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STRATEGY FOR IMPROVING MILITARY HUMAN RESOURCE COMPETENCE IN THE ERA OF ARTIFICIAL INTELLIGENCE: CONCEPTUAL AND POLICY REVIEW

Alif Septian[1*], Sinta Khomariah[2]
[1]Universitas Dirgantara Marsekal Suryadama Jakarta, Jalan Halim Perdana Kusuma No. 1, Jakarta 13610, Indonesia
[2]Universitas Negeri Jakarta, Jalan Rawamangun Muka No. 11, Jakarta 13220, Indonesia

[*]Correspondence E-Mail: alifalseptian@gmail.com
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ABSTRACT

The rapid development of artificial intelligence (AI) in the defense sector demands a fundamental transformation in military human resource (HR) competency strategies. This conceptual and policy review aims to identify key competency domains for AI-enabled military forces, map global policy responses, and formulate an integrated development strategy for the Indonesian context. Through thematic synthesis of 112 scholarly articles (2015–2025) and 18 international defense policy documents, the study identifies three mutually reinforcing competency clusters: technical–algorithmic literacy, adaptive cognitive and teamwork skills, and ethical–legal judgment. These are structured within the Military AI Competency Model (MAICM), which comprises four maturity levels. International benchmarking shows that countries such as the United States, NATO members, and Singapore have developed dual-track education (technical and ethical), rapid experimentation environments (sandboxing), and multisector talent ecosystems. In contrast, Indonesia's defense HR policy remains fragmented across branches, lacks depth in competencies, and overlooks ethical and cross-domain data governance dimensions. To address these gaps, the study proposes the 3-E Strategy—Education, Experimentation, Ecosystem—which includes AI-integrated curricula, joint innovation labs, and military–academic–industry exchange programs. This study's novelty lies in its holistic approach, combining HR development theory with defense policy analysis, and its integrative model aligning competency building with organizational culture and civil–military relations—contributing to social sciences and humanities through ethical AI education, iterative policy evaluation, and institutional reflexivity.

Keywords*: Military Artificial Intelligence, Human Resource Development, Defense Policy, Competency Model, Ethical AI*

INTRODUCTION

Amid the accelerating technological revolution, Artificial Intelligence (AI) has become a disruptive force that not only transforms the economic and social landscape but also redefines the concepts of national security and defense (Johnson, 2019; Weissmann, 2025). The military sector, historically recognized as a pioneer in adopting cutting-edge technology, now faces a new challenge: how to ensure that its human resources can effectively synergize with the increasingly intelligent systems being developed. This challenge is not merely about mastering technology, but also about shaping critical thinking capacity, fostering interdisciplinary collaboration, and upholding moral integrity when dealing with the ethical complexities of AI use in military operations. The fundamental issue thus lies in how military human resource (HR) development strategies can be adapted and optimized in the AI era.

The urgency of this issue is reflected in various reports and policy documents that highlight the disparity between the rapid advancement of AI and the preparedness of military institutions to respond. For instance, the report by Verbivska et al. (2023) notes that many developed countries have begun formulating competency frameworks for AI integration into military operations, whereas developing countries are still grappling with basic infrastructure issues. In Indonesia, Nugraha et al. (2024) observe that the digital transformation in the defense sector has not been accompanied by systemic HR capacity-building, particularly in ethical and technological interoperability aspects. This reveals that the challenge of HR development can no longer be addressed through technical training alone but requires a more strategic and multidimensional approach.

Various studies have attempted to address this challenge through diverse approaches. Mayer (2023) and Schaefer et al. (2021) underscore the importance of developing algorithmic literacy among military personnel as a basic requirement for dealing with autonomous AI systems. Meanwhile, Jacobsen & Liebetrau (2023) and Malmio (2023) show that technological dominance does not automatically guarantee military superiority without leadership that understands the ethical implications of AI use in warfare. Studies by Ahmad & Adler (2025) and Serhieiev et al. (2025) identify that multisectoral approaches—integrating military, academia, and industry—are more effective in building sustainable competencies. Furthermore, research by Bharathi et al. (2024) and García et al. (2024) advocates for the development of innovation ecosystems that enable adaptive learning processes through simulation and experimentation, rather than relying solely on classical training.

Similar findings are observed in Singapore’s defense policy studies, which demonstrate the effectiveness of dual education models—combining engineering and ethics studies—in producing personnel who are not only technically skilled but also reflective and visionary (Matthews & Timur, 2024; Raska, 2024). NATO has begun adopting a similar approach by emphasizing cross-national integration in AI training and cross-border talent exchange (Radanliev, 2025). In the United States, the Department of Defense through the Joint Artificial Intelligence Center has developed an AI Talent Framework that links operational needs with HR competency standards (Molnar et al., 2022; Poseliuzhna, 2023). Even in Southeast Asia, Thailand and Malaysia have started designing AI-based military curricula for their defense academies (Rodrigo et al., 2025; Schuldt, 2021).

However, most of these studies focus on major countries or institutions with advanced infrastructure and funding, leaving a gap in understanding how developing countries like Indonesia can formulate realistic, adaptive, and contextual HR development strategies. Additionally, existing studies tend to be fragmented—separated between technical, policy, and humanistic perspectives—when in fact these aspects are closely interconnected within the modern, complex, and interdisciplinary military domain.

It is within this context that the present study seeks to explore less-traveled paths. Rather than merely offering a list of technical competencies, this paper integrates conceptual and policy-based approaches to holistically address the challenges of military HR development. By reviewing over a hundred scholarly publications and nearly twenty defense policy documents from various countries, this study assembles a comprehensive map of the competencies required, how nations are preparing for them, and what can be tailored to Indonesia's context. This approach subtly introduces a new perspective to the discourse on military HR development: that competencies are not only about capabilities but also about values, policy structures, and learning ecosystems.

Therefore, this paper aims to formulate a strategy for developing Indonesian military HR competencies that are adaptive to the challenges of the AI era, emphasizing the synergy between education, experimentation, and ecosystem partnerships. This goal not only strengthens the relevance of the findings to local contexts but also contributes conceptually to the development of social sciences and humanities, particularly in understanding how military institutions can evolve into dynamic and ethical learning entities amid the relentless tide of technological advancement.

RESEARCH METHOD

This study employs a narrative-scoping review approach as the primary method to address three central questions: (1) what competencies are required for AI-based military forces, (2) how are developed countries building such competencies, and (3) how can an integrative development strategy be formulated for the Indonesian context. This approach was chosen for its ability to synthesize two highly heterogeneous data streams—empirical and conceptual scholarly literature, and normative, application-oriented defense policy documents. Given the wide variation in data types, research designs, and policy forms examined, conventional quantitative or meta-analytic methods were deemed unsuitable. Thus, the narrative-scoping review provides a comprehensive and reflective methodology appropriate for unpacking the complexities of this topic (Agarwal et al., 2023; Dehkordi et al., 2021).

The research design follows five stages developed by Dehkordi et al. (2021): (1) formulating the research question, (2) identifying relevant literature sources, (3) selecting appropriate sources, (4) data charting, and (5) collating, summarizing, and reporting the results systematically. To ensure process transparency, each stage was documented using the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews) flow diagram, which maps the number of articles found, screened, excluded, and ultimately analyzed.

The data required for this study fall into two main categories. First, scholarly publications discussing the intersection of AI and military HR development, including journal articles, conference papers, and dissertations. Second, defense policy documents and national or international alliance strategies related to military HR development in the context of digitalization and AI integration. The study focuses on military competency variables such as technical-algorithmic literacy, adaptive and collaborative capabilities, and ethical/legal judgment. The goal is to extract and map development strategies that have been or are being implemented globally.

Data collection was conducted in February 2025 using six major academic databases: Scopus, Web of Science, PubMed, ProQuest, IEEE Xplore, and Google Scholar. Additionally, policy document searches were conducted through four main repositories: NATO Library, U.S. Defense Technical Information Center (DTIC), ASEAN Defence Ministers' Meeting (ADMM) repository, and the digital library of the National Library of Indonesia. The search strategy combined three conceptual blocks using Boolean operators: ("military" OR "armed forces" OR "defense") AND ("artificial intelligence" OR "machine learning" OR "autonomous system*") AND ("human resource*" OR "competenc*" OR "talent" OR "education" OR "training"). Truncation and proximity operators (NEAR/3) were used where supported by each database. Forward-backward citation chasing and manual searches were conducted in eight key journals such as the Journal of Strategic Studies and AI & Society to ensure coverage of seminal references.

Inclusion criteria were carefully defined: publications must have been published between January 2015 and January 2025, written in English or Indonesian, and available in full text. Accepted publication types include peer-reviewed articles, conference proceedings, doctoral dissertations, and official policy documents such as white papers and national strategies. Opinion-only sources, blogs, or news articles were excluded from the analysis. Selection was conducted independently by two researchers, with inter-rater agreement (Cohen's κ) of 0.84, indicating substantial agreement. Disagreements were resolved through open discussion.

The collected data were extracted using a template recording bibliographic information, research objectives, methods, AI domains, competency constructs, and key findings. All qualitative content was imported into NVivo 14 software and inductively coded. Initial codes were then grouped into high-level themes that formed three major competency clusters: technical–algorithmic, cognitive adaptive and collaborative, and ethical–juridical. Analytical memos were used to link findings to theories of human resource development and relevant socio-technical frameworks.

To complement the thematic analysis, a policy mapping exercise was conducted on 18 defense or AI strategy documents from key countries and alliances between 2018 and 2024. Each document was assessed against 12 indicators derived from the Military AI Competency Model (MAICM) framework, such as the existence of a competency taxonomy, ethical training modules, and cross-sector talent development pathways. Each indicator was scored (0 = absent, 1 = implicit, 2 = explicit), and the results were visualized to illustrate Indonesia's policy position within the global landscape and to identify gaps needing attention.

Data validation was performed by linking thematic findings from academic literature with those from policy documents, as well as with regional and national contexts. This ensured coherence between academic discourse and actual policy directions, and enriched the analysis of the Indonesian context as the focal point of the study. This validation serves as a critical bridge to ensure that the proposed strategy is not only theoretically sound but also operationally viable within policy and institutional frameworks.

The main limitations of this research lie in language scope and document availability. Since only English and Indonesian literature and publicly accessible sources were included, classified initiatives or the most recent policies released after January 2025 are likely not covered. Nevertheless, the chosen approach enables a broad and in-depth mapping and offers a solid conceptual foundation for the development of military HR policies in Indonesia in the era of artificial intelligence.

RESULTS AND DISCUSSION

The Dynamics of Military Competency Transformation in the Age of AI

A major transformation is underway in the global military landscape, where Artificial Intelligence (AI) is no longer merely a supporting tool but has become a new axis for operations, decision-making, and even the very structure of military organizations. Amidst this technological revolution, the shift extends far beyond weaponry or combat systems—it is fundamentally reshaping the foundation of human resource (HR) competencies in the military, often in unseen ways. AI compels the military to move beyond traditional competencies centered on physical strength and structural discipline toward more complex forms of proficiency: understanding algorithms, navigating digital ethics, and collaborating in human–machine teams.

The urgency to redefine these competencies is evident in three main trends: the automation of command and control systems, the escalation of cyber warfare, and the integration of AI into intelligence and logistics processes. These trends demand not only technical comprehension but also cognitive adaptability, and ethical-legal reasoning. This is not a futuristic projection—an analysis of 112 scholarly publications (2015–2025) reveals that 78% underscore the importance of technical–algorithmic literacy as a foundational requirement for AI-enabled militaries. Surprisingly, more than 61% also emphasize cognitive adaptability and team collaboration, while 47% highlight the importance of ethical and legal reasoning (see Table 1).

This distribution suggests a key pattern: these three clusters do not exist in isolation but reinforce one another as part of a systemic whole. Training programs that focus solely on coding skills without ethical understanding—or vice versa—will create significant capability gaps. This aligns with the arguments of Akter et al. (2023), Doshi et al. (2025), and Talajić et al. (2024), who stress that successful technological transitions in organizations are not solely driven by advanced tools but by the integration of humans, social structures, and technical systems. In the military context, this means that AI mastery must evolve alongside institutional reforms and the cultivation of new operational and moral values.

Table 1 Conceptual Findings: AI-Based Military HR Competency Clusters

Competency Cluster	Source Proportion (%)	Number of Articles (n=112)	Key Capability Elements
Technical–Algorithmic	78%	87	Fundamentals of data engineering, model interpretability, AI-based decision support tools
Cognitive Adaptability & Teamwork	61%	68	Rapid sensemaking under uncertainty, human–machine team protocols, cross-disciplinary collaboration
Ethical–Legal	47%	53	Compliance with the Law of Armed Conflict (LOAC), bias mitigation, accountability, and public trust

Source: Research analysis, 2025

To map this transformation process, the article develops and tests a four-stage framework—Military-AI Competency Maturity Model (MAICM)—which outlines the progression of military AI competencies from Awareness to Innovation. Table 2 details the organizational indicators and typical training interventions at each stage.

Table 2 Four Stages of AI-Based Military Competency Development (MAICM)

Stage	Organizational Indicators	Training Interventions
Awareness	AI mentioned in doctrine; ad hoc pilot projects; limited budgets	Mass digital literacy MOOCs
Application	Narrow specialist teams (cyber/logistics); ML use in limited units	Vendor workshops, short-term certification programs
Integration	Interconnected data across branches; updated joint doctrine; centralized AI authority	AI modules in staff colleges; inter-branch rotations
Innovation	Algorithm co-design by soldiers and civilian technologists; active ethics boards; AI as cultural value	Hack-week sandboxes; AI fellowships; academic partnerships

Source: Research analysis, 2025

Most armed forces in developing countries, including Indonesia, currently fall between the Awareness and Application stages. At this point, while AI has entered official discourse, practical mastery is still limited to small groups of specialists—often within IT or intelligence branches—working in silos with little inter-unit communication. AI literacy is typically built through generic vendor training or MOOCs that are not yet contextualized to national military needs. Our data shows that among 18 defense policy documents reviewed, only 5 (27%) included plans for centralized AI authorities or cross-branch integration mechanisms.

Bottlenecks often emerge when technical training is not accompanied by cognitive and legal capacity building (Clauss, 2024; Gaessler & Piezunka, 2023). For example, field algorithm experiments without legal operational guidance often fail to mature into strategic prototypes due to a lack of accountability frameworks. Hence, countries that have reached the Integration or Innovation stages—such as the United States and Singapore—employ simultaneous training approaches: algorithmic modules are taught alongside LOAC case studies; AI experimentation involves multidisciplinary teams; and military education curricula include instructors from diverse fields—data engineers, cognitive psychologists, and military lawyers.

In the long term, AI competency in the military is not merely about acquiring new skills but about an organizational cultural transformation. The Innovation stage reflects an ideal condition where military personnel co-innovate with civilian technologists in "living lab" ecosystems while navigating ethical dilemmas in real-time. At this point, AI is no longer viewed as a technology to adopt, but as a new operational language embedded in defense mindsets and structures (Doshi et al., 2025; Hackett et al., 2023).

Thus, this dynamic leads us to conclude that the development of military HR competencies in the AI era cannot be handled in a fragmented or technocratic manner. It requires a holistic and cross-cluster approach. Imbalance in one cluster will slow overall progress. As the literature trend shows, even well-funded countries may remain stuck in the Application stage without deep institutional reforms. Conversely, countries with limited resources but strong political will and interdisciplinary learning strategies can leapfrog toward Integration.

Three Core Competency Clusters for AI-Enabled Military Readiness

The rapid development of Artificial Intelligence (AI) within global military structures requires not just technological adoption, but a comprehensive transformation of the human competency architecture underpinning defense forces. Readiness for AI-based warfare demands not only technical proficiency but also ethical awareness, adaptive cognitive capacity, and cross-sector collaboration skills. Through a thematic synthesis of 112 recent academic publications (2015–2025), this study identifies three mutually reinforcing competency clusters: technical–algorithmic literacy, adaptive–collaborative cognition, and ethical–legal assessment. These clusters form a multidimensional competency foundation necessary for navigating increasingly complex socio-technological interactions (Costa et al., 2022; Heyder et al., 2023).

First, technical and algorithmic literacy emerges as the dominant cluster, cited in 78% of reviewed publications. This includes foundational knowledge of data engineering, machine learning model interpretation, and the application of AI-based decision tools in tactical and logistical scenarios (Poseliuzhna, 2023; Weissmann, 2025). However, technical mastery alone is insufficient without understanding the limitations and potential biases of autonomous systems, which pose strategic risks if overlooked (Escandon-Barbosa & Salas-Paramo, 2025).

Second, adaptive cognitive abilities and collaborative capacity are highlighted in 61% of the literature. These competencies are vital for personnel to deal with uncertainty, build contextual understanding alongside AI systems, and collaborate across disciplines, including with non-military actors (Ferràs-Hernández et al., 2023; Goh et al., 2025). The effectiveness of AI integration in defense systems heavily relies on the quality of human–machine relationships, team trust, and shared learning processes within organizational ecosystems (Guo & Lyu, 2021).

Third, ethical and legal competencies—though only present in 47% of sources—have seen significant growth since 2021. This includes understanding international humanitarian law (LOAC), awareness of algorithmic bias, principles of explainability, and public accountability (Holota & Tytkovskyi, 2022; Kar et al., 2021). These competencies are essential to ensure that the use of AI in military contexts is not only technologically valid but also morally and legally legitimate.

These clusters are not standalone domains. Rather, the data shows that effective AI-enabled military HR development can only be achieved through parallel and integrative development across all three clusters. These findings reinforce the argument that technical competency must grow alongside ethical readiness and collaborative capacity, forming an adaptive and reflective learning ecosystem (Ismael & Lalla, 2024). In this context, the Military AI Competency Model (MAICM) proposes four capacity development levels—Awareness, Application, Integration, and Innovation—which reflect not just technical growth but also organizational maturity and inter-actor synergy within the defense system.

Furthermore, this approach aligns with Mukherjee & Agrawal (2023) and Myers & Ramsey (2023), who stress the integration of technical, social, and ethical skills in navigating cross-sectoral automation. In military contexts, failure to balance these three dimensions risks internal governance breakdowns that may pose greater threats than external adversaries. The following table presents a conceptual synthesis of the three key competency clusters based on frequency in the literature and their core capability elements:

Table 3 Three Key Competency Clusters for AI-Based Military Readiness

Competency Cluster	Frequency (%)	Number of Articles (n=112)	Key Capability Elements
Technical and Algorithmic	78%	87	Data engineering foundations, model interpretability, mission-oriented AI use
Adaptive and Collaborative Cognition	61%	68	Rapid sensemaking, human–machine teamwork, cross-sector collaboration
Ethical and Legal	47%	53	LOAC compliance, bias mitigation, accountability, public trust

Source: Research analysis, 2025

This mapping not only provides direction for developing competency models within MAICM but also offers a strategic framework for developing countries like Indonesia to avoid falling into the trap of techno-enthusiasm. Instead, AI-based military HR development must be rooted in a balanced and comprehensive understanding—technical, social, and ethical—to build an inclusive, responsive, and sustainable defense governance system.

Best Practices and Global Policy Responses to AI Competency Challenges

As the wave of artificial intelligence (AI) adoption spreads across the global defense sector, policy responses reveal a significant divergence between countries with proactive, integrated approaches and those still relying on generic and sectoral policies. This study analyzes 18 strategic policy documents, including white papers, national AI strategies, and defense modernization guidelines from countries such as the United States, Singapore, Germany, NATO, China, and Indonesia. The mapping employs 12 indicators based on the Military AI Competency Model (MAICM), covering dimensions such as education, experimentation, ethical governance, and cross-sector partnerships. The findings show that countries that have reached integration or innovation stages within the MAICM framework share one key trait: AI competency policies are not separate from national defense architecture but are bound together within a synchronized and progressive strategic narrative.

The United States ranks highest in the gap analysis with a score of 11 out of 12 indicators. The Department of Defense's 2023 Strategy for Data, Analytics & AI Adoption goes beyond technological modernization by including concrete steps in human resource development—for example, integrating AI ethics curricula into intermediate and advanced military education, and establishing a cross-departmental AI Education Steering Group (García et al., 2024; Hackett et al., 2023). This strategy is followed by dual-track education initiatives at military academies such as West Point, which combine algorithmic studies and moral philosophy. Similar findings appear in NATO's 2024 AI Strategy, which links AI system interoperability with talent interoperability, building joint career pipelines among member states to enhance cross-border training and knowledge exchange (Gaessler & Piezunka, 2023; Kar et al., 2021).

Singapore ranks third with a score of 8 out of 12, thanks to the successful operationalization of the AI Co-Lab between the Defence Science and Technology Agency (DSTA) and Thales, which provides a military-civilian collaborative sandbox laboratory. This facility not only produces local AI prototypes but also enhances soldiers' technical skills through real-world projects tested in simulated combat scenarios (Rodrigo et al., 2025; Schuldt, 2021). This approach creates a strong learning loop between education and experimentation, accelerating systemic human capital development in defense.

In contrast, China scores moderately (7/12), as its large-scale AI talent acceleration programs—including incentives for diaspora scientists and integrated training schemes—still emphasize quantity over ethical quality. The main critique of this approach is the absence of modules on explainability and international humanitarian law in the training of autonomous systems operators (Guo & Lyu, 2021).

Indonesia scores only 4 out of 12, primarily because its National AI Strategy (2020–2045) has yet to be tailored for the defense sector. This study finds that Indonesia's approach remains sectoral, with each military branch (Army, Navy, Air Force) developing technological training independently, without shared competency standards or an ethics curriculum recognized across institutions (Prakosa et al., 2024). Moreover, there are no operational AI testing labs (sandboxes) for defense use, and no systematic large-scale engagement with universities or tech companies has been established.

Table 4 Policy Mapping Across Countries

Country/Institution	MAICM Score (max. 12)	Best Practices	Remaining Challenges
United States	11	Dual-track education (STEM–ethics), operational sandbox, regular policy evaluation	Curriculum scalability across military branches
NATO	9	Joint talent pipeline, collective ethical standards	Capacity disparities among member states
Singapore	8	Military-civil Co-Lab, rapid experimentation, industry engagement	Dependence on foreign vendors
China	7	National talent mobilization, mass training	Minimal ethical and humanitarian regulation
Indonesia	4	Early awareness via National AI Strategy	Fragmented training, lack of sandbox and ethics curriculum

Source: Research findings, 2025

This table demonstrates that global best practices are not solely based on technical advancements but rather on the integration of three key pillars: dual-track education, experimental infrastructure, and cross-sector ecosystems. High-scoring countries have military education systems that systematically combine technical training and the humanities, testing labs that enable real-world project-based learning, and active partnership structures with universities and industries. In other words, successful development of AI-based military competencies requires synchronized orchestration among military, civilian, and academic actors.

Conversely, Indonesia faces three interrelated fundamental challenges: (1) fragmented ownership, namely the absence of a single authority governing AI human resource training across military branches; (2) skill-depth deficit, in the form of a limited number of mid-level officers proficient in advanced technologies to bridge strategy and implementation; and (3) ethical training vacuum, referring to the absence of mandatory modules on AI ethics and humanitarian law in the training of autonomous system operators (Serhieiev et al., 2025). These three issues are not merely technical challenges but institutional ones, requiring reforms in the governance of defense human resources in the AI era. Through this analysis, it becomes evident that Indonesia cannot merely adopt technology, but must develop policy intelligence that matches the complexity of military AI challenges. Without policies that simultaneously and strategically integrate the dimensions of education, experimentation, and partnership, Indonesia risks becoming a passive user of AI—lacking the capability to direct, evaluate, or even be accountable for the technologies used in its defense systems.

Gaps and Implementation Challenges in the Indonesian Context

As Indonesia enters an increasingly competitive military technology era in the Indo-Pacific region, the readiness of defense human resources to manage, develop, and lead the use of artificial intelligence (AI) is becoming ever more urgent. However, MAICM-based mapping shows that Indonesia still faces significant structural gaps. These are not only technical but stem from policy design weaknesses, institutional governance issues, and a military education ecosystem not yet adaptive to AI dynamics.

One of the most fundamental problems is the absence of a nationally standardized AI competency framework for the defense sector. To date, no official document regulates competency levels, training structures, or career development stages for officers in advanced technologies. Existing IT training is typically generic, not AI-focused, and fragmented across military branches. This results in weak mid-to-strategic-level skill depth, where only a small proportion of officers can comprehend the operational, ethical, and strategic implications of AI implementation in defense systems. Internal data from the Ministry of Defense shows that of 1,200 officer graduates each year, only 3.5% receive advanced technical training that addresses algorithmic or data-driven decision-making issues (Prakosa et al., 2024).

Furthermore, no integration of AI ethics curricula has been found in Indonesia's military education system, whether at the military academy or command and staff college (Sesko) levels. In contrast, experiences from the United States and NATO show that ethical competence is not merely a supplement but a foundation for operating autonomous systems in accordance with the law of armed conflict (LOAC) and rules of engagement (RoE). The absence of such curriculum limits discourse on moral and legal responsibilities regarding AI use in combat, even among strategic policymakers. For comparison, West Point and Bundeswehr University have routinely integrated courses such as "AI Ethics for Warfighters" and "Autonomy & International Law" into officer training since 2019 (Radanliev, 2025; Schaefer et al., 2021).

Institutional fragmentation is another serious challenge. No single entity within the Ministry of Defense or TNI Headquarters is specifically responsible for coordinating AI human capital development. Small-scale initiatives exist separately within R&D, training centers, or partner university research units, but without systemic connections. This results in redundancy on one hand and strategic voids on the other. A defense policy study on ASEAN countries by Diva et al. (2024) notes Indonesia as one of the few nations without a national defense AI talent registry or mechanisms for tracking and deploying trained personnel across sectors.

This lack of integration has long-term consequences for Indonesia's strategic position in global military tech competition. While countries like Singapore, South Korea, and even Vietnam are integrating AI into tactical decision-making and drone-based maritime surveillance systems, Indonesia is still grappling with basic questions: who will develop, operate, and ethically evaluate such systems independently? Without competent human capital, Indonesia will continue relying on foreign vendors for critical technologies—a condition that not only creates strategic dependency but also undermines operational sovereignty. A study by Adityayuda et al. (2024) reports that 72% of Indonesia's AI-based defense procurements between 2018 and 2022 came from abroad, and 88% lacked technology transfer or technical training.

Beyond institutional shortcomings, the formulation of Indonesia's military AI policy is also shaped by complex sociopolitical dynamics and civil–military relations. Since the reform era, defense policymaking has been largely dominated by formal command structures rather than co-creation based on technocratic expertise. This explains why the national AI strategy documents issued by BRIN and the Ministry of Communication and Informatics in 2020 barely mention defense—a signal that the military sector still operates in a closed policy silo. According to policy analysis by Sumarno et al. (2022), the failure to build policy-bridging mechanisms between civilian sectors (research, academia, tech industry) and the military has hindered more progressive cross-sector innovation.

This situation is exacerbated by the lack of incentives for civilian AI experts to contribute to the defense sector. The absence of fellowship schemes for civilian data scientists or career paths for academics interested in defense innovation reinforces an already entrenched civil–military divide. Meanwhile, countries such as Estonia, Australia, and Canada have established part-time reserve fellowship schemes that allow civilian AI experts to "wear the uniform" and work on defense projects for several months each year without derailing their academic careers (Pombo et al., 2021). These challenges show that Indonesia's gap lies not in the potential of its human capital or technical capacity per se, but in the absence of a system that integrates all three: education, experimentation, and ecosystem. As long as the approach remains sectoral and administrative—rather than strategic and synchronized—Indonesia's opportunity to build an independent, ethical, and adaptive military AI capability will continue to lag behind.

Table 5 Gaps in Indonesian Military AI Governance vs. Global Best Practices

spect	Current State in Indonesia	Global Best Practice
AI Competency Framework	No national standard; fragmented branch-specific training	MAICM adopted across services; standardized in NATO & US
AI Ethics Curriculum	Not integrated into military education	Mandatory modules at military academies and staff colleges
Interagency Coordination	High fragmentation; no central authority	AI Governance Office at MoD as strategic coordinator
Civilian and Academic Involvement	Minimal, no formal collaboration schemes	Fellowships & formal MoUs with universities and tech firms

Source: Research findings, 2025

3-E Strategy: Measurable Recommendations for Strengthening the Competence of Indonesian Military Human Resources

In response to the structural, cultural, and institutional limitations that hinder Indonesia's readiness to face the military technological competition based on artificial intelligence (AI), the 3-E strategy — Education, Experimentation, Ecosystem — emerges as a measurable and relevant transformative solution. This framework offers not only a technocratic roadmap but also positions military HR policy reform within an ethical, humanistic, and participatory framework. Each pillar of the 3-E strategy is designed to directly address the specific gaps previously identified, and all are framed within the paradigm of Human-Centered Military Transformation by Maathuis (2023), which emphasizes the alignment of high-tech adoption with human values, institutional transparency, and public trust.

Starting with the Education pillar, this approach demands a comprehensive reform of the military education curriculum, particularly in institutions such as the Command and Staff College, by integrating a dual-track education model combining STEM and ethics. In developed countries such as the United States and the United Kingdom, this integration has become a standard practice to produce officers who are not only technologically competent but also possess strong moral and legal frameworks in the use of AI (Myers & Ramsey, 2023; Surina et al., 2020). In the Indonesian context, this curriculum transformation aims to end inter-branch fragmentation—a structural problem currently hindering competency uniformity (see Table 6). By producing at least 200 AI-literate officers annually through a standardized MAICM program, education becomes a long-term foundation for technological readiness.

Table 6 3-E Strategy for Enhancing Indonesia's Military AI Capabilities

Aspect	Education	Experimentation	Ecosystem
Strategic Meaning	Systemic up-skilling: Integrating AI and ethics into military education from cadets to senior staff; dual-track model (STEM + ethics) following practices in the US and NATO.	Learning-by-doing: Collaboration among military personnel, engineers, and academics in low-bureaucracy labs; annual Red Team–Blue Team sprints to test tactics and code.	Whole-of-nation talent pipeline: Formal MoUs with universities, tech companies, and ASEAN AI centers; fellowships for civilian data scientists as reserve components.
Relevance to Indonesia's Gaps	Addressing the skill deficit by producing ~200 AI-literate officers annually; the MAICM curriculum ends inter-branch training fragmentation.	Transforming sporadic pilot projects into a sustainable innovation cycle; generating Indonesia-specific data and doctrine.	Unifying fragmented ownership; a talent registry prevents brain-drain and facilitates redeployment of skilled HR.
Hidden Success Factors	Linking graduation with promotion; recruiting civilian lecturers to teach ethics and data science in military academies.	Sandbox governance must involve legal observers to ensure LOAC compliance; awards for units that successfully operationalize prototypes.	Clear IPR framework so companies retain commercial rights while the military maintains operational sovereignty; leverage ASEAN forums to strengthen AI ethics competence.
Strategic Risks If Ignored	Training becomes symbolic ("checkbox") without rigorous evaluation; producing paper degrees without real competence.	Without a secure sandbox, prototypes risk being deployed prematurely or abandoned due to lack of funding.	

Source: Research findings, 2025

Moving to the Experimentation pillar, transformation cannot take place solely in the classroom. Joint AI experimentation laboratories must be established as low-bureaucracy spaces where soldiers, engineers, and academics can collaboratively develop algorithms, test doctrines, and simulate tactical scenarios in a learning-by-doing environment. The presence of experimental sandboxes, complete with legal oversight mechanisms to ensure compliance with international humanitarian law (LOAC), is essential to ensure that innovation processes do not exceed ethical or operational boundaries. Through the Red Team–Blue Team approach — where one team designs the AI system and another attempts to disrupt it — the Indonesian military can build resilient-by-design systems and develop playbooks tailored to local conditions (Escandon-Barbosa & Salas-Paramo, 2025; Poseliuzhna, 2023).

Meanwhile, the Ecosystem pillar is crucial for bridging the gap between the military and the civilian community, including universities, technology industries, and regional institutions such as ASEAN AI Centres. Through formal partnerships (MoUs) and reserve fellowship schemes, civilian data scientists can "put on the uniform" in part to contribute to defense research without becoming permanent military members. This aligns with successful practices in Singapore and South Korea, where civilian sector involvement has been shown to accelerate military innovation capacity and reduce the risk of technological lag (Gaessler & Piezunka, 2023; Hackett et al., 2023). Furthermore, the development of a talent registry and a clear intellectual property rights (IPR) framework will prevent talent migration to the private sector while preserving military operational sovereignty.

These three pillars do not function in isolation but reinforce one another within a single strategic architecture. Graduates of AI education programs will fill experimental laboratories; the results of these experiments will feed back into the curriculum, and cross-sectoral collaboration in the ecosystem will strengthen adaptive capacity and innovation resources. Thus, Education provides the intellectual foundation, Experimentation becomes the innovation catalyst, and Ecosystem ensures sustainability and systemic responsiveness.

To ensure that this strategy does not remain merely conceptual, it requires governance and evaluation systems based on concrete metrics. The following table summarizes the key performance indicators for implementing the 3-E strategy over the 2025–2027 time horizon.

Table 7 overnance and Metrics for Implementing Defense AI Strategy (2025–2027)

Performance Indicator	Annual Target	Oversight Body
Number of graduates from the MAICM program	≥ 200 per year	Defense University Council + TNI HR Chief
Number of operational experimental sandboxes	2 (Army Aviation & Joint ISR)	AI Governance Office, Ministry of Defense
External fellowship participation rate	15 civilian scientists + 30 reservist data scientists	Joint Talent Council
Doctrine update cycle	2 major doctrines with AI inserts within 24 months	Doctrine Division, TNI General Staff

Source: Research findings, 2025

If fully utilized, this strategy has the potential to position Indonesia as a regional leader in ethical and responsive military AI governance. However, if neglected or implemented only partially, Indonesia risks falling behind its neighboring countries in military digital readiness. More severely, this lack of preparedness could exacerbate a legitimacy crisis and erode public trust in the military as a national institution that should remain adaptive to the times. Therefore, the adoption of the 3-E strategy is not merely a technological agenda, but an institutional reform agenda rooted in human values and the ideal of sovereign and inclusive national defense.

CONCLUSION

In facing strategic challenges in the era of artificial intelligence, the development of Indonesia's military human resource competence can no longer rely on partial, sectoral, or merely administrative approaches. This study shows that the required competency transformation encompasses not only improving technical literacy but also strengthening adaptive cognitive capacity, interdisciplinary teamwork, and the integration of ethical and legal values at every stage of AI use. By mapping international policy trends and formulating the Military AI Competency Model (MAICM) framework, this study affirms that developing military human resource competence in the digital era must be systemic and long-term. The 3-E Strategy—combining reform of the military education curriculum, experience-based algorithmic experimentation, and the development of a cross-sectoral talent ecosystem—is proposed not merely as a structural innovation but as a bridge between technological demands and the human values at the core of military professionalism. The primary novelty of this study lies in its approach that integrates a conceptual competency management framework with defense policy analysis in the Indonesian context, offering a design for military HR transformation that is not only adaptive to global AI dynamics but also aligned with local needs and democratic governance principles.

ETHICAL STATEMENT AND DISCLOSURE

This study was conducted in accordance with established ethical principles, including informed consent, protection of informants' confidentiality, and respect for local cultural values. Special consideration was given to participants from vulnerable groups to ensure their safety, comfort, and equal rights to participate. No external funding was received, and the authors declare no conflict of interest. All data and information presented were collected through valid research methods and have been verified to ensure their accuracy and reliability. The use of artificial intelligence (AI) was limited to technical assistance for writing and language editing, without influencing the scientific substance of the work. The authors express their gratitude to the informants for their valuable insights, and to the anonymous reviewers for their constructive feedback on an earlier version of this manuscript. The authors take full responsibility for the content and conclusions of this article.

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