Contemporary Journal of Applied Sciences (CJAS)
Vol. 4, No. 2 February 2026: 157-168

Innovation in the Self-Defence System of Indonesian Air Force Transport Aircraft and its Implications for Tni Military Operations to Enhance the Security of Air Transport Operations

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ARTICLE INFO

Keywords: Innovation, Self Defense System, Indonesian Air Force Transport Aircraft, Security Improvement, Air

Received: 7, December
Revised: 28, January
Accepted: 15, February

ABSTRACT

This research is entitled "Self Defense System Innovation on Indonesian Air Force Transport Aircraft: Implications for TNI Military Operations to Improve Security of Air Transport Operations." Currently, TNI AU transport aircraft are not equipped with Self Defense System, which makes them vulnerable to threats, especially in conflict areas such as Papua. The purpose of this research is to provide recommendations regarding Self Defense System innovation on TNI AU transport aircraft and its implications for TNI military operations to improve national defense. The research method used is descriptive analysis through literature study, data collection and processing, school manuscript materials, and empirical observations. The theory used is Triple Helix, which integrates collaboration between the government (TNI AU), defense industry (PT DI, GMF, and PT ITS), and academics. The research results show that collaboration between the Indonesian Air Force (TNI AU), the defense industry, and academia can realize the innovation of the Self Defense System on TNI AU transport aircraft. In conclusion, the development and implementation of the Self Defense System on TNI AU transport aircraft through the Triple Helix collaboration can improve Indonesia's air defense capabilities. The implementation of this innovation not only protects the TNI AU's strategic assets, but also ensures the success of critical missions, both domestically and internationally.

INTRODUCTION

In today's modern world, Indonesia faces increasingly significant and complex challenges. The increasingly rapid flow of change and the strong impact of globalization add to the complexity of the problems faced by this nation. Furthermore, the unresolved economic crisis has also triggered national political and economic instability. Security disturbances tend to increase, often giving rise to conflict and vulnerability. The implications of various social conflicts, both horizontal in various regions and vertical, such as separatist movements in Aceh and Papua, pose a serious threat to the integrity and sovereignty of the Unitary State of the Republic of Indonesia (Maekel Eugaliel Pindonta Sembiring & Arthur Josias Simon, 2022) . These vulnerabilities, if not immediately addressed, could threaten the existence and survival of the nation and state. Indonesia also plays a vital role in world peacekeeping missions, frequently involved in various global crises. For example, several months ago, Indonesia sent a C-130J aircraft to Palestine to provide humanitarian aid (Public Relations Bureau of the Secretariat General of the Ministry of Defense, 2024) . However, before the aircraft departed, serious discussions ensued because the aircraft was not equipped with *a Self-Defense System* . Without *a Self-Defense System* , aircraft are highly vulnerable to attacks from both Israel and Hamas, threatening the safety of the mission. This situation demonstrates the importance of innovation in air defense to ensure the security of critical missions, both domestically and internationally.

The Indonesian Air Force, as an integral part of the Indonesian National Armed Forces (TNI), has the primary task of upholding the nation's sovereignty and integrity (SETNEG, 2004) . Together with other defense components, the Indonesian Air Force plays a role in safeguarding and maintaining the territorial integrity of the Republic of Indonesia. One form of application is conducting airlift operations *with* operational patterns adjusted to the escalation of threats. This includes sending troops to vulnerable areas to address vulnerabilities that occur within the country (Hapsara et al., 2023) . Therefore, operational readiness of aircraft that guarantees security from enemy attacks is very necessary, especially for strategic transport aircraft.

This security is crucial for TNI operations to run safely and smoothly. However, currently, TNI Air Force transport aircraft are not equipped with *a Self Defense System* , making them vulnerable to enemy attacks when carrying out missions in conflict areas. The latest C-130 transport aircraft, such as the C-130J and C-130 Ex RAAF, do not yet have this defense system. Without *a Self-Defense System* , these aircraft are highly vulnerable to being shot by *Man-portable air-defense systems* (MANPADs) when carrying out humanitarian missions or war missions because they do not have adequate air defense. Seeing this problem, the author sees the need for innovation in the development of *Self-Defense Systems* , on Indonesian Air Force transport aircraft with the aim of increasing the security and effectiveness of military operations. To overcome this problem, coordinated efforts are needed to support the implementation of *Self-Defense System innovations* on Indonesian Air Force transport aircraft. These efforts must be carried out both at the central and work unit levels. In the field of personnel, it is necessary to implement education and training that are appropriate to their

duties and fields. This includes *transfer of technology* (ToT) and operation training to ensure personnel have the required capabilities. In the field of facilities and infrastructure, it is necessary to conduct an inventory and proposal of facilities needed to support the operation of *the Self-Defense System* . In addition, in the field of software, revision, inventory, socialization, and supervision of technical data are needed to ensure that all technical aspects support the implementation of *the Self-Defense System* .

To realize this innovation, synergy between the domestic defense industry, academics, and Indonesian Air Force technicians is crucial. This collaboration can be done through *reverse engineering* and practical applications in the field. Local defense industries, such as PT DI, GMF, and PT ITS, can play a role in the development and production of *the Self Defense System* , while academics can contribute through research and technology development. Indonesian Air Force technicians will ensure that the developed technology can be implemented effectively in daily operations. By implementing this innovation, it is hoped that *the Self Defense System* on Indonesian Air Force transport aircraft can increase the effectiveness and security of TNI military operations. *The Self Defense System* will provide additional protection for aircraft during missions in vulnerable areas, both in domestic and international operations. This innovation will strengthen national defense, ensure the success of critical missions, and make the Indonesian Air Force more respected in the region. In addition, the implementation of *the Self Defense System* will help complete all missions safely, providing a sense of security for Indonesian Air Force personnel and the Indonesian people.

Thus, innovation in the development of *a Self-Defense System* on Indonesian Air Force transport aircraft is a crucial step that must be implemented immediately. Through synergy between the government, defense industry, and academia, this innovation can be implemented effectively (Owuondo, 2024) . The results will not only enhance Indonesia's air defense capabilities but also ensure the success of the TNI's military operations in various missions. This innovation will be a strategic step in safeguarding the sovereignty and integrity of the Unitary State of the Republic of Indonesia (NKRI), as well as contributing to world peace through Indonesia's active participation in international missions.

LITERATURE REVIEW

Air Power Theory

The Air Power theory is closely related to the concept of *Self Defense System* in Indonesian Air Force transport aircraft in the context of increasing the security of air transport operations . Air Power refers to the strength or superiority of a country through the use of air power, especially fighter aircraft and other air support. Air Marshal (Ret.) Fadjar Prasetyo stated that the transformation of air power in the modern era is the basis of Indonesia's air defense in the present and future, taking into account changes in the map of military power and regional and global geopolitics (Apridar et al., 2009) . This transformation includes three main aspects: organizational reform, technological modernization, and operational readiness. Organizational reform is needed to build a more agile,

effective, and efficient structure. Technological modernization means acquiring modern weapons systems that are results-based and system-oriented. Operational readiness involves innovation in both sectors to transform the operational readiness of the Indonesian Air Force as a strategic instrument of the state in securing national interests. In the context of the implications for TNI military operations and increasing national defense, the Indonesian Air Force must be able to face two spectrums of war, namely asymmetric and symmetric, with conventional weaponry. The Indonesian Air Force's conventional air force must possess a primary weaponry system (alutsista) that supports multi-domain operations. Therefore, innovation in the development of *the Self-Defense System concept* on transport aircraft is crucial to ensuring the safety of every mission undertaken. This *Self-Defense System concept* has a direct correlation with the Indonesian Air Force's ability to carry out missions safely and effectively, which ultimately will enhance national defense. This transformation not only ensures operational readiness and the security of personnel and equipment, but also strengthens the Indonesian Air Force's strategic position in facing various future threats and challenges. Thus, innovation in *the Self-Defense System concept* on transport aircraft is a crucial step towards realizing the vision of transforming air power that is resilient and responsive to global dynamics.

***Triple Helix* Theory .**

The Triple Helix theory, developed by Henry Etzkowitz and Loet Leydesdorff in 1995, offers a framework for fostering innovation through collaboration between three key actors: academia, industry, and government. First, academia, comprised of universities and research institutions, contributes knowledge, expertise, and the latest research findings (Cai & Etzkowitz, 2020) . Through collaboration with government and industry, academia can apply its knowledge to the development of systems for Indonesian Air Force transport aircraft. Second, industry plays a role in translating knowledge and technology into commercial products and services. Industry is responsible for applying knowledge from academia and government support to develop technologies applicable to transport aircraft self-defense systems. Industry also collaborates with the Indonesian Air Force to effectively integrate these technologies into aircraft. Third, the government, in this case the Indonesian Air Force, plays a leading role in implementing this innovation. The Indonesian Air Force must coordinate collaboration between academia and industry, and provide the necessary funding and resources for technology development. Furthermore, the government is also responsible for preparing all components and infrastructure, including aircraft that will be equipped with the self-defense system. Synergistic collaboration between these three actors enables the development and implementation of more effective and efficient defense technology, ultimately enhancing the nation's defense capabilities.

METHODOLOGY

The method of writing this journal uses a qualitative method with descriptive analysis through various approaches, including literature studies, data collection and processing, and school manuscript materials. In addition, empirical observations were also carried out to obtain more in-depth and accurate data. The approach used is a systemic approach, which views material as a totality consisting of elements that are interconnected, related, influencing, and dependent on each other. This approach allows the author to view the problem holistically, ensuring that each element discussed in the manuscript supports each other and together towards the expected goal. Thus, the preparation of this manuscript aims to provide a comprehensive and systematic description of the *Self Defense System innovation* on Indonesian Air Force transport aircraft and its implications for TNI military operations to improve Air Transport Operational Security .

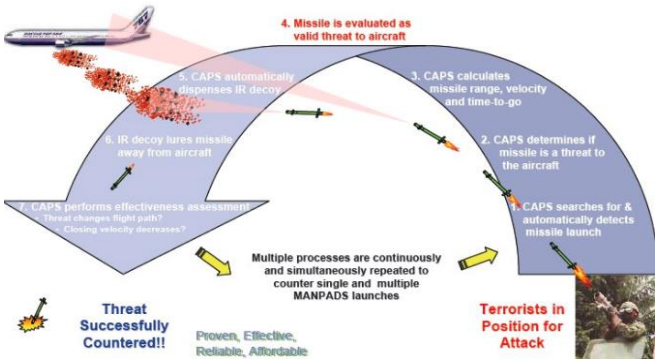
RESEARCH RESULT

Innovation *Self Defense System* on Transport Aircraft.

The Indonesian Air Force (TNI AU) must acquire technology with a results-based approach, such as modern, integrated systems, including *the Self-Defense System on* TNI AU transport aircraft . This technological reform and modernization need to be implemented through coordination with relevant agencies. Innovation in *the Self-Defense System,* in accordance with the theory of air power transformation of air power in the modern era, will transform the operational readiness of the TNI AU as a strategic instrument of the state in securing national interests. In the author's view, *innovation in the Self-Defense System that can be applied to all* TNI AU transport aircraft is essential. This innovation must be supported by calculations, analysis, testing, and testing that prioritize safety to achieve operational mission success (Lindsay, 2020) . *The Self-Defense System* works by detecting radiation from launched missiles. Sensors automatically recognize potential threats and select countermeasures , all without pilot interaction. In the final stage, the aircraft can launch activated decoys to deceive the missile.

This *Self-Defense System* is designed to deal with threats from more than one missile simultaneously and provides 360-degree protection through four sensor points installed at various angles of the aircraft. In addition to sensors, this system consists of *an Electronic Controller Unit* , *Dispensing Unit* , *Missile Approach Warning Sensor* , *CIV-IR Decoy, Electronic Power Unit* , *Control and Display Unit* (CDU), *Security Key* . This innovation is planned to be tested on the C-130 EX RAAF aircraft belonging to Air Squadron 33, which has a basic structure that allows the installation of the system. This system is able to protect the aircraft from threats with a 360-degree protection radius around the aircraft. With the implementation of *the Self Defense System* , it is hoped that the Indonesian Air Force transport aircraft can carry out missions more safely and effectively, thereby increasing the success of military operations and strengthening national defense. This *Self Defense System* is designed to provide comprehensive and automatic protection, enabling the Indonesian Air Force to operate more

confidently in various situations, including in conflict areas and in international missions. This innovation is a strategic step to achieve better operational readiness and build a strong air force that is responsive to global dynamics.



General image of *a Self Defense System* that works by detecting radiation from missiles launched by the enemy, then the aircraft launches *a decoy* autonomously.

Improving operational readiness through *the Self-Defense System* also has a direct impact on enhancing national defense. With safer and more secure transport aircraft, the Indonesian Air Force can be more effective in carrying out military operations that support national defense, such as deploying troops to strategic areas, logistics operations, and evacuation missions. Furthermore, the ability to protect aircraft from missile threats increases the resilience and sustainability of these missions, ultimately strengthening national defense capabilities. This innovation also reflects the Indonesian Air Force's adaptation to developments in global military technology, where threats are increasingly complex and multifaceted. By adopting *Self-Defense System technology* , the Indonesian Air Force demonstrates its ability to keep up with and anticipate changes in the global military power map. This is crucial for maintaining Indonesia's strategic position on the international stage, especially in the face of threats emanating from countries with more advanced military capabilities.

In order to implement the innovation of installing a self-defense system on Indonesian Air Force transport aircraft, a series of important documents will be issued that will serve as legal and technical references in this modification process. These documents will serve as written references that ensure that each stage of the modification is carried out in accordance with applicable regulations and standards, and are an integral part of the airworthiness certification permit application process (Johnson, M., & Wang, 2023) . These documents are divided into three main categories: Compliance Documents, Technical Documents, and Drawing Documents. Compliance Documents contain evidence of compliance with all relevant regulatory requirements and safety standards, ensuring that the modification is in accordance with legal provisions and has obtained approval from the relevant authorities (Johnson, M., & Wang, 2023) . Technical Documents include detailed technical information regarding system specifications, installation procedures, testing, and maintenance, which ensures that modifications do not interfere with the overall performance of the aircraft (Davis, T., & Miller, 2023) . While Drawing Documents contain technical drawings and

diagrams that visually show the installation process and layout of the self-defense system on the aircraft, ensuring that every detail of the modification can be implemented precisely according to the approved design (Thompson, E., & Zhao, 2023) . All of these documents will play an important role in obtaining airworthiness certification, so that the modifications made can be officially recognized and meet the required safety standards.

Implementation of *the Self Defense System* .

To support the implementation of *Self Defense System innovation* on Indonesian Air Force transport aircraft and improve the Security of Air Transport Operations , various steps need to be taken at the central and work unit levels. In terms of facilities and infrastructure, available facilities must be maximized for the installation of *Self Defense System* . Depohar 10, which is responsible for carrying out heavy maintenance and repairs as well as transport aircraft fabrication, is equipped with general tools, special tools, and fabrication facilities (TNI AU, 2024b) . In addition, the facilities of PT. Dirgantara Indonesia (PT.DI) must also be utilized. PT.DI has capabilities in fabricating aircraft components and *airframes* . Its location close to Sathar 15 in Bandung allows for optimal collaboration in *reverse engineering the Self Defense System* .

In terms of personnel, the Indonesian Air Force (TNI-AU) has experienced and knowledgeable human resources in transport aircraft technology. However, to reverse engineer *the Self-Defense System* , additional technical training is required involving technicians from domestic industries, such as software experts from PT Infoglobal (Yoon, 1992) . Technology transfer from Garuda Maintenance Facility Aero Asia, which is currently collaborating with Lockheed Martin on a C-130 aircraft modernization contract, is also crucial (Hilkevics & Hilkevics, 2017) . Once the Self-Defense System is installed, operational training involving TNI-AU test pilots and test pilots from PT.DI is required to ensure smooth integration and operation (Boyd et al., 2021) .

The software field is also crucial to support maintenance activities. This software encompasses engineering, technical publications, and interrelated information systems (Katz et al., 2020) . In the engineering aspect, studies and analyses are required to guide the implementation of *Self-Defense System innovations* , including the revision and inventory of existing Technical Orders (Bu et al., 2020) . Technical publications such as Technical Orders (TO), Technical Manuals (TM), Maintenance Manuals, and Work Cards from the USAF or aircraft manufacturers must be disseminated to users and crews to ensure proper understanding and use (Zhang et al., 2019) . By maximizing existing facilities and infrastructure, improving personnel skills through training and technology transfer, and ensuring adequate software support, *Self-Defense System innovations* on Indonesian Air Force transport aircraft can be successfully implemented. This will improve the operational readiness of the Indonesian Air Force and strengthen national defense, ensuring that Indonesian Air Force transport aircraft can carry out missions more safely and effectively in various situations.

Parties that can realize Self Defense System Innovation .

To realize the *Self Defense System innovation* on Indonesian Air Force transport aircraft, synergy is needed between three main agencies in accordance with the application of the *Triple Helix Theory* : government, industry, and academia. The Indonesian Air Force will lead the implementation of this innovation by involving several key units. The Indonesian Air Force Research and Development Service (Dislitbangau) will act as the main sector, coordinating collaboration with the defense industry and academia for research, development, testing, and application of *Self Defense System technology* (TNI AU, 2024a) . The Indonesian Air Force Safety and Occupational Safety and Occupational Safety and Occupational Safety and Health Center (Puslaiklambangjaau) will ensure the certification and airworthiness of *the Self Defense System* (TNI AU, 2024c) , while Maintenance Depot 10 will prepare the facilities and infrastructure and personnel needed for the implementation of this system.

The domestic defense industry plays a crucial role in the implementation of the Self-Defense System innovation on Indonesian Air Force transport aircraft, with PT. Dirgantara Indonesia (PT. DI) as one of the main actors. As a leading aircraft manufacturer in Indonesia, PT. DI has extensive experience and capabilities in aircraft fabrication and assembly. PT. DI's role in this project is not only limited to providing facilities and infrastructure, but also includes in-depth technical collaboration to ensure that *the Self-Defense System* can be effectively integrated into military transport aircraft. PT. DI will utilize the latest technology and experienced human resources to support the modification process, from design, testing, to implementation of this complex system (Kruger & Steyn, 2021) . PT. DI's success in carrying out this task will be a clear demonstration of the national defense industry's ability to adapt and meet the increasingly complex needs of modern defense equipment, while strengthening Indonesia's defense technology independence on the global stage. (Bimantoro, 2019) , will collaborate in terms of facilities, infrastructure, and aircraft fabrication experience. PT. Garuda Maintenance Facility Aero Asia Tbk (GMF) will play a key role in supporting the innovation of Self Defense System on Indonesian Air Force transport aircraft by leveraging their extensive experience in C-130 aircraft modernization (Kudaravalli et al., 2017) .

As one of the largest aircraft maintenance and repair companies in Southeast Asia, GMF has in-depth technical expertise and state-of-the-art facilities capable of handling various types of military aircraft. GMF's experience in C-130 aircraft modernization, which involves avionics system upgrades, engine performance enhancements, and structural repairs, gives them an advantage in understanding the complexities associated with military aircraft modifications. In this project, GMF will work closely with the Indonesian Air Force to ensure that the new *Self Defense System* can be effectively and safely integrated into the transport aircraft fleet. This collaboration covers various aspects, from technical design and testing to ongoing maintenance to ensure that the installed system can operate optimally under various operational conditions. GMF's success in this project will not only strengthen Indonesia's air defense capabilities but also affirm their position as a reliable strategic partner for the

Indonesian Air Force (TNI AU) and the national defense industry (Yulianto et al., 2023) . PT. Infoglobal Teknologi Semesta (PT. ITS), with its in-depth expertise in avionics and weapon control systems, will play a crucial role in supporting the implementation of *the Self Defense System* on TNI AU transport aircraft. As a company with a strong reputation for developing and integrating avionics and weapon control systems, PT. ITS will provide the necessary software and hardware analysis to ensure that all components of this system function harmoniously and efficiently. Software analysis will include the development of control algorithms and sensor integration, while on the hardware side, PT. ITS will ensure that all physical components are designed and installed with high precision. This collaboration will support the success of the project and strengthen domestic defense technology capabilities, while ensuring increased security and operational readiness of TNI AU transport aircraft in facing various threats. (Bimantoro, 2019) .

Academics play a vital role in supporting *Self-Defense System innovation* on Indonesian Air Force transport aircraft, by contributing realistic conceptual thinking and thorough technical calculations (Kivimäki et al., 2019) . Indonesian Air Force officers who have studied at leading engineering universities such as Bandung Institute of Technology (ITB) and Bandung Institute of Technology (ITS), as well as graduates from universities abroad such as the United States, Japan, and Australia, will collaborate closely with the defense industry and the Indonesian Air Force (TNI AU) (Navío-Marco et al., 2023) . This collaboration aims to ensure that all technical and scientific aspects of *the Self-Defense System* can be implemented optimally and in accordance with operational needs (Dzedzickis et al., 2022) . This synergy between government, industry, and academia is key to realizing innovations that not only improve the operational readiness of transport aircraft but also strengthen the security of air transport operations (Saliceti-Piazza et al., 2003) . With the *Self-Defense System* , Indonesian Air Force transport aircraft will be better prepared to carry out missions with a higher level of security in various situations, making this step part of the strategy to build a resilient air force that is responsive to evolving global dynamics. This innovation also emphasizes the Indonesian Air Force's commitment to maintaining air sovereignty and protecting national interests amid increasingly complex security challenges.

CONCLUSIONS AND RECOMMENDATIONS

The need for reliable air transportation using Indonesian Air Force transport aircraft is crucial to support TNI operations, ensuring their successful and safe completion. Based on the discussion of *Self-Defense System innovations* on Indonesian Air Force transport aircraft, several conclusions can be drawn:

First, the innovative *Self-Defense System* on Indonesian Air Force transport aircraft works by detecting radiation from launched missiles. This system automatically identifies potential threats and selects countermeasures *without* pilot interaction. The aircraft then deploys decoys to deflect the missiles. This automated process significantly contributes to the success of Indonesian Air Force operational missions by enhancing aircraft and personnel safety.

Second, to implement *the Self-Defense System* on Indonesian Air Force transport aircraft, support is needed in the areas of facilities and infrastructure, personnel, and software. Maximizing the role of Indonesian Air Force units and the domestic defense industry is crucial to realizing this concept. This collaboration will ensure that all elements necessary for the operationalization of *the Self-Defense System* are available and functioning properly, thus supporting the operational tasks of the Indonesian Air Force and Air Transport Operational Security .

Third, to ensure *the Self-Defense System* is well integrated into Indonesian Air Force transport aircraft, synergy is needed through collaboration between the Indonesian Air Force, domestic industry, and academia. This cooperation agreement between the three parties will help realize effective and efficient *Self-Defense System innovation* . This collaboration aims to achieve successful TNI operations, thereby gaining respect for the Indonesian Air Force in the region and enhancing the nation's overall defense.

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