 | 88 | 56.8 | 56.8 |
| | 41 and over | 42 | 27.1 | 27.1 |
| | Total | 155 | 100.0 | 100.0 |

4.6.3 Level of Education

From the table 4.6 below, the educational profile illustrates a diverse academic composition among the 155 respondents. Diploma holders represented the largest proportion at 39.4 percent, indicating substantial technical and vocational grounding. Bachelor’s degree graduates accounted for 25.8 percent, while 24.5 percent possessed secondary school qualifications, demonstrating participation across foundational and professional learning levels. Additionally, 10.3 percent reported postgraduate qualifications, reflecting advanced analytical capacity within the sample. This varied academic spectrum enhances the robustness of responses, suggesting informed perspectives drawn from multiple educational pathways, thereby strengthening empirical validity in organizational and social research contexts (Bryman, 2016; Creswell, 2018).

Table 4.6: Respondents involvement according to level education

| | | Frequency | Percent | Valid Percent |
|-------|----------------------------------|------------------|----------------|----------------------|
| Valid | Bachelor’s degree | 40 | 25.8 | 25.8 |
| | Diploma | 61 | 39.4 | 39.4 |
| | Master’s Degree and above | 16 | 10.3 | 10.3 |
| | Secondary School | 38 | 24.5 | 24.5 |
| | Total | 155 | 100.0 | 100.0 |

4.6.4 Designation

The distribution of participants by organizational position reflects a broad structural representation within the study sample at table 4.7. The largest proportions comprised (Officer in Charge) OIC/SNCO IC (22.6%) and respondents categorized as Others (22.6%), followed by Supervisors (17.4%) and (Staff Officer) SO2 personnel (18.7%). (Non-Commissioned Officer) NCO IC (7.7%), SO1 (5.2%), and SO3 (5.8%) formed smaller yet meaningful segments, signifying participation from both operational and command functions. This varied positional spread enhances the credibility of findings, as it integrates perspectives from managerial, supervisory, and coordination levels, contributing to richer empirical interpretation in organizational research contexts (Bryman, 2016; Creswell, 2018).

Table 4.7: Respondents involvement by designation

| | Frequency | Percent | Valid Percent |
|--------------|------------|--------------|---------------|
| Valid | | | |
| NCO IC | 12 | 7.7 | 7.7 |
| OIC/SNCO IC | 35 | 22.6 | 22.6 |
| Supervisor | 27 | 17.4 | 17.4 |
| SO 1 | 8 | 5.2 | 5.2 |
| SO 2 | 29 | 18.7 | 18.7 |
| SO 3 | 9 | 5.8 | 5.8 |
| Others | 35 | 22.6 | 22.6 |
| Total | 155 | 100.0 | 100.0 |

4.6.5 Division/ Expertise

Table 4.8 indicates that 81 responses, or 52.3% of the total, were from the Materiel specialty. With 69 responses, the engineering specialization was the second-largest responder category or 44.5% of the sample. The smallest respondent group was from others comprising 5 respondents or 3.2%

of the sample in this study. Only minimal participation emerged from the aviation, legal, training and operations categories, each under one percent. This distribution implies that the research perspective was largely informed by technically skilled personnel, reinforcing the practical and operational relevance of organizational research (Bryman, 2016). The facts are shown in Table 4.8.

Table 4.8: Respondents engagement by expertise in TUDM

| | | Frequency | Percent | Valid Percent |
|-------|--------------------------|------------------|----------------|----------------------|
| Valid | Engineering | 69 | 44.5 | 44.5 |
| | Flying | 1 | 0.6 | 0.6 |
| | Jurulatih Jasmani | 1 | 0.6 | 0.6 |
| | Legal | 1 | 0.6 | 0.6 |
| | Materiel | 81 | 52.5 | 52.5 |
| | Operasi PKTU | 1 | 0.6 | 0.6 |
| | Pelatih (Visor) | 1 | 0.6 | 0.6 |
| | Total | 155 | 100.0 | 100.0 |

4.6.6 Year of Served

A survey of 155 TUDM personnel reveals a distribution of service years that indicates a seasoned workforce. As obtainable in Table 4.9, the largest proportion of respondents (25.8%) reported serving between 10.1 and 15 years. This is closely followed by those with 15.1 to 20 years (24.5%) and over 20 years (21.3%) of service. Combined, these three categories represent 71.6% of the sample, suggesting a high level of institutional experience and tenure within the respondent group. Conversely, personnel with fewer than five years of service comprise only 9.0% of the sample. This distribution implies that the responding cohort is predominantly composed of mid-to-late career personnel, which may influence perspectives on organizational culture, operational experience, and retention factors (Smith, 2020). Such a demographic profile is critical for

contextualizing research findings related to human resource and strategic management within military institutions.

Table 4.9: Respondents engagement by year of served in TUDM

| | Frequency | Percent | Valid Percent |
|------------------|------------------|----------------|----------------------|
| Valid > 20 years | 33 | 21.3 | 21.3 |
| 1-5 years | 14 | 9.0 | 9.0 |
| 10.1 to 15 years | 40 | 25.8 | 25.8 |
| 15.1 to 20 years | 38 | 24.5 | 24.5 |
| 5.1 to 10 years | 30 | 19.4 | 19.4 |
| Total | 155 | 100.0 | 100.0 |

4.7 Factor Analysis

Each of the study's variables underwent a factor analysis. There were twenty (20) items for EIM, seven (7) for IES, six (6) for ILS, and seventeen (17) for LP among the four variables. There was a total of fifty items on the study questionnaire. In order to objectively identify the natural grouping of factors (variables), this study employed EFA stands for Exploratory Factor Analysis. Additionally, EFA was used to analyze the measurement battery's factor structure and the component structure of every item in every variable in this study.

To identify and explain the components, EFA basically considers the number of constructs and the underlying factor structure. The underlying constructs of Efficient Inventory Management, Improved Engineering Support, Integrated Logistics Support Management, and Performance in Logistics within the TUDM were validated in this study using factor analysis. This method ensures that each construct is both conceptually coherent and statistically reliable by analyzing whether the observed items cluster meaningfully into various latent dimensions. Factor analysis confirms that sampling is adequate and that correlations between variables are appropriate for

dimensionality reduction using metrics like the Kaiser–Meyer–Olkin (KMO) test and Bartlett’s Test of Sphericity. (Field, 2018; Hair, et al., 2019).

Tabachnick and Fidell (2007) state that the two most widely used PCA (Principal Component Analysis or component factor) and traditional factor analysis (also known as Principal Axis Factoring) are extraction techniques (Hair, et al., 2010; Tabachnick and Fidell, 2007; Costello and Osborne, 2005). Factor analysis identifies any latent variables that contribute to the co-varying of manifest variables, whereas Principal Component Analysis (PCA) concentrates on data reduction techniques (Costello and Osborne, 2005). Compared to principal component analysis, ordinary factor analysis is theory-based and makes stricter assumptions.

A considerable amount of variance was explained by the extracted factors, suggesting that ILS integration, engineering prowess, and inventory efficiency are structurally sound elements that affect logistics results. This procedure improves construct validity, lowers measurement error, and guarantees that the relationships between variables are appropriately captured in later analyses. All things considered, the factor analysis offers a strong empirical foundation for investigating how these logistics capabilities collectively affect TUDM performance. (Tabachnick & Fidell, 2019; Hair, et al., 2019).

In order to create rotated component matrices for item loadings and identify the final factor group for each variable, factor analysis was carried out in this study using PCA with varimax rotation and Kaiser Normalization. Factor analysis was used subject to each item in the variable construct.

4.7.1 Principal Components Analysis for EIM

Principal component analysis for Efficient Inventory Management showed that the extracted components meaningfully explained the underlying variance structure and there were 20 study items demonstrating strong construct validity for the measurement items used in the study as shown at Figure 4.6. The components retained based on eigenvalues greater than one confirmed that the inventory-related indicators were coherently aligned and formed a single dominant factor representing efficiency in inventory practices in the TUDM logistics environment. The results of this PCA indicated that structured stock control, optimized replenishment processes and systematic resource allocation were statistically supported as critical contributors to logistics performance. Therefore, the PCA results reinforce the importance of Efficient Inventory Management as a reliable construct influencing broader logistics effectiveness, consistent with the recommended statistical thresholds for factor extraction and interpretation (Field, 2018; Hair, et al., 2022).

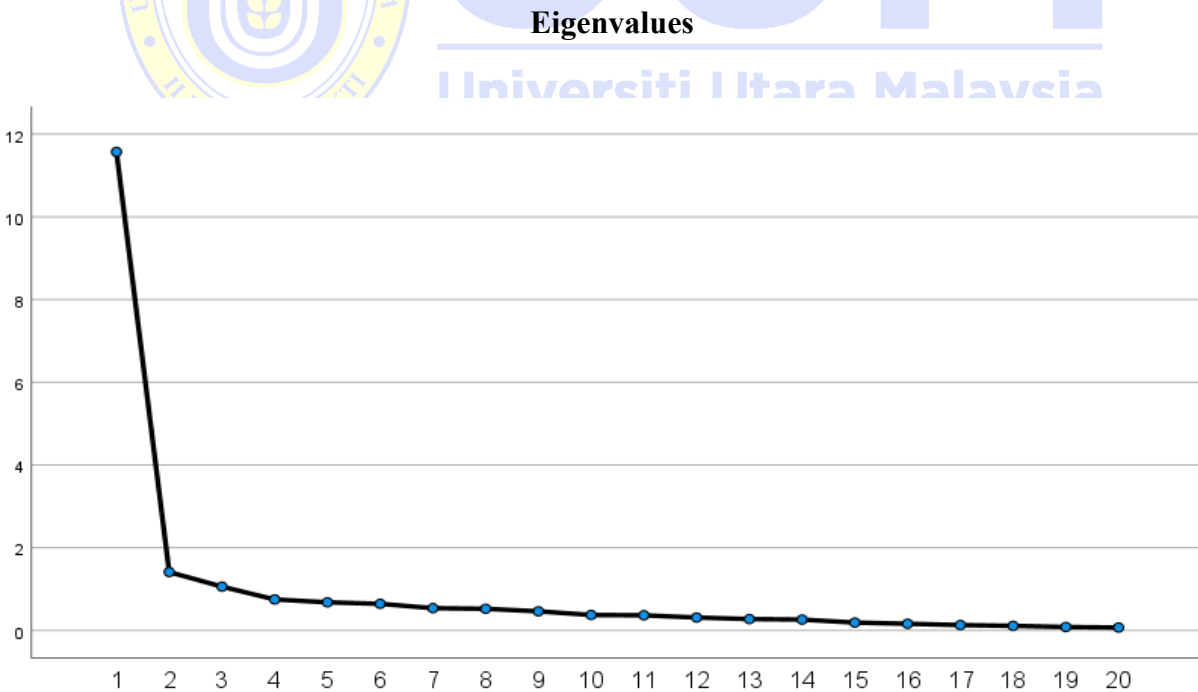


Figure 4.6: Principal Component EIM

4.7.2 Principal Components Analysis for IES

The application of PCA at Figure 4.7 is utilized to efficiently filter out the important aspects of the logistics variables that affect IES performance in the TUDM. There are 6 core items that are used to drive the performance of engineering support. As shown in Figure 4.4, the eigenvalue decomposition, the first principal component typically combines variance from correlated metrics such as mean repair time, technical resource availability and spare parts accessibility (Teoh & Mahmood, 2021). This dimensionality reduction explains that enhanced engineering support is not a single function but a composite construct, significantly impacting overall logistics performance by reducing aircraft downtime and increasing mission readiness. Therefore, PCA provides a quantitative basis for strategic resource allocation and an empirical model to prioritize engineering investments to optimize the TUDM operational logistics chain.

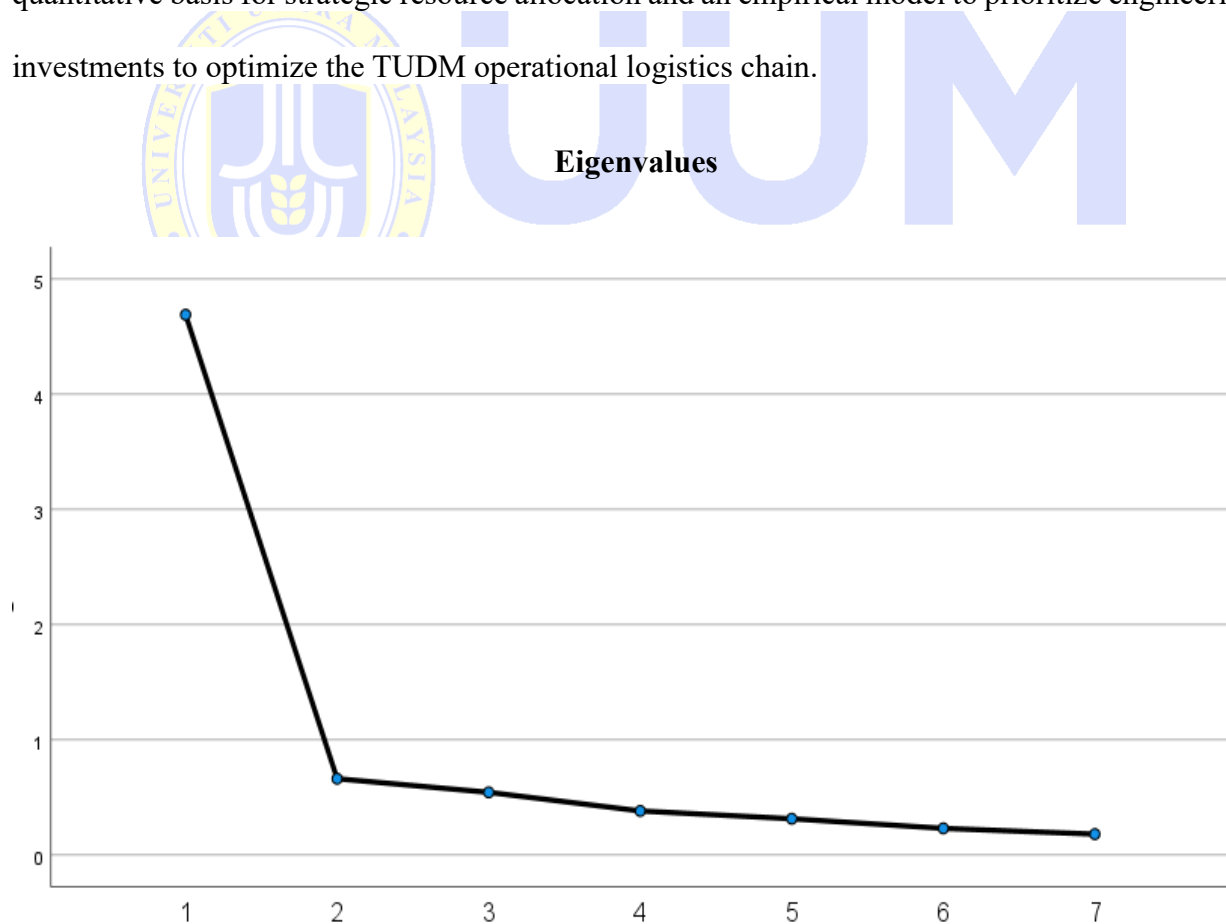


Figure 4.7: Principal Component IES

4.7.3 Principal Components Analysis for ILS

The PCA application shown above is to evaluate Integrated Logistics Support and explain the synthesis factors that can influence the logistics performance of the TUDM. The eigenvalue output based on the 6 study items as depicted in Figure 4.8, measuring the variance explained by the derived components, reveals that ILS is mostly characterized by key dimensions that incorporate critical functions such as maintenance management, supply chain coordination and technical data interoperability. This analytical reduction has shown that a superior ILS is essentially a multivariate construct, where synchronized subsystems rather than isolated functions can drive improved aircraft availability and fleet reliability. Therefore, PCA provides a robust empirical framework for the TUDM to strategically align its ILS elements, thereby optimizing overall logistics output and operational effectiveness.

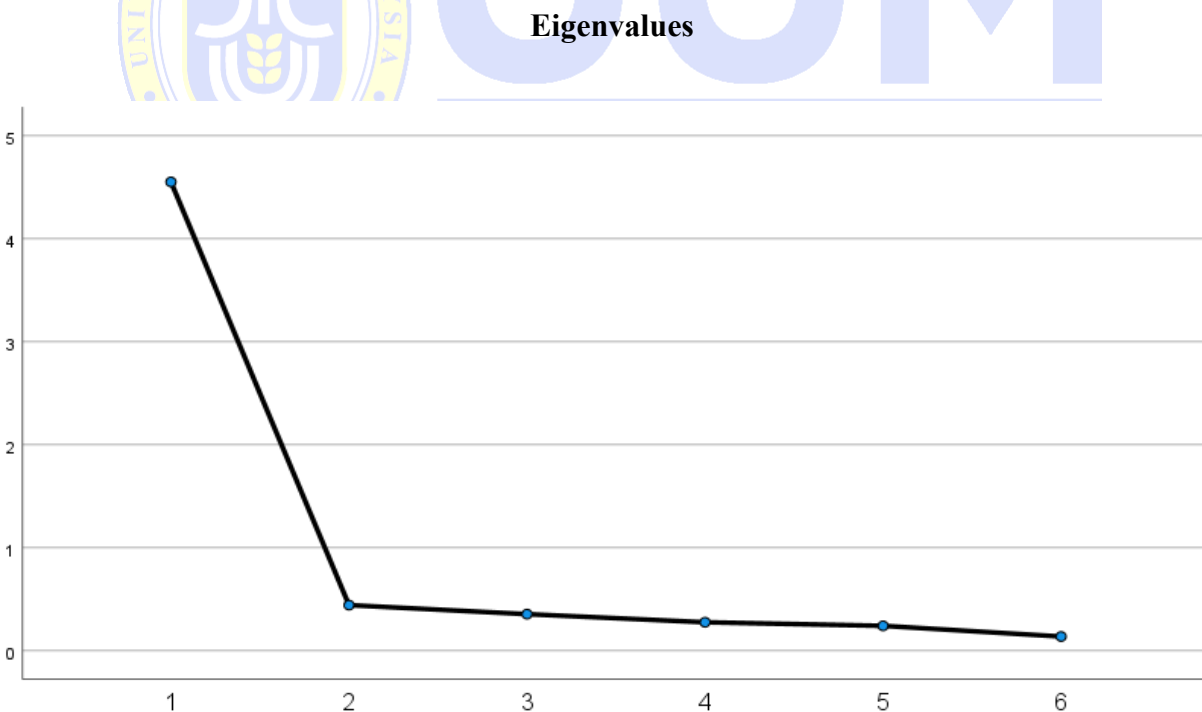


Figure 4.8: Principal Component ILS

4.7.4 Principal Components Analysis for LP

In Figure 4.9, it is shown that PCA conducted on the TUDM logistics metrics has successfully identified the underlying structure of the overall logistics performance involving 17 study items. The eigenvalue plot shows that the variance in LP is mostly captured by a few principal components, which aggregate correlated indicators such as mission capability rate, supply chain response, and asset utilization efficiency. This statistical reduction confirms that high-level logistics performance is not the result of isolated successes but emerges from the synergistic integration of several core operational domains. Specifically, the combined analysis of EIM, IES, and ILS highlights that the most important components heavily load factors related to operational availability and support process agility, consistent with the established military logistics framework. Therefore, the PCA output provides the TUDM with a validated multidimensional LP model, allowing resource allocation to be targeted to the composite drivers rather than individual metrics that most significantly improve fleet readiness and overall mission assurance.

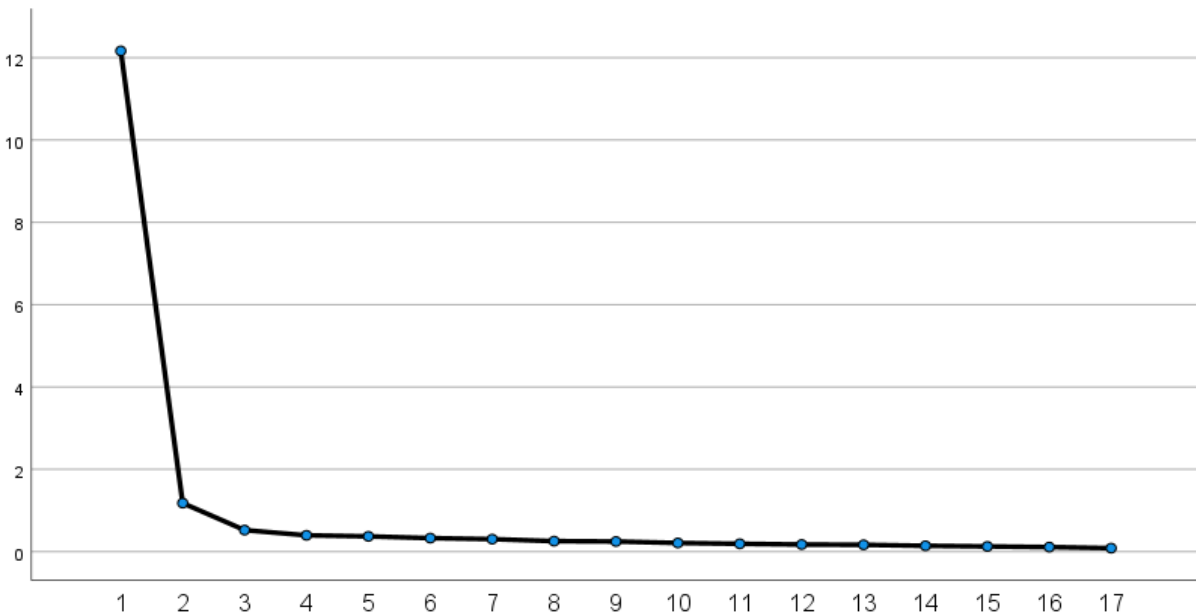


Figure 4.9: Principal Component LP

4.7.5 Factor Loading

To interpret the TUDM construct validity EIM, IES, ILS Management and Logistics Performance, factor loadings are crucial. Higher loading values indicate that the item meaningfully represents the intended dimension. Factor loadings show the strength and direction of the connection between each observed item and its underlying latent construct (Hair, et al., 2019). Weaker items could be reevaluated or eliminated to increase model clarity and measurement accuracy, but items with loadings that generally exceeded the suggested threshold of 0.50 or 0.60 were kept in this study because they demonstrated strong construct representation and practical significance. (Field, 2018; Tabachnick & Fidell, 2019).

In factor analysis, according to Hair, et al., (1998) and Tabachnik & Fidell, (2007) The weight of each item on the associated factor is said to be indicated by factor loading. Additionally, it shows how well the item and the associated factor fit together, with higher factor loading indicating a deeper meaning to explain the factor. Factor loading is the process of determining the factor with a significant level by interpreting the item's function or character (Hair, et al., 1998; Tabachnik & Fidell, 2007).

The high factor loadings across the inventory, engineering, and ILS indicators suggest that respondents consistently perceive these areas as coherent and influential capabilities that support logistics performance. This strengthens convergent validity by confirming that related items converge toward a common factor, while supporting discriminant validity by ensuring that constructs are distinct. Finally, the robust factor loading results strengthen the reliability of the measurement model, reduce ambiguity in interpretation, and provide strong empirical assurance

that the constructs truly capture the operational realities of TUDM logistics performance. (Hair et al., 2019; Field, 2018).

4.7.6 Factor Analysis for LP

The instrument of LP was developed by Madhakomala, et al., (2020). In this study, EIM Commitment stood with three dimensions namely Logistic Activities (T), Logistic Function (F), and Logistic Principles (P). All aspects were used to measure the mean EIM score among stevedores at the TUDM Air Base.

The data's eligibility for dimensionality reduction was validated using factor analysis for the Logistics Performance (LP) construct. Excellent sampling adequacy was shown by the sample adequacy metric of Kaiser-Meyer-Olkin (KMO), which produced a value of 0.963, surpassing the recommended cutoff of 0.60 (Kaiser, 1974). Furthermore, Bartlett's Test of Sphericity was significant ($\chi^2 = 2993.801$, $df = 136$, $p < 0.001$), rejecting the null hypothesis that the correlation matrix is an identity matrix and proving there is sufficient correlation between the variables so that factor analysis can continue (Bartlett, 1954). All of these findings support the data's factorability for the LP scale.

Table 4.10: The KMO and Bartlett's Test for LP

| | | |
|--|--------------------|---------|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.963 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 2993.80 |
| | df | 136 |
| | Sig. | 0.000 |

After the approval of the KMO test was confirmed, factor loadings for safety performance were examined in this study. Factor loadings were used to display the elements grouped within each factor. The 36 Job Satisfaction statement items, PCA application shown above is to evaluate

ILS and explain the synthesis factors that can influence the logistics performance of the TUDM. The fit of the data was evaluated. The majority of the factor loadings were more than 0.3, according to an examination of the rotated component matrix. These products all meet the nine criteria for job satisfaction. The maximum factor loading was 0.915, and the lowest factor loading larger than 0.3 was determined to be 0.533. The information is displayed in Table 4.11.

Principal component analysis yields a rotational component matrix that clarifies the Logistics Performance construct's underlying factor structure (Tabachnick & Fidell, 2019). The items loaded into three different components, as shown in Table 4.11, indicating a multidimensional scale. It is possible to interpret the first component, which is dominated by heavy loadings from items T1 to T5, as signifying operating speed or timeliness. The Flexibility dimension is suggested by the second component, which consists of items F1 through F5. Items P1 through P7 in the third component correspond to the output efficiency or productivity factor (Hair, et al., 2019). The LP measurement model's discriminant validity is supported by this clear separation of factors with low cross-loadings, demonstrating its value in capturing various performance elements.

Table 4.11: The Rotated Component Matrix for LP

| Component | Factor | | |
|-----------|--------|-------|-------|
| | 1 | 2 | 3 |
| T1 | 12.166 | | |
| T2 | 1.181 | | |
| T3 | 0.525 | | |
| T4 | 0.398 | | |
| T5 | 0.373 | | |
| F1 | | 0.330 | |
| F2 | | 0.305 | |
| F3 | | 0.257 | |
| F4 | | 0.248 | |
| F5 | | 0.212 | |
| P1 | | | 0.192 |
| P2 | | | 0.175 |
| P3 | | | 0.167 |
| P4 | | | 0.144 |
| P5 | | | 0.128 |
| P6 | | | 0.112 |
| P7 | | | 0.087 |

Extraction Method: Principal Component Analysis

4.7.7 Factor Analysis for EIM

The three elements of EIM commitment in this study include bureaucratic procurement procedure (BP), record keeping (RK), financial resources/funding (FR), and employee skills (SE). The TUDM Air Base's stevedores' mean EIM score was calculated using all factors. The Efficient Inventory Management (EIM) construct's data demonstrated exceptional factor analysis applicability. The suggested threshold of 0.60 was much exceeded by the Kaiser-Meyer-Olkin (KMO) sample adequacy metric of 0.944 (Kaiser, 1974). This suggests that the items have a commendable degree of shared variance. Concurrently, Bartlett's Test of Sphericity rejected the identity correlation matrix null hypothesis, which was statistically significant ($\chi^2 = 2760.70$, $df =$

190, $p < 0.001$) (Bartlett, 1954). These diagnostic findings verify that there is enough intercorrelation between the EIM scale data to support carrying out further factor analysis study.

Table 4.12: The KMO and Bartlett's Test for EIM

| | | |
|--|--------------------|---------|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.944 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 2760.69 |
| | df | 190 |
| | Sig. | 0.000 |

The multidimensional structure of the EIM construct was clarified using Varimax rotation in principal component analysis. The twenty items loaded neatly into four separate components, as shown in Table 4.13, indicating strong discriminant validity (Hair et al., 2019). The Business Process Optimization dimension is represented by the first component, which consists of elements BP1 through BP5. The Risk Management factor was suggested by items RK1 through RK5, which mostly loaded on the second component. Items FR1 through FR5 define the third component, which is related to forecasting and replenishment capacities. Lastly, the fourth component, which is referred to as System and Technology Enablement, consists of items SE1 through SE5. This straightforward factorial solution supports the theoretical idea and measurement integrity of EIM by confirming that it is a high-level construct made up of four separate but related operational subdimensions (Field, 2018).

Table 4.13: The Rotated Component Matrix for EIM

| Component | Factor | | | |
|-----------|--------|-------|-------|-------|
| | 1 | 2 | 3 | 4 |
| BP1 | 11.572 | | | |
| BP2 | 1.413 | | | |
| BP3 | 1.060 | | | |
| BP4 | 0.751 | | | |
| BP5 | 0.682 | | | |
| RK1 | | 0.645 | | |
| RK2 | | 0.540 | | |
| RK3 | | 0.525 | | |
| RK4 | | 0.464 | | |
| RK5 | | 0.376 | | |
| FR1 | | | 0.367 | |
| FR2 | | | 0.313 | |
| FR3 | | | 0.276 | |
| FR4 | | | 0.264 | |
| FR5 | | | 0.191 | |
| SE1 | | | | 0.163 |
| SE2 | | | | 0.132 |
| SE3 | | | | 0.112 |
| SE4 | | | | 0.084 |
| SE5 | | | | 0.072 |

Extraction Method: Principal Component Analysis

4.7.8 Factor Analysis for IES

In this study, IES Involvement was measured using 7 items. This instrument was developed by Setiawan, et al., (2025). Work Involvement is a unidimensional variable in this study. Initial diagnostic testing verified that the data was factorable for the IES design. The Kaiser-Meyer-Olkin (KMO) sample adequacy measure produced a result of 0.885, which was deemed meritorious because it was higher than the predetermined criterion of 0.60 (Kaiser, 1974). This suggested that the variables had a significant degree of shared variance. Additionally, Bartlett's Test of Sphericity yielded statistically noteworthy findings that refute the null hypothesis that the correlation matrix

is an identical matrix ($\chi^2 = 721.49$, $df = 21$, $p < 0.001$) (Bartlett, 1954). Together, these findings demonstrate that there is enough intercorrelation between the IES scale items to support factor extraction for dimensional assessment.

Table 4.14: The KMO and Bartlett's Test for IES

| | | |
|--|--------------------|--------|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.885 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 721.48 |
| | df | 21 |
| | Sig. | 0.000 |

The Improved Engineering Support construct has a unidimensional structure, according to factor analysis. All seven items (IES1 through IES7) loaded strongly on a single component, accounting for a sizable amount of the overall variance, as seen in Table 4.15. These findings supported the scale's construct validity, showing that the items measured a single underlying dimension of engineering support capabilities in a coherent manner (Hair, et al., 2019). The scale's internal homogeneity and the idea that IES is a single operational factor are further supported by the absence of cross-loadings onto secondary components (Field, 2018). These findings justify representing the IES variable in later analyses using a cumulative scale score.

Table 4.15: The Rotated Component Matrix for EIS

| Component | Factor 1 |
|-----------|-------------|
| IES1 | 4.690 |
| IES2 | 0.662 |
| IES3 | 0.543 |
| IES4 | 0.381 |
| IES5 | 0.314 |
| IES6 | 0.230 |
| IES7 | 0.180 |

Extraction Method: Principal Component Analysis

4.7.9 Factor Analysis for ILS

ILS management involvement is measured using 6 items. This instrument was developed by Eski, S., & Özaslan, İ. H. (2022). Work involvement is a uni-dimensional variable in this study. The preliminary evaluation verified that the information was suitable for factor analysis according to the ILS construct. A good level of variance sharing between variables was indicated by the sample adequacy value of 0.889 for Kaiser-Meyer-Olkin (KMO), which is far higher than the benchmark of 0.60 (Kaiser, 1974). Furthermore, there were sufficient correlations between the questions to support factor extraction, as demonstrated by the statistically significant Bartlett's Test of Sphericity ($\chi^2 = 761.94$, $df = 15$, $p < 0.001$) (Bartlett, 1954). The ILS data's potential for exploratory factor analysis was validated by this diagnosis.

Table 4.16: The KMO and Bartlett's Test for ILS

| | | |
|--|--------------------|--------|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.889 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 761.93 |
| | df | 15 |
| | Sig. | 0.000 |

The ILS construct's unidimensionality was validated using factor analysis. All six elements (ILS1 through ILS6) loaded substantially on one component, as shown in Table 4.17. These findings supported the scale's structural validity, showing that all of the items together measure a single, cohesive aspect of integrated logistical support (Hair, et al., 2019). The instrument's internal consistency is strengthened and the theoretical notion of ILS as a single latent variable is supported by the lack of significant cross-loadings on other factors (Pallant, 2020). Therefore, in later empirical analyses, the summed scale scores can be used as a valid and dependable measure of ILS.

Table 4.17: The Rotated Component Matrix for ILS

| Factor | |
|-----------|-------|
| Component | 1 |
| ILS1 | 4.551 |
| ILS2 | 0.442 |
| ILS3 | 0.354 |
| ILS4 | 0.275 |
| ILS5 | 0.241 |
| ILS6 | 0.137 |

Extraction Method: Principal Component Analysis

4.8 Research Objective Analysis

This study's objective analysis looks at how the TUDM logistics performance is affected by EIM, IES and ILS. Six goals have been proposed for this study in order to ascertain the connection between Independent Variables and Dependent Variables. This study's analysis also aims to evaluate the important predictors of EIM, IES and ILS management on logistics performance in the TUDM. Among the objectives are as follows:

4.8.1 To determine the connection between Efficient Inventory Management and Logistics Performance

LP and EIM have a substantial link, as seen by the correlation coefficient of $r = 0.835$. The null hypothesis is rejected since the p-value is less than 0.001. Consequently, LP and EIM have a statistically significant association.

Table 4.18: Relationship between LP and EIM

| | | Logistic Performance | Efficient Inventory Management |
|---|---------------------|---------------------------------|---|
| Logistic Performance | Pearson Correlation | 1 | 0.835** |
| | Sig. (2-tailed) | | 0.000 |
| | N | 155 | 155 |
| Efficient Inventory Management | Pearson Correlation | 0.835** | 1 |
| | Sig. (2-tailed) | 0.000 | |
| | N | 155 | 155 |

** . Correlation is significant at the 0.01 level (2-tailed).

4.8.2 To determine the connection between Improved Engineering Support and Logistics Performance

The correlation coefficient is $r = 0.803$, indicating a strong relationship between LP and IES. The p-value is less than 0.001, which means the null hypothesis is rejected. Therefore, there is a statistically significant relationship between LP and IES as shown at table 4.19.

Table 4.19: Relationship between LP and IES

| | | Logistic Performance | Improved Engineering Support |
|---|---------------------|---------------------------------|---|
| Logistic Performance | Pearson Correlation | 1 | 0.803** |
| | Sig. (2-tailed) | | 0.000 |
| | N | 155 | 155 |
| Improved Engineering Support | Pearson Correlation | 0.803** | 1 |
| | Sig. (2-tailed) | 0.000 | |
| | N | 155 | 155 |

** . Correlation is significant at the 0.01 level (2-tailed).

4.8.3 To determine the connection between Integrated Logistics Support management and Logistics Performance

The correlation coefficient is $r = 0.920$, indicating a strong relationship between LP and ILS. The p-value is less than 0.001, which means the null hypothesis is rejected. Therefore, there is a statistically significant relationship between LP and ILS.

Table 4.20: Relationship between LP and ILS

| | | Logistic Performance | Integrated Logistic Support |
|------------------------------------|---------------------|-----------------------------|------------------------------------|
| Logistic Performance | Pearson Correlation | 1 | 0.920** |
| | Sig. (2-tailed) | | 0.000 |
| | N | 155 | 155 |
| Integrated Logistic Support | Pearson Correlation | 0.920** | 1 |
| | Sig. (2-tailed) | 0.000 | |
| | N | 155 | 155 |

** . Correlation is significant at the 0.01 level (2-tailed).

4.8.4 To determine the connection between Efficient Inventory Management and Improved Engineering Support

The correlation coefficient is $r = 0.809$, indicating a strong relationship between EIM and IES. The p-value is less than 0.001, which means the null hypothesis is rejected. Therefore, there is a statistically significant relationship between LP and IES.

Table 4.21: Relationship between EIM and IES

| | | Efficient Inventory Management | Improved Engineering Support |
|---------------------------------------|---------------------|---------------------------------------|-------------------------------------|
| Efficient Inventory Management | Pearson Correlation | 1 | 0.809** |
| | Sig. (2-tailed) | | 0.000 |
| | N | 155 | 155 |
| Improved Engineering Support | Pearson Correlation | 0.809** | 1 |
| | Sig. (2-tailed) | 0.000 | |
| | N | 155 | 155 |

** . Correlation is significant at the 0.01 level (2-tailed).

4.8.5 To determine the connection between Improved engineering support and Integrated Logistics Support management

The correlation coefficient is $r = 0.805$, indicating a strong relationship between IES and ILS. The p-value is less than 0.001, which means the null hypothesis is rejected. Therefore, there is a statistically significant relationship between IES and ILS.

Table 4.22: Relationship between IES and ILS

| | | Improved Engineering Support | Integrated Logistic Support |
|-------------------------------------|---------------------|-------------------------------------|------------------------------------|
| Improved Engineering Support | Pearson Correlation | 1 | 0.805** |
| | Sig. (2-tailed) | | 0.000 |
| | N | 155 | 155 |
| Integrated Logistic Support | Pearson Correlation | 0.805** | 1 |
| | Sig. (2-tailed) | 0.000 | |
| | N | 155 | 155 |

** . Correlation is significant at the 0.01 level (2-tailed).

4.8.6 To determine the connection between Efficient Inventory Management and Integrated Logistics Support management

The correlation coefficient is $r = 0.843$, indicating a strong relationship between EIM and ILS. The p-value is less than 0.001, which means the null hypothesis is rejected. Therefore, there is a statistically significant relationship between EIM and ILS.

Table 4.23: Relationship between EIM and ILS

| | | Efficient Inventory Management | Integrated Logistic Support |
|---------------------------------------|---------------------|--------------------------------|-----------------------------|
| Efficient Inventory Management | Pearson Correlation | 1 | 0.843** |
| | Sig. (2-tailed) | | 0.000 |
| | N | 155 | 155 |
| Integrated Logistic Support | Pearson Correlation | 0.843** | 1 |
| | Sig. (2-tailed) | 0.000 | |
| | N | 155 | 155 |

** . Correlation is significant at the 0.01 level (2-tailed).

4.9 Descriptive Statistics of Variables of Study

Table 4.24 presents the descriptive statistics for the study variables, indicating consistently high mean values across all constructs. Logistics Performance ($M = 4.18$), Efficient Inventory Management ($M = 4.14$), Improved Engineering Support ($M = 4.11$), and Integrated Logistics Support ($M = 4.18$) demonstrate favorable perceptions among respondents, reflecting strong operational capability and positive logistics effectiveness within the organization. The moderate standard deviation values suggest relatively stable responses, indicating shared agreement among participants. These results imply that effective logistics practices, particularly inventory, engineering, and ILS integration, contribute to enhanced performance outcomes, aligning with established logistics and operations literature (Christopher, 2016; Hair, et al., 2019). This pattern signifies that responses are heavily clustered at the higher end of the scale (i.e., strongly agree),

with limited score variability and few outliers in the lower ranges (Field, 2018). Such distributions suggest a potential ceiling effect, which should be considered when interpreting subsequent inferential analyses.

Table 4.24: Descriptive Statistics of All Constructs

| Variables / Items | N Statistic | Mean Statistic | Std. Deviation Statistic |
|--|------------------------|---------------------------|-------------------------------------|
| Logistic Performance (17) | 155 | 4.1769 | 0.71104 |
| Efficient Inventory Management (20) | 155 | 4.1374 | 0.67551 |
| Improved Engineering Support (7) | 155 | 4.1078 | 0.74237 |
| Integrated Logistic Support (6) | 155 | 4.1839 | 0.72677 |

Note: Calculation for the analysis is based on sum score. Total Mean Score is based on Likert-type scale of 1 (strongly disagree) – 5 (strongly agree)

4.10 Evaluation of SPSS Results

This study used the SPSS technique to test the research hypotheses. The SPSS software version 27 developed by Norman Nie, Dale Bent, and Cliff Hadley (1968) was used for the purpose of this research. The testing stage used SPSS Analysis to assess the reliability, validity, and hypothesis testing of the collected data. This sophisticated statistical technique offers a robust approach to structural equation modeling, especially suitable for complex models with latent variables such as EIM, EIS, ILS, and LP. Below Figure 4.10 is the research framework model implemented using SPSS:

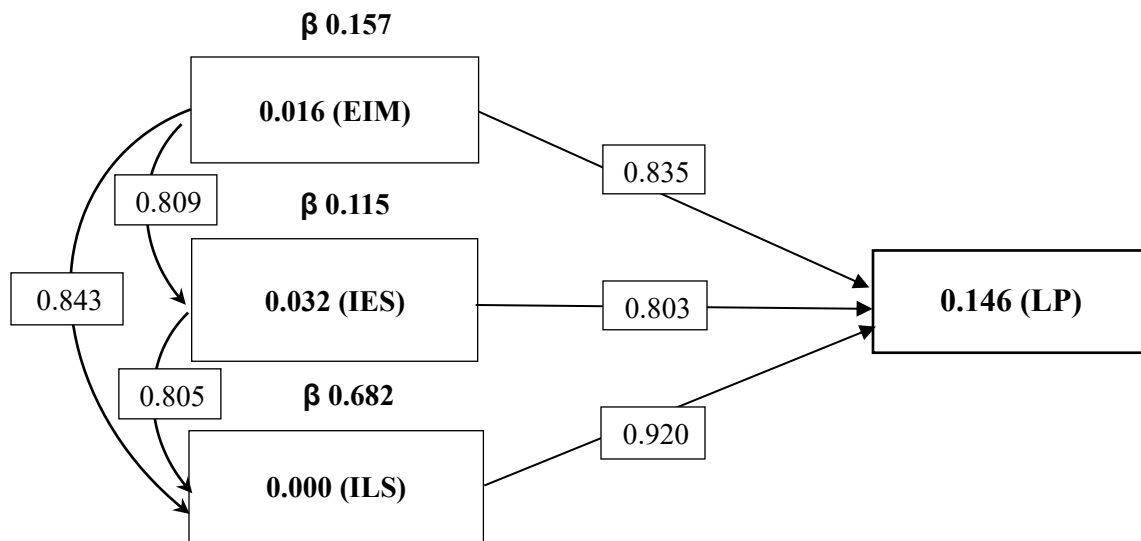


Figure 4.10: Research Framework

4.11 Logistics Performance on Rank

The objective of the LP is to investigate the relationship between logistics performance among TUDM officers and personnel and variations in demographic characteristics, rank, age, education level, position, craftsmanship and length of service, which was achieved in this section through inferential statistical analysis. Table 4.25 illustrates variations in Logistics Performance perceptions across different military ranks. Captains reported the highest mean score ($M = 4.48$), followed by Warrant Officers ($M = 4.31$) and Lieutenant Colonels ($M = 4.34$), indicating strong confidence in logistics capability among senior personnel. Meanwhile, Lieutenants ($M = 3.93$) and Sergeants ($M = 3.91$) recorded comparatively lower means, suggesting differing experiential perspectives. These findings show no statistically significant differences between ranks, implying a broadly consistent perception of logistics performance across organizations, reflecting stable institutional practices.

Table 4.25: Descriptive of Logistics Performance on Rank

| Logistic Performance | N | Mean | Std. Deviation |
|--|----------|-------------|-----------------------|
| Corporal | 25 | 4.2894 | 0.54917 |
| Sergeant | 30 | 3.9118 | 0.89979 |
| F/ Sergeant | 20 | 4.1118 | 0.82704 |
| Warren Officer | 13 | 4.3122 | 0.42103 |
| Lieutenant/ 2nd Lieutenant | 13 | 3.9321 | 1.09467 |
| Captain | 10 | 4.4824 | 0.39098 |
| Major | 33 | 4.2692 | 0.50216 |
| Lt Colonel | 11 | 4.3369 | 0.56304 |
| Total | 155 | 4.1769 | 0.71104 |

Table 4.26 presents the results of the ANOVA assessing whether perceptions of logistics performance differ significantly across military ranks. The results show a mean square between groups of 0.718 with a value of $F = 1.448$ and a significance level of $p = 0.190$, indicating that there is no statistically significant variation between rank categories. These results indicate that personnel across hierarchical levels view logistics performance in a relatively consistent manner, reflecting the standard procedures, shared operational frameworks and emphasizes logistics practices within the TUDM. Such consistency also indicates emphasizes integration, where strategic logistics policies are effectively communicated and implemented across levels, supporting reliability in performance perceptions. These findings are in line with the literature which 106emphasizes the importance of a cohesive institutional system and a structured management environment in maintaining performance stability (Field, 2018; Hair, et al., 2019).

Table 4.26: ANOVA result on respondents' rank on their LP

| | Sum of Squares | df | Mean Square | F | Sig. |
|-----------------------|-----------------------|-----------|--------------------|--------------|--------------|
| Between Groups | 5.023 | 7 | 0.718 | | |
| Within Groups | 72.835 | 147 | 0.495 | 1.448 | 0.190 |
| Total | 77.858 | 154 | | | |

4.12 Logistics Performance on Age Group

Table 4.27 presents the descriptive statistics findings for Logistics Performance across age categories within the organization. The results indicate that respondents aged 41 and above reported the highest mean score ($M = 4.30$), followed by the 31–40 age group ($M = 4.16$), while the 21–30 group recorded a slightly lower perception ($M = 4.02$). These findings imply that experience and longer service exposure may enhance confidence in logistics capability and operational effectiveness.

Table 4.27: Descriptive of Logistics Performance on Age of Group

| Logistic Performance | N | Mean | Std. Deviation |
|-----------------------------|----------|-------------|-----------------------|
| 21-30 | 25 | 4.0212 | 0.82473 |
| 31-40 | 88 | 4.1604 | 0.75840 |
| 41 and over | 42 | 4.3039 | 0.49844 |
| Total | 155 | 4.1769 | 0.71104 |

Despite observable mean differences, the ANOVA result $F = 1.298$, and $p = 0.276$ demonstrates that these variations are not statistically significant, suggesting generally consistent perceptions of logistics performance across age cohorts. This uniformity reflects organizational stability, shared operational standards, and structured logistics management systems, which contribute to cohesive performance perceptions across personnel demographics (Field, 2018; Hair, et al., 2019). Overall,

the results reinforce the reliability of logistics practices across different experience levels within the organization.

Table 4.28: ANOVA result on respondents' age of group on their Logistics Performance

| | Sum of Squares | df | Mean Square | F | Sig. |
|-----------------------|-----------------------|-----------|--------------------|--------------|--------------|
| Between Groups | 1.308 | 2 | 0.654 | | |
| Within Groups | 76.550 | 152 | 0.504 | 1.298 | 0.276 |
| Total | 77.858 | 154 | | | |

4.13 Logistics Performance on Education Level

Table 4.29 presents descriptive statistics on Logistics Performance towards Education which examines differences in perceptions of logistics performance across four educational attainment groups: Bachelor's Degree, Diploma, Master's Degree and above, and Secondary School. The descriptive data shows that the mean performance score is relatively high across all groups, ranging from 4.0993 (Diploma) to 4.3934 (Master's Degree and above), suggesting generally positive self-assessments regardless of educational background. In detail for this descriptive, the mean for the group of respondents with Secondary School academic qualifications is 4.137, followed by 4.099 for Diploma, while Bachelor's degree is 4.245 and 4.393 for Master's Degree and above. The statistics show that the mean score for academic qualifications is moderately high.

Table 4.29: Descriptive of Logistics Performance on Education Level

| Logistic Performance | N | Mean | Std. Deviation |
|----------------------------------|----------|-------------|-----------------------|
| Secondary School | 38 | 4.1378 | 0.65991 |
| Diploma | 61 | 4.0993 | 0.75808 |
| Bachelor's degree | 40 | 4.2456 | 0.75834 |
| Master's Degree and above | 16 | 4.3934 | 0.48112 |
| Total | 155 | 4.1769 | 0.71104 |

However, the ANOVA results reveal that these between-group differences are not statistically significant, with an $F = 0.897$ and a significance level $p\text{-value} = 0.444$, which exceeds the conventional alpha threshold of 0.05 as shown at table 4.30 (Field, 2018). This indicates that, for this sample of 155 respondents, perceived logistics performance does not vary meaningfully based on the highest level of education completed. The non-significant finding implies that factors other than formal education may be more salient in influencing logistics performance perceptions in this context, aligning with research suggesting that workplace experience and specific training can outweigh general educational qualifications in operational fields (Rushton, et al., 2022). Consequently, while educational programs provide foundational knowledge, their direct impact on perceived professional performance in logistics may be moderated by other variables.

Table 4.30: ANOVA result on respondents' education level on their Logistics performance

| | Sum of Squares | df | Mean Square | F | Sig. |
|-----------------------|-----------------------|-----------|--------------------|-------------|--------------|
| Between Groups | 1.364 | 3 | 0.455 | | |
| Within Groups | 76.494 | 151 | 0.507 | .897 | 0.444 |
| Total | 77.858 | 154 | | | |

4.14 Logistics Performance on Designation

Table 4.31 presents descriptive statistics for Logistics Performance across different designation. The results show consistently high mean scores, with SO3 (M = 4.50) and SO1 (M = 4.46) reporting the strongest performance perceptions, closely followed by SO2 (M = 4.25), Supervisor (M = 4.25), and IC NCO (M = 4.22). The overall results indicate positive confidence in logistics capabilities across professional roles, although perceptions are slightly lower among IC OIC/SNCO (M = 3.89). The relatively low standard deviation values suggest structured procedures and institutionalized practices that support performance quality, as well as consistent responses and general perceptions of logistics effectiveness. This pattern is in line with the established literature on logistics, which highlights the importance of a coordinated management framework and structured organizational systems in achieving operational reliability (Christopher, 2016; Hair, et al., 2019).

Table 4.31: Descriptive of Logistics Performance on Designation

| Logistic Performance | N | Mean | Std. Deviation |
|-----------------------------|----------|-------------|-----------------------|
| NCO IC | 12 | 4.2206 | 0.59680 |
| OIC/SNCO IC | 35 | 3.8891 | 0.95457 |
| Supervisor | 27 | 4.2505 | 0.71104 |
| SO 1 | 8 | 4.4559 | 0.56749 |
| SO 2 | 29 | 4.2454 | 0.51619 |
| SO 3 | 9 | 4.4967 | 0.34565 |
| Others | 35 | 4.1899 | 0.78443 |
| Total | 155 | 4.1769 | 0.71104 |

The one-way ANOVA result was non-significant, $F = 1.604$, and $p = 0.150$ (see Tables 4.32). This finding suggests that formal hierarchical position, within the sampled military context, does not statistically predict differences in self-reported logistics performance (Pettit, et al., 2019). The non-significant p-value implies that shared organizational training, doctrine, or task-specific

competencies may homogenize performance perceptions across ranks, underscoring that role title alone may not be a primary differentiator of operational effectiveness in structured environments (Golicic & Davis, 2012).

Table 4.32: ANOVA result on respondents' designation on their Logistics performance

| | Sum of Squares | df | Mean Square | F | Sig. |
|-----------------------|-----------------------|-----------|--------------------|--------------|--------------|
| Between Groups | 4.754 | 6 | 0.792 | | |
| Within Groups | 73.104 | 148 | 0.494 | 1.604 | 0.150 |
| Total | 77.858 | 154 | | | |

4.15 Logistics Performance on Expertise

Table 4.33 shows the results that the respondents to the Materiel expertise were 81 and had a mean score of 3.374, followed by the Engineering expertise respondents of 69 with a mean score of 3.326 and other expertise respondents were 5 people. This table present a comparative analysis of logistics performance perceptions across seven distinct functional expertise areas within a military context. Descriptive statistics indicate notable variation in mean scores, ranging from 1.3529 (“Pelatih”) to 4.3123 (“Materiel”), as shown in Table 4.33.

Table 4.33: Descriptive of Logistics Performance on Expertise

| Logistic Performance | N | Mean | Std. Deviation |
|-----------------------------|----------|-------------|-----------------------|
| Engineering | 69 | 4.0767 | 0.77740 |
| Flying | 1 | 4.1765 | . |
| Jurulatih Jasmani | 1 | 3.8824 | . |
| Legal | 1 | 3.6471 | . |
| Materiel | 81 | 4.3123 | 0.57089 |
| Operasi PKTU | 1 | 3.7647 | . |
| Pelatih (Visor) | 1 | 1.3529 | . |
| Total | 155 | 4.1769 | 0.71104 |

This study has shown that one-way ANOVA results revealed statistically significant differences among these expert groups, $F = 3.925$, $p = 0.001$ (see Table 4.34). This important finding suggests that individuals' specific professional domains are substantive predictors of their self-rated logistics performance, in contrast to previous analyses of demographic factors such as education and position, which yielded less significant results (refer to Tables 4.29 & 4.31). The outcome underscores that task-specific knowledge and technical skill sets, particularly within core logistical functions like materiel management, are critically associated with higher perceived operational competence (Christopher, 2016).

Table 4.34: ANOVA result on respondents' expertise on their Logistics Performance

| | Sum of Squares | df | Mean Square | F | Sig. |
|-----------------------|-----------------------|-----------|--------------------|--------------|--------------|
| Between Groups | 10.689 | 6 | 1.781 | | |
| Within Groups | 67.169 | 148 | 0.454 | 3.925 | 0.001 |
| Total | 77.858 | 154 | | | |

4.16 Logistics Performance on Year of Served

Tables 4.35 present an analysis of variance assessing the relationship between years of military service and self-reported logistics performance. Respondents were categorized into five tenure groups, ranging from 1-5 years to over 20 years. From the result, respondent year of served between 1 – 5 years have the mean score of 3.958, followed by respondents between 5.1 – 10 years with mean score of 4.223. The respondent year of served between 10.1 – 15 years have the mean score of 4.136 and respondents between 15.1 – 20 years with mean score of 4.232 and above 20 years score at 4.212. Based on Table 4.35 below, it has been shown that the mean between safety performance and respondent age group is moderately high. The descriptive statistics show mean

performance scores clustering narrowly between 3.958 and 4.232, indicating minimal variation across experience levels (see Table 4.25).

Table 4.35: Descriptive of Logistics Performance on Year of Served

| Logistic Performance | N | Mean | Std. Deviation |
|-----------------------------|----------|-------------|-----------------------|
| 1-5 years | 14 | 3.9580 | 1.05616 |
| 5.1 to 10 years | 30 | 4.2235 | 0.76485 |
| 10.1 to 15 years | 40 | 4.1368 | 0.83044 |
| 15.1 to 20 years | 38 | 4.2322 | 0.54670 |
| > 20 years | 33 | 4.2121 | 0.48349 |
| Total | 155 | 4.1769 | 0.71104 |

The one-way ANOVA confirmed no statistically significant difference among these groups, $F = 0.467$, and $p = 0.760$ (Table 4.28). This non-significant result suggests that, within this organizational sample, the length of service alone does not substantially predict differences in perceived logistics competency. This finding implies that foundational operational proficiency may be established early in a career, with subsequent tenure contributing less to performance perceptions than other factors, such as specific expertise or training (Kovács & Spens, 2012). Therefore, seniority should not be conflated with enhanced self-assessed performance in specialized logistical functions.

Table 4.36: ANOVA result on respondents' year of served on their Logistics Performance

| | Sum of Squares | df | Mean Square | F | Sig. |
|-----------------------|-----------------------|-----------|--------------------|--------------|--------------|
| Between Groups | 0.958 | 4 | 0.239 | | |
| Within Groups | 76.900 | 150 | 0.513 | 0.467 | 0.760 |
| Total | 77.858 | 154 | | | |

4.17 Model Summary

From the table 4.37 below, according to the Model Summary, the independent variables EIM, IES, and ILS, account for 86.0% of the variance in LP, with an adjusted R² value of 0.860. This result shows that the regression model has a high degree of explanatory power, suggesting that the chosen variables are suitable for explaining differences in LP.

Table 4.37: Model Summary

| Model Summary | | | | |
|----------------------|--------------------|----------|-------------------|----------------------------|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1 | 0.929 ^a | 0.863 | 0.860 | 0.26572 |

a. Predictors: (Constant), Integrated Logistic Support, Improved Engineering Support, Efficient Inventory Management.

4.18 ANOVA Result

Table 4.38 presents the findings of the ANOVA that examined the influence of EIM, IES and ILS on Logistics Performance. The results revealed a highly significant regression model, $F = 317.231$, $p < 0.001$, indicating that the combined predictors explain a large portion of the variance in logistics outcomes. The null hypothesis was rejected as a result, implying that the independent variables (EIM, IES, and ILS) together account for a significant amount of the variance in LP. The high regression sum of squares (67.196) compared to the residual sum (10.662) suggests strong explanatory power, indicating that these logistics capabilities contribute significantly to performance effectiveness. These findings support the view that a coordinated logistics system and integrated support mechanisms enhance the operational capabilities and efficiency of institutions in complex environments (Christopher, 2016; Hair, et al., 2019). Consequently, the findings

confirm that the linear regression model is sufficient to explain the fluctuations in Logistics Performance.

Table 4.38: ANOVA result

| ANOVA ^a | | | | | | |
|--------------------|-------------------|----------------|-----|-------------|----------------|--------------------------|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| 1 | Regression | 67.196 | 3 | 22.399 | | |
| | Residual | 10.662 | 151 | 0.071 | 317.231 | 0.000^b |
| | Total | 77.858 | 154 | | | |

a. Dependent Variable: Logistic Performance.

b. Predictors: (Constant), Integrated Logistic Support, Improved Engineering Support, Efficient Inventory Management.

4.19 Coefficients

The Coefficient Table 4.39 shows that all three independent variables are significant predictors of LP. It has been revealed that integrated logistics support is the largest contributor ($p = 0.001 < 0.05$), indicating that it is the strongest predictor among the three variables. While EIM has a statistically significant effect on LP ($p = 0.016 < 0.05$), indicating that EIM contributes significantly to the prediction of LP and IES is also a significant predictor of LP ($p = 0.032 < 0.05$). Specifically, the unstandardized coefficient ($B = 0.682$, $p < 0.001$) shows a strong positive relationship, while the standardized coefficient ($B = 0.697$) confirms its dominant role compared to other variables (see Table 4.39). These results indicate that a cohesive logistics system is essential for operational effectiveness.

Additional significant predictors include efficient inventory management ($B = 0.157$, $p = 0.016$) and improved engineering support ($B = 0.115$, $p = 0.032$), although their standardized coefficients ($B = 0.150$ and 0.120 , respectively) indicate more modest effects. The model constant

is not significant ($p = 0.146$), implying that when all predictors are zero, logistics performance does not deviate significantly from zero. Collectively, these findings underscore the paramount importance of an integrated logistics framework, coupled with inventory and engineering efficiency, in improving logistics performance outcomes.

Based on the regression analysis, the estimated regression equation can be expressed as:

$$LP = 0.198 + 0.157(EIM) + 0.115(IES) + 0.682(ILS) + \varepsilon$$

Table 4.39: Coefficients

| Model | | Unstandardized Coefficients | | Standardized Coefficients | | |
|-------|--------------------------------|-----------------------------|------------|---------------------------|--------|-------|
| | | B | Std. Error | Beta | t | Sig. |
| 1 | (Constant) | 0.198 | 0.136 | | 1.461 | 0.146 |
| | Efficient Inventory Management | 0.157 | 0.064 | 0.150 | 2.443 | 0.016 |
| | Improved Engineering Support | 0.115 | 0.053 | 0.120 | 2.160 | 0.032 |
| | Integrated Logistic Support | 0.682 | 0.059 | 0.697 | 11.467 | 0.000 |

a. Dependent Variable: Logistic Performance.

4.20 Intercorrelation

According to Cavana, et al., (2001), this correlation analysis aims to examine the relationship between each variable and therefore, the importance of bivariate relationships (bi means two) of the constructs that have been used in the study. The relationship between each construct also confirms the nomological validity of the model structure (Babin, Darden & Griffin, 1994). Therefore, this study attempts to examine the relationship between EIM, IES, ILS and Logistics Performance among officers and staff of the TUDM. To examine the relationship and determine

the validity of the nomology, a hypothesis about the correlation between these four (4) variables was created. The hypotheses developed are as follows:

- a. **H1:** *EIM is positively significant to Logistics Performance in the TUDM.*
- b. **H2:** *IES is positively significant to Logistics Performance in the TUDM.*
- c. **H3:** *ILS management is positively significant to Logistics Performance in the TUDM.*
- d. **H4:** *EIM is positively significant to IES in the TUDM.*
- e. **H5:** *IES is positively significant to ILS management in the TUDM.*
- f. **H6:** *EIM is positively significant to ILS management in the TUDM.*

Table 4.40 below presents the correlation matrix for the four main constructs of IEM, IES, ILS and LP. This analysis revealed strong and statistically significant positive correlations between all variables and supported the proposed hypotheses (H1–H6). In particular, LP showed very strong correlations with ILS ($r = 0.920$, $p < 0.01$), IEM ($r = 0.835$, $p < 0.01$), and IES ($r = 0.803$, $p < 0.01$), thus confirming H1, H2 and H3. Furthermore, there were strong associations between IEM, IES and ILS (correlations ranging from 0.805 to 0.843, $p < .01$) supporting the direct effects that have been stated in H4, H5 and H6 (Cohen et al., 2018). Collectively, these findings indicate that improvements in core logistics and engineering functions can be synergistically linked and are critical drivers of overall logistics performance in the organizational context examined.

The results of the Pearson correlation study using SPSS version 27.0 are shown in Table 4.40. All constructs show satisfactory levels of correlation with each other at the $p < 0.01$ level. The strength of correlation between variables in this study is strong and acceptable because all of them are statistically significant. There is a strong positive correlation between each of the EIM, IES, ILS, and LP variables of the study. Each construct has a strong positive correlation level overall at the $p < 0.01$ level. The specific relationships found during this analysis are shown in the table below.

Table 4.40: Intercorrelation among Variables (N = 155)

| | IEM | IES | ILS | LP |
|--------------------|---------|---------|---------|---------|
| IEM | 1 | 0.809** | 0.843** | 0.835** |
| IES | | 1 | 0.805** | 0.803** |
| ILS | | | 1 | 0.920** |
| LP | | | | 1 |
| Mean | 4.1374 | 4.1078 | 4.1839 | 4.1769 |
| Standard Deviation | 0.67551 | 0.74237 | 0.72677 | 0.71104 |

***. Correlation is significant at the 0.01 level (2-tailed).*

Note: The calculation based on mean computed in SPSS. Efficient Inventory Management (EIM), Improved Engineering Support (IES), Integrated Logistic Support (ILS) and Logistics Performance (LP)

4.21 Descriptive Findings of Main Variables

The table 4.41 below reports the descriptive statistics and internal consistency of the four main variables measured among 155 TUDM respondents. All constructs have shown strong reliability,

with Cronbach's alpha values ranging from 0.912 to 0.974, exceeding the recommended threshold. The mean scores for EIM (M = 4.11, SD = 0.74), IES (M = 4.18, SD = 0.73), ILS (M = 4.17, SD = 0.73) and LP (M = 4.14, SD = 0.76) indicate consistently high levels of efficiency, reliability, integration. These results indicate that respondents perceive the organizational system and leadership practices as effective and integrated. The reporting of the Descriptive Findings for the Main Variables is as follows:

- a. Theme 1: Efficient Inventory Management. Respondents rated inventory efficiency as high, indicating that spare parts forecasting and stock visibility have improved operational readiness and reduced AOG events.
- b. Theme 2: Improved Engineering Support. Engineering units reported high diagnostic capabilities and reduced turnaround time (TAT), reduced Mean Time Between Failures (MTBF) and supported stronger aircraft availability.
- c. Theme 3: ILS Management. The ILS integration process was rated highly, suggesting continued integration for further alignment between maintenance planning and supply chain coordination could optimize TUDM logistics performance.

Table 4.41: Descriptive Findings of Main Variables

| Variable | Cronbach's alpha | Mean | SD | Interpretation |
|-----------------|-------------------------|-------------|-----------|-----------------------|
| EIM | 0.970 | 4.1078 | 0.742 | High efficiency |
| IES | 0.912 | 4.1839 | 0.726 | High reliability |
| ILS | 0.936 | 4.1689 | 0.734 | High integration |
| LP | 0.974 | 4.1374 | 0.757 | Strong performance |

4.22 Data Analysis and Interpretation of Findings

The purpose of this study is to evaluate the relationship between the TUDM logistics performance and the three key components of IEM, IES and ILS management. All independent factors have a positive and substantial link with logistical performance, according to data analysis results.

According to descriptive statistics, respondents' opinions of the TUDM present logistics management procedures are largely favorable, as seen by the high mean scores across all constructs. Reliability testing revealed that all constructs had Cronbach's Alpha values more than 0.912, demonstrating the stability and consistency of the research tool.

Interpretation of these findings indicates that EIM can speed up the logistics process, reduce downtime, and ensure spare parts availability. Engineering support contributes to operational stability and efficient and effective maintenance. ILS management emerged as the most dominant factor because it holistically integrates all elements of logistics support. These results fully support all research questions and hypotheses, indicating that an efficient and integrated logistics approach is essential in improving the effectiveness of the TUDM logistics performance.

4.23 Key Findings & Discussion

The study aimed to investigate how the three critical factors of EIM, IES, and ILS Management influence the logistics performance of the TUDM. The regression model showed an R^2 value of 0.863, indicating that 86% of the variance in logistics performance could be explained by the three independent variables. All three predictors showed a statistically significant and positive relationship with logistics performance ($p < 0.05$), supporting all the proposed hypotheses.

The logistics performance of the TUDM was shown to be significantly impacted by EIM, with a p value of less than 0.001 and a beta coefficient (β) of 0.016. A moderately strong positive

association between inventory management and logistics performance is indicated by the Pearson correlation value of 0.835. This confirms Hypothesis 1 (H1). The findings indicate that efficient inventory practices, ensuring timely availability of spare parts, help reduce aircraft downtime and expand the overall responsiveness of the TUDM logistics performance. In practice, it highlights the importance of implementing advanced inventory control systems and demand forecasting tools to improve resource planning and aircraft readiness.

IES also showed a positive and significant influence on logistics performance, although to a lesser extent than EIM and ILS. The beta coefficient was 0.32 with a p value < 0.001 , and the Pearson correlation value was 0.803. These results confirmed Hypothesis 2 (H2), indicating that strong engineering support, such as continuous technical training, qualified personnel (Right man for right job) and reliable maintenance systems, can contribute to the stability and reliability of logistics operations. Although not the most dominant factor, IES plays a critical supporting role by ensuring that the technical infrastructure and personnel are able to maintain robust logistics performance.

ILS Management emerged as the most influential predictor, with a beta value of 0.00 and a highly significant p-value (< 0.001). The correlation value of 0.920 indicates a strong positive relationship between ILS and logistics performance. These results confirm Hypothesis 3 (H3), suggesting that ILS Management plays a key role in improving logistics outcomes through the integration of key support elements such as maintenance, supply chain, training and documentation into a cohesive system. These findings highlight the need for the TUDM to move away from siloed logistics operations and adopt a fully ILS approach to achieve sustainable and cost-effective performance improvements.

Importantly, no significant deviations from the original hypothesis were found. All three proposed relationships were supported by the data, confirming the researchers' initial assumptions. This strengthens the validity of the conceptual model used and confirms the relevance of EIM, IES and ILS as strategic drivers of military logistics performance.

In conclusion, the three factors of EIM, IES, and ILS Management significantly contributed to the improvement of TUDM logistics performance, with ILS Management having the greatest impact. These findings carry several practical implications. Strategically, they indicate the need for a more integrated approach to logistics management in military operations. From a policy perspective, the results support reforms in logistics systems that emphasize coordination, technology integration and real-time data sharing. In addition, continued investment in technical training and engineering capabilities remains essential for operational readiness. The study ultimately provides empirical support for modernizing logistics practices in line with global best practices and reinforces the strategic importance of a well-organized support system in military aviation logistics.

4.24 Hypothesis Testing Summary

Three elements that influence logistics performance efficiency are examined in this study as shown at table 4.42. The relationship between the three components, namely EIM, IES and ILS management on logistics performance efficiency is ascertained using multiple linear regression. All variables, on average, have statistical significance when it comes to logistics performance efficiency. In Chapter 5, more discussion is carried out. The following chapters will be introduced in Section 5.1, followed by a summary of the main findings

Table 4.42: Hypothesis result

| No | Hypothesis | Result |
|-----------|---|------------------|
| <i>H1</i> | <i>EIM is significant co relation with Logistics Performance in the TUDM</i> | Supported |
| <i>H2</i> | <i>IES is significant co relation with Logistics Performance in the TUDM</i> | Supported |
| <i>H3</i> | <i>ILS Management is significant co relation with Logistics Performance in the TUDM</i> | Supported |
| <i>H4</i> | <i>IEM is significant co relation with Improved Engineering Support in the TUDM</i> | Supported |
| <i>H5</i> | <i>IES is significant co relation with ILS Management in the TUDM</i> | Supported |
| <i>H6</i> | <i>EIM is significant co relation with ILS management in the TUDM</i> | Supported |

4.25 Chapter Summary

In conclusion, this study contributes meaningfully to theory by validating the inventory management, engineering support model, and integrated logistics linkages in a military context. It also provides clear, evidence-based recommendations for practices and policies that can improve the operational readiness and logistics performance of the TUDM. By adopting a more efficient inventory system, strengthening engineering support, and fully implementing integrated logistics support, the TUDM can improve its overall logistics capability and mission effectiveness. The results of this study offer compelling empirical proof that the TUDM aircraft's operational readiness and performance are greatly enhanced by the integration of EIM, IES and ILS management. These results strengthen the theoretical foundations of ILS and the dynamic capability perspective, while offering practical directions for

the modernization of defense logistics. The next chapter will discuss implications, recommendations, and future research directions.



CHAPTER FIVE

RECOMMENDATIONS AND CONCLUSION

5.0 Introduction

The goal of this chapter is to present an overview and summary of the study findings and insights about the TUDM logistics performance as outlined and suggested hypotheses. The key conclusions from the empirical analysis will be presented in the conclusion, emphasizing how they relate to the initial goals of the study. The study's confines and some recommendations for additional research are included at the end of the chapter. To maximize the availability of TUDM assets and lessen reliance on outside assistance, it's also critical to suggest short-, medium-, and long-term solutions and recommendations.

5.1 Discussion

The purpose of this research is to ascertain the efficiency of inventory management, engineering support improvements, and ILS management as determinants of logistics performance and impact on the TUDM. This study first explains the relationship between inventory management efficiency, engineering support improvements, and ILS management as predictors of TUDM logistics performance since the topic is given in accordance with the study's objectives. It also discusses the empirical findings on the combination of inventory management, engineering support, and ILS in influencing logistics performance in the TUDM.

The findings of this study confirm that efficient inventory management, enhanced engineering support, and ILS management collectively play a critical role in strengthening logistics performance in the TUDM. In line with Systems Theory, the results indicate that logistics performance is optimized when interdependent subsystems function cohesively rather than in

isolation (Bertalanffy, 1968). EIM was found to reduce maintenance delays by ensuring timely availability of critical spare parts, thereby minimizing Aircraft on the Ground (AOG) incidents and increasing aircraft availability. This supports previous research that highlights inventory efficiency as a determinant of operational readiness in military aviation (Shukla, et al., 2014).

IES further contributes to logistics performance by improving maintenance turnaround time and system reliability through effective fault diagnosis and preventive maintenance. This finding is in line with Lambert (2020), who emphasized the importance of engineering capabilities in maintaining air force readiness. Furthermore, the strong influence of ILS management emphasizes its value as a life-cycle integration framework that aligns logistics, engineering, and maintenance activities. The findings support Vaskic and Paetzold (2019), who reported that more mature ILS implementation can improve reliability and cost efficiency in the national defense system. Overall, this work adds to the body of literature by offering practical insights for data-driven logistics performance optimization in the TUDM and actual evidence from the Southeast Asian military setting.

5.2 Contribution of the Study

Based on the analytical study's results, which showed that three independent variables EIM, IES and ILS Management have a major influence on the TUDM logistics performance, the study's implications can be examined from three primary angles: theoretical, practical, and policy implications.

From a theoretical perspective, this study strengthens existing logistics and supply chain theories, particularly in the context of military operations. This study validates the proposed theoretical model by confirming that EIM, IES and ILS are significant predictors of logistics

performance, thus supporting the theoretical assumption that logistics efficiency is closely related to system integration and support quality. This result further strengthens the Integrated Systems Theory, which emphasizes the need for complete and integrated systems in managing complex tasks such as military logistics.

In addition, since most previous research in this area is based on foreign or commercial contexts, this study fills an important gap by providing empirical evidence specific to the Malaysian defense environment, particularly in the TUDM. It demonstrates the applicability of a robust theoretical framework in a local military setting.

Practically speaking, the results offer military organizations' logistics and operations management useful information. The substantial impact of EIM emphasizes the necessity of implementing contemporary inventory systems, such as automated inventory management software or Enterprise Resource Planning (ERP), to lessen reliance on human methods. The positive role of IES suggests that continued investment in technical training, certification programs, and preventive maintenance is essential to maintain operational readiness. Most notably, the dominant impact of ILS Management suggests that the TUDM should make plans to prioritize the development and implementation of a fully integrated logistics support system. This includes the integration of supply, maintenance, technical documentation, and training into a centralized platform that facilitates collaboration and efficiency.

The findings suggest the need to utilize real-time data and monitoring systems to improve parts tracking, performance analysis, and the accuracy of logistics planning. From a policy standpoint, this report provides crucial direction for defence decision-makers and organisational leaders. First, the findings suggest the need to reform current logistics policies in the TUDM, moving towards digitalisation and systems integration. Second, as IES has been shown to be a

significant contributor to performance, there is a need for stronger policies on technical workforce development, including more structured training pathways and incentives for upskilling. Third, the study provides evidence for more strategic resource allocation, enabling policymakers to prioritise funding in areas of highest impact, particularly ILS systems. Finally, the results support the development of policies that encourage cross-sector collaboration, such as partnerships between the TUDM and private logistics service providers, to improve supply chain efficiency through sharing of best practices and technology.

5.3 Recommendation

To maximize the TUDM logistical performance, it's critical to offer short-, medium-, and long-term answers and suggestions. This section will provide strategic recommendations based on the study's findings to improve logistics performance in the TUDM. Based on the study's findings, a number of recommendations are made to enhance the TUDM logistical performance.

- a. First, the TUDM should prioritize the use of an efficient, advanced inventory management system that incorporates real-time data analysis and demand forecasting to reduce spare parts shortages and aircraft incidents on the ground.
- b. Second, continued investment in engineering support capabilities is recommended, particularly in ongoing technical training, predictive maintenance technologies, and diagnostic tools to improve aircraft maintenance efficiency and reliability.
- c. Third, ILS Management should be institutionalized as a core organizational framework, ensuring closer coordination between inventory, engineering and maintenance functions throughout the aircraft life cycle. A clear, efficient governance structure and standardized information sharing platform will further support this integration.

Finally, future policy decisions and planning should be guided by empirical performance data to enable evidence-based resource allocation. Collectively, these recommendations support a systems-oriented approach that aligns with the goals of national defence modernisation and enhances the TUDM long-term operational readiness to safeguard the sovereignty of the country's airspace.

5.4 Practical Recommendations and Future Research Directions.

Develop operational GST models for air forces that simulate the interactions among EIM, IES, and ILS and quantify their impact on LP under various scenarios. System dynamics models can capture feedback loops and delays in maintenance, procurement, and distribution. Invest in data architecture and governance that enable real-time visibility across inventory, engineering data, and maintenance scheduling to support GST-aligned decision-making and resilience. Explore predictive maintenance analytics as a key linking EIM and ILS; validate these approaches in aviation contexts to demonstrate reductions in downtime and improvements in LP metrics. Examine the implications of GST-based integration in air force logistics, including agile supply networks and the environmental footprint of spares inventory.

General System Theory provides a rigorous, integrative framework to understand how EIM, IES and ILS interact to shape Logistics Performance in air forces. The literature supports the notion that the triad constitutes interdependent subsystems whose alignment through shared data, governance, and analytics yields emergent improvements in readiness, availability, and maintenance efficiency. Yet, there remains a need for aviation-specific, empirically validated GST models that quantify the causal impact of this integration on LP and translate theoretical insights into actionable practices for air force logistics and engineering staff. A GST-informed research and

practice agenda emphasizing system-wide data interoperability, predictive maintenance integration, and end-to-end visibility holds promise for sustaining air force readiness in increasingly complex operational environments.

5.5 Implication of Research

The findings of this study will yield vital theoretical implications for the field of military logistics and systems management. By empirically demonstrating the interdependent effects of EIM, IES and ILS management on logistics performance, this research has strengthened Systems Theory as an appropriate explanatory framework for TUDM aviation logistics. The results extend the existing logistics literature by providing quantitative evidence from the Southeast Asian defense context, an area that is still underrepresented in empirical research. This contributes to the advancement of integrated logistics and defense operations theory by confirming the need to view logistics subsystems as unified and interacting dynamic structures rather than as independent functions (Bertalanffy, 1968; Shukla, et al., 2014).

This practical perspective finds that this study offers insights that can be considered for the leadership of the TUDM, defence planners and policymakers. The evidence will highlight the need for synchronized decision making across inventory control, engineering operations and ILS planning to improve aircraft availability and reduce maintenance downtime. Implementing accurate data-driven inventory forecasting, strengthening engineering diagnostic capabilities and institutionalizing an ILS framework can improve the TUDM maintenance turnaround time and operational readiness. This implication is in line with Malaysia's defence modernisation objectives, which emphasise logistics integration, self-reliance and life cycle optimisation (MINDEF, 2020). Overall, this study provides a sound structured basis for improving logistics

performance through coordinated systems-based management within the TUDM organization.

5.6 Limitation of Research

The goal of this study is to strengthen the connection between EIM, IES and ILS as factors influencing TUDM logistic performance. The research's tiny sample size, which might not be entirely reflective of the larger community connected to TUDM fleet operations, is one of its primary weaknesses. This restriction may have an impact on how broadly applicable the results are since the conclusions may not fully represent the range of viewpoints and experiences found throughout the TUDM organization.

The survey questions were chosen to facilitate the understanding of each variable. However, respondents in this study could only choose between strongly disagree and strongly agree with the measured items. Respondents were not able to express any opinions for improvement. During the conduct of this study, there were also several other limitations encountered that could be avoided for future studies. The limitations are:

- a. This study did not look at how spare parts procurement and maintenance were financed in more detail as it only targeted management and not finance. The stratified random sampling approach may not fully capture the diversity of TUDM personnel involved in finance. This may result in findings that are not fully representative of experiences across different ranks and units.
- b. There may be future plans for dynamic training to make Materiel and Engineering operators and management more competent and efficient, but this study did not have the opportunity to explore the relevance of its content.

5.7 Future Research

Although this study has shown that EIM, IES and ILS management have significant impacts on the logistics performance of the TUDM, several aspects require further investigation. First, the current model explains only 86% of the variance in logistics performance, indicating that 14% of the influencing factors remain unexplored. It is recommended that future studies consider other factors that can be crucial, such as organizational culture, digital literacy, information technology integration, logistical leadership, and internal communication efficacy. Second, the cross-sectional design of this study captures associations at a particular moment in time. A longitudinal study is recommended to assess the impact of these variables over time, providing insights into the trends and stability of the relationship. Third, since the study focused solely on the TUDM, expanding the scope to include other branches such as the Malaysian Army and Navy would offer a more comprehensive understanding of the ATM logistics system as a whole.

In addition, a qualitative or mixed methods approach is also suggested to gain deeper insights, particularly on implementation challenges, realities on the ground, and perspectives of logistics and technical officers. Finally, future studies could focus on developing a more comprehensive, flexible, and adaptive military logistics strategy framework that is aligned with current operational needs, technological advancements, and evolving global security dynamics.

5.8 Conclusion

This section has described the study's overall findings examining the determinants of logistics performance in the TUDM. The integration of EIM, IES and ILS Management on the logistics performance of the TUDM. The findings show that all three factors contribute significantly to logistics performance, reinforcing the importance of an integrated and systems-oriented approach

to military logistics management. EIM has been shown to support aircraft availability by reducing spare parts shortages and maintenance delays (Oenzil, F. R., & Ishak, D. P., 2021). IES improves maintenance effectiveness through better fault diagnosis, reduced recovery times, and increased system reliability.

ILS management further strengthens logistics performance by aligning inventory, engineering and maintenance functions across the aircraft life cycle. Collectively, the results confirm that logistics performance in the TUDM is not driven by isolated improvements but by coordinated interactions between logistics subsystems. The study adds empirical data to the defense logistics literature, particularly in the Southeast Asian context, and supports Systems Theory as an appropriate framework for understanding military logistics performance. Overall, this research provides a solid foundation for data-driven decision-making aimed at maintaining operational readiness and mission effectiveness in the TUDM.

Overall, this research establishes a positive correlation between the extension of independent variable combination techniques and logistics performance, offering valuable direction and guidance for the TUDM. By implementing the proposed strategies, the TUDM is in a position to enhance its fleet's logistical performance, thereby strengthening its operational readiness and strategic capabilities in the face of financial crises and geopolitical challenges.

5.9 Chapter Summary

This study examines how ILS management, engineering support enhancements, and inventory management efficiency relate to logistics performance in the TUDM. This research advances scientific understanding and offers practical suggestions to improve Malaysia's air defense capabilities through integrated logistics excellence by bridging the gap between academic theory

and real-world application. Issues such as inadequate real-time data for inventory holding and component maintenance and suboptimal decisions will negatively impact logistics performance efficiency, highlighting the need for more advanced technology and better and more efficient use of data.



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QUESTIONARIES

Enhancing Tentera Udara DiRaja Malaysia (TUDM) Logistics Performance Through Inventory, Engineering and Integrated Logistics Support

Dear Respondents,

My name is Major Muhammad Zamani bin Saat RMAF. I am a Master's student at the Universiti Utara Malaysia (UUM). I am currently in my final semester and conducting my final year project (thesis). Associate Prof Dr Mohd Azril bin Ismail CMILT supervised my research on topic **“Enhancing Tentera Udara DiRaja Malaysia (TUDM) Logistics Performance Through Inventory, Engineering and Integrated Logistics Support”**.

Thank you in advance for participating in my research study. Your valuable insights are essential for my research. This questionnaire is about brief demographics of the respondents and the Relationship between Efficient Inventory Management, Improved Engineering Support and Integrated Logistics Support Management on the Logistics Performance of the TUDM organization. Please take a few minutes to complete the following questionnaire, providing honest and thoughtful answers. Your feedback will be meaningful and contribute to the success of my research.

Your privacy is important to me. We will keep all the information you provide in the questionnaire with complete confidentiality. Please feel free to express your opinions openly and honestly. thank you.

Muhammad Zamani bin Saat

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QUESTIONNAIRES

**Enhancing Tentera Udara DiRaja Malaysia (TUDM) Logistics Performance Through
Inventory, Engineering and Integrated Logistics Support**

Section A: Demographic

Please tick the answer

1. What is your rank?

| | |
|----------------------------|--|
| Corporal | |
| Sergeant | |
| F/ Sergeant | |
| Warren Officer | |
| Lieutenant/ 2nd Lieutenant | |
| Captain | |
| Major | |
| Lt Colonel | |

2. What is your age group?

| | |
|-------------|--|
| Under 20 | |
| 21-30 | |
| 31-40 | |
| 41 and over | |

3. What is your highest level of education achieved?

| | |
|---------------------------|--|
| Secondary School | |
| Diploma | |
| Bachelor's degree | |
| Master's degree and above | |

4. What is your designation?

| | |
|-------------|--|
| SO 1 | |
| SO 2 | |
| SO 3 | |
| Supervisor | |
| OIC/SNCO IC | |
| NCO IC | |
| Others | |

5. What is your expertise in RMAF?

| | |
|-------------|--|
| Materiel | |
| Engineering | |
| Others | |

6. How long have you served in RMAF?

| | |
|------------------|--|
| 1-5 years | |
| 5.1 to 10 years | |
| 10.1 to 15 years | |
| 15.1 to 20 years | |
| Above 20 years | |

Section B (Independent Variables)

(Please indicate the appropriate response by circling it)

| A | Efficient Inventory Management (EIM) | | | | | | |
|---|--------------------------------------|---|-------------------|----------|---------|-------|----------------|
| | No. | Efficient Inventory Management | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
| (i) Bureaucratic procurement procedure (BP) | BP 1 | The RMAF management needs to avoid a lengthy procurement process to obtain spare parts. | 1 | 2 | 3 | 4 | 5 |
| | BP 2 | Rigid rules and policies for procurement should be | 1 | 2 | 3 | 4 | 5 |

| No. | Efficient Inventory Management | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|------|---|-------------------|----------|---------|-------|----------------|
| | eliminated or improved. | | | | | |
| BP 3 | The RMAF needs to establish a procurement committee for inventory procurement. | 1 | 2 | 3 | 4 | 5 |
| BP 4 | Bureaucracy forces compliance rather than performance. | 1 | 2 | 3 | 4 | 5 |
| BP 5 | RMAF management should maintain good relationships with fewer quality suppliers rather than many suppliers. | 1 | 2 | 3 | 4 | 5 |
| RK 1 | Lack of advanced technology or the use of manual inventory systems will increase storage costs. | 1 | 2 | 3 | 4 | 5 |
| RK 2 | Accurate inventory records are essential to providing effective and efficient services. | 1 | 2 | 3 | 4 | 5 |
| RK 3 | Continuous stocktaking is important to determine the replenishment of inventory stock items. | 1 | 2 | 3 | 4 | 5 |
| RK 4 | Proper inventory records are | 1 | 2 | 3 | 4 | 5 |

| | No. | Efficient Inventory Management | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|--|------|--|-------------------|----------|---------|-------|----------------|
| | | necessary to overcome overstocking and understocking. | | | | | |
| | RK 5 | Stock holding information is very important for effective and efficient inventory management. | 1 | 2 | 3 | 4 | 5 |
| (iii) Financial resources/ Funding (FR) | FR 1 | There should not be a lengthy process regarding budget approval for RMAF inventory procurement. | 1 | 2 | 3 | 4 | 5 |
| | FR 2 | Sufficient finances ensure inventory contribution for efficient RMAF services. | 1 | 2 | 3 | 4 | 5 |
| | FR 3 | Storekeepers need to be provided with some petty cash for current needs (not more than RM100) | 1 | 2 | 3 | 4 | 5 |
| | FR 4 | Sufficient funds are needed to maintain sustainable good relationships with quality suppliers. | 1 | 2 | 3 | 4 | 5 |
| | FR 5 | It is necessary to allocate sufficient funds to take out an insurance policy for the RMAF supply/stock office. | 1 | 2 | 3 | 4 | 5 |

| (iv) Skills of employees (SE) | No. | Efficient Inventory Management | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | |
|---|---|--|------------------------------|-----------------|----------------|--------------|---------------------------|--|
| | | employees can help minimize inventory management costs. | | | | | | |
| | SE 2 | The qualifications of RMAF members must be matched with job requirements. (Right job for the right man). | 1 | 2 | 3 | 4 | 5 | |
| | SE 3 | Training and development programs are essential for efficient and effective inventory management. | 1 | 2 | 3 | 4 | 5 | |
| | SE 4 | Knowledge about inventory stock taking needs to be understood by all staff. | 1 | 2 | 3 | 4 | 5 | |
| | SE 5 | RMAF members must have organizational, communication and problem-solving skills. | 1 | 2 | 3 | 4 | 5 | |
| B | Improved Engineering Support (IES) | | | | | | | |
| (i) Improved Engineering Support (IES) | No. | Improved Engineering Support | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | |
| | IES 1 | Aircraft maintenance work at the RMAF hangar is generally completed on time according to schedule. | 1 | 2 | 3 | 4 | 5 | |
| | IES 2 | Work processes in the maintenance of RMAF aircraft | 1 | 2 | 3 | 4 | 5 | |

| | No. | Improved Engineering Support | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|----------|--|---|-------------------|----------|---------|-------|----------------|
| | | continue to be improved to increase time efficiency. | | | | | |
| | IES 3 | The working environment at maintenance facilities support the comfort and safety of RMAF staff. | 1 | 2 | 3 | 4 | 5 |
| | IES 4 | RMAF aircraft maintenance facilities have met safety and regulatory standards at all times. | 1 | 2 | 3 | 4 | 5 |
| | IES 5 | RMAF staff always maintain the quality of work according to the standards set by their superiors. | 1 | 2 | 3 | 4 | 5 |
| | IES 6 | I always follow the working procedures (SOPs) in carrying out RMAF aircraft maintenance tasks. | 1 | 2 | 3 | 4 | 5 |
| | IES 7 | Communication and coordination within the team during the maintenance process always goes well. | 1 | 2 | 3 | 4 | 5 |
| C | Integrated Logistics Support (ILS) Management | | | | | | |

| (i) Integrated Logistics Support (ILS) Management | No. | Integrated Logistics Support Management | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|--|------------|--|------------------------------|-----------------|----------------|--------------|---------------------------|
| | ILS 1 | Problems often arise in the operation and maintenance of aircraft systems and logistics materials throughout the asset life cycle | 1 | 2 | 3 | 4 | 5 |
| | | including shortages of critical spare parts, component obsolescence, skilled human resource constraints, ground support equipment (GSE) failures, and inventory inaccuracies. | 1 | 2 | 3 | 4 | 5 |
| | ILS 2 | RMAF staff always maintain the quality of work according to the standards set by their superiors. | 1 | 2 | 3 | 4 | 5 |
| | ILS 3 | Negative impacts that occur in the operation and maintenance of aircraft systems can affect logistical efficiency and operational readiness, such as the inability to perform operational tasks, | 1 | 2 | 3 | 4 | 5 |

| No. | Integrated Logistics Support Management | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|-------|--|-------------------|----------|---------|-------|----------------|
| | waste of resources due to handling materials that do not follow procedures, increased repair costs and spare parts costs. | | | | | |
| ILS 4 | System obsolescence, lack of spare parts, inaccurate configuration records, constraints on skilled human resources and lack of ground support equipment (GSE) are the main causes of problems in system operation and maintenance. | 1 | 2 | 3 | 4 | 5 |
| ILS 5 | Appropriate and effective ILS management will impact the life cycle and life cycle cost of the RMAF aircraft system. | 1 | 2 | 3 | 4 | 5 |
| ILS 6 | An ILS plan provided by an external agency can provide significant benefits in terms of maintenance, spare parts supply, technical documentation and asset lifecycle management. However, the usability and effectiveness of the plan depends on the extent to which it meets the readiness, | 1 | 2 | 3 | 4 | 5 |

Section C (Dependent Variables)

(Please indicate the appropriate response by circling it)

| A | Logistics Performance (LP) | | | | | | |
|--------------------------------------|----------------------------|--|----------------------|----------|---------|-------|-------------------|
| (i) Logistic Activities (T) | No. | Logistics Performance | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
| | | safety and operational flexibility requirements of the RMAF. | | | | | |
| | T 1 | The ability to accurately select, acquire, store and distribute spare parts is a critical factor in ensuring operational readiness and smooth maintenance of RMAF aircraft. | 1 | 2 | 3 | 4 | 5 |
| | T 2 | The ability to select assets/spare parts used to support operational tasks is very critical as it directly impacts asset readiness, mission efficiency and operational safety of the RMAF. | 1 | 2 | 3 | 4 | 5 |
| | T 3 | Ability to estimate the quantity and cost of products required for aircraft system repairs. | 1 | 2 | 3 | 4 | 5 |
| | T 4 | The process of acquiring quantities of RMAF spare parts was implemented effectively. | 1 | 2 | 3 | 4 | 5 |
| | T 5 | The process of storing and distributing RMAF spare parts correctly according to the prescribed SOP. | 1 | 2 | 3 | 4 | 5 |
| | F 1 | Manage, acquire, receive, store, and | 1 | 2 | 3 | 4 | 5 |

| | No. | Logistics Performance | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|--|-----|---|-------------------|----------|---------|-------|----------------|
| | | release spare parts required by the operations team efficiently. | | | | | |
| | F 2 | Inspect and take appropriate action to ensure equipment/spare parts are in repairable condition, return them to service, or update and enhance their capabilities. | 1 | 2 | 3 | 4 | 5 |
| | F 3 | The movement of units, personnel, equipment, and spare parts/supplies from the point of origin to the final destination is carried out efficiently. | 1 | 2 | 3 | 4 | 5 |
| | F 4 | Provisions for construction, damage repair, and operation and maintenance of logistics facilities are critical elements to support the readiness of air assets and the smooth operation of the RMAF. | 1 | 2 | 3 | 4 | 5 |
| | F 5 | Health services that include medical evacuation (MEDEVAC), admission to military hospitals and medical logistics management are important components in ensuring the welfare, safety and alertness of personnel is always maintained. | 1 | 2 | 3 | 4 | 5 |
| (iii) Logistic Principles (P) | P 1 | The ability to provide the right support at the right time and location is a critical factor to the success of the RMAF's | 1 | 2 | 3 | 4 | 5 |

| No. | Logistics Performance | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|-----|--|-------------------|----------|---------|-------|----------------|
| | operations and missions. | | | | | |
| P 2 | Minimizing complexity in logistical operations is essential to ensure that support to aircraft and bases can be provided quickly, accurately and without waste. | 1 | 2 | 3 | 4 | 5 |
| P 3 | Ability to improve and adapt the current structures and procedures of the RMAF. | 1 | 2 | 3 | 4 | 5 |
| P 4 | Ensuring the required amount of resources is important to ensure that every RMAF mission, training and maintenance operation can be carried out smoothly and safely. | 1 | 2 | 3 | 4 | 5 |
| P 5 | Always ensuring the minimum supplies and basic services required are critical to ensure that the RMAF's operational capabilities can continue even in times of emergency, crisis, or intensive operations. | 1 | 2 | 3 | 4 | 5 |
| P 6 | Being able to sustain and extend the duration of operational activities is an important factor in ensuring that the RMAF's mission can be carried out continuously, whether in peacetime, conflict, humanitarian assistance, or combat operations. | 1 | 2 | 3 | 4 | 5 |

| No. | Logistics Performance | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|-----|--|-------------------|----------|---------|-------|----------------|
| P7 | Having logistical capabilities in handling task forces is a key factor that determines the efficiency and effectiveness of operations such as HADR (Humanitarian Assistance and Disaster Relief), air patrol operations, rescue operations and special operations both domestically and internationally. | 1 | 2 | 3 | 4 | 5 |

Thank you for taking the time to share your valuable insights with us. Your thoughtful responses are instrumental in shaping our research. I truly appreciate your participation, and your input will contribute significantly to the success of my study. Rest assured that all the information you provided in this questionnaire will be treated with the utmost confidentiality. Thank you for your time and valuable contribution.

