ISSN: 2443-2415

PROCEEDINGS

ICMST 2024

INTERNATIONAL CONFERENCE ON MARITIME SCIENCE AND TECHNOLOGY

INDONESIA NAVAL TECHNOLOGY COLLEGE

The 8th ICMST-2024

FIELD:

1. OPERATION RESEARCH
2. HUMAN RESOURCE
3. POLICY STRATEGY
4. LOGISTIC MANAGEMENT

SURABAYA, JUNE 27th 2024

PROCEEDINGS

INDONESIA NAVAL TECHNOLOGY COLLEGE
POSTGRADUATE INTERNATIONAL CONFERENCE

"SMART DEFENSE DEFENSE STRATEGY TO SUPPORT TASK OF INDONESIA NAVY"

Field :

1. **Operation Research,**
2. **Human Resource,**
3. **Policy Strategy,**
4. **Logistic Management.**

SURABAYA, JUNE 27th 2024

POSTGRADUATE STUDIES PROGRAM
INDONESIA NAVAL TECHNOLOGY COLLEGE

Proceedings

Indonesia Naval Technology College
Postgraduate International Conference

These Proceedings have been published by :

Directorate of Postgraduate Studies Programs
Indonesia Naval Technology College
Bumimoro Krembangan Surabaya, 60178
Telp. 031-99000582 ; 031-3298840, 031-3298076 ;
Fax. 031-99000583
www.sttal.ac.id

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PREFACE

On behalf of the Organizing Committee, it is my pleasure to welcome you to the Postgraduate International Conference on Operation Research. It is hosted by The Indonesia Naval Technology College (STTAL) and is being supported by Indonesia Navy.

The main theme of International Conference includes Operation Research, Logistics Management, Policy and Strategy, Naval Technology. The goal of the conference is to provide a platform to academics, scholars, researchers and practitioners to present and disseminate the latest innovative ideas, research results, and findings on various aspects of Maritime Science.

On behalf of the organizing committee, I wish to thank all authors for their papers and contributions to this conference. I would like to thank the keynote speakers for sharing their wealth of experiences and knowledge in Maritime Science.

Finally, I would like to thank all speakers, participants and attendees. I look forward to days of stimulating presentations, debates, friendly interactions and thoughtful discussions that will forward Maritime Science.

Surabaya, 27 June 2024
Chairman of Committee,

Dr. Okol Sri Suharyo
Commander Navy

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FIELD IV : LOGISTICS MANAGEMENT.....

STTAL COMMANDANT SPEECH
ON
THE 8TH INTERNATIONAL CONFERENCE ON MARITIME SCIENCE AND TECHNOLOGY (ICMST)
SEKOLAH TINGGI TEKNOLOGI ANGKATAN LAUT (STTAL) 2024
"SMART DEFENSE STRATEGY TO SUPPORT TASKS OF INDONESIAN NAVY"

The Honorable,

- Mr. Jitendra Kumar Ojha, thinker or strategist on geopolitics - security and former head of training of research and analysis wing.
- vice admiral (retired) Prof. Dr. Ir. Amarulla Octavian, ST., M.SC., DESD., IPU., ASEAN. ENG., Deputy Head Of The National Research Agency.
- The distinguished, all Indonesian Navy Major Commands' Commandants or the representatives.
- STTAL officials, seminar invitees and participants both offline and online.

Assalamuallaikum wr. wb.

Good Morning

may peace be upon us

Om Swastiastu, Namo Buddhaya.

Greeting of Virtue

First of all, let’s convet our praise and gratitude to allah swt, because of his blessing today, thursday, june 27, 2024 we can gather in the STTAL postgraduate building surabaya for the 8th international conference on maritime science and technology (ICMST) on "smart defense strategy to support tasks of Indonesian Navy”, which is organized by the indonesian naval technology college (or STTAL).

Allow me, on behalf of the commandant of the naval technology college, express my highest sense of respect, pride and gratitude for the presence of the speakers and seminar participants, both offline and online at this event.

The Distinguished Guests,

Indonesia is the largest archipelagic country in the world and is supported by geographical characteristics and a long history as a maritime country. however, with such vast oceans and territory, it can inflict challenges and threats to indonesian nation. preserving and maintaining sovereignty with the coastline of 108,000 kilometers with a total of 17,504 islands and the exclusive economic zone of more than 3,000,000-kilometer square is complicated task. thus, it requires a very strong maritime force, especially the navy.

The tasks of the Indonesian Navy cover a wide range of responsibilities, including safeguarding the country's sovereignty, protecting maritime resources, conducting maritime patrols and supporting disaster relief efforts. the smart defense initiative is critical to safeguarding the country's maritime interests, securing maritime lines of communication, combating transnational threats and enhancing regional stability. the smart defense is essential to be carried out as an effort for integrating cutting-edge technologies such as unmanned aerial vehicles (uavs), maritime surveillance systems, cyber defense capabilities, and utilization of artificial intelligence (AI).

In order to participate in encouraging the use of smart defense to optimize navy resources, to increase interoperability with regional partners and to deal effectively with maritime threats which are evolving effectively, this STTAL postgraduate international seminar is held by theme "smart defense strategy to support tasks of the Indonesian Navy".

We do appreciate the invited speakers, all academic civitas, the moderators and the seminar participants we are proud of and we also hope that this international seminar can provide knowledge and insight as well as provide literacy in the context of the smart defense system.

The Distinguished Guests,

The material that will be presented by the speaker is very important for us to listen and to pay attention together, therefore make the best use of this seminar time. i hope and pray this seminar will be encourage further studies, papers and researches

which pay valuable role and input not only for the Indonesian Navy but also for the indonesian armed forces and indonesian nation in supporting the maritime security in the context of realizing national defense strength.

Have a good seminar, and hopefully this seminar will run orderly and properly and we are always in the protection of god the almighty, ALLAH SWT. Thank you.

wa billahi taufiq wal hidayah

Wassalaamu'alaikum WR.WB.

COMMANDANT OF
THE NAVAL TECHNOLOGY COLLEGE,

DR. MUKHLIS, S.T., M.M.
FIRST ADMIRAL

Jitendra Kumar Ojha: Bio-profile

- Jitendra Kumar Ojha represents a blend of hands-on practitioner leaders turned strategists and thinkers on governance, security and geopolitics. He has a special knack in anticipating evolving geopolitical, governance and security scenarios and offer innovative solutions. He is a former civil servant/diplomat who served for nearly 26 years with the Govt of India, mostly with Cabinet Secretariat and Ministry of External Affairs, before prematurely retiring in 2018 in the rank of Joint Secretary. Apart from diplomatic assignments abroad and professional leadership roles in New Delhi, he was also one of the youngest Joint Secretaries of Govt of India to head a premium National Academy for 3 years that imparted training in External Security, Intelligence and Geopolitics. He has also attended National Defence College programme in New Delhi for policy planners in area of National Security.

- Mr Ojha has a post graduate degree in Political Studies from Jawahar Lal Nehru University (or JNU), New Delhi. He also has two shorter research degrees (Master of Philosophy-M Phil) in "Diplomacy" and "Defence & Strategic Studies" from JNU New Delhi and University Madras respectively. He has reinforced his professional exposures by briefly dabbling in areas like behavioural psychology, Neuroanatomy, Human anthropology and history of major civilizations besides security and warfare strategies under supervision of experts.

- He has devised a futuristic perspective on democratic governance to optimize security-governance output of post-colonial democracies. He has named it as Indocracy. The word "Indo" identifies whole of South East Asia together with the Indian subcontinent as a common civilizational entity named as Indo-Asia. At one point of time, this region had attained exceptional prosperity, security and tranquility and advancement of knowledge, on the strength of its scientific and humanist values. However, many of these values had started decaying much before the dawn of Christianity and Islam, despite intermittent phases of resurrection. Even though Indocracy is inspired by values/wisdom of the past, it has attempted to further refine the contemporary scientific principles and practices of democratic governance. Due to a ban in India on publishing without permission for individuals like Mr Ojha, this work is not in public domain.

- Jitendra Kumar Ojha - a former career intelligence officer and one of the youngest Joint Secretaries of Govt of India to head Training Academy of Research & Analysis Wing (R&AW)- represents a rare blend of hands-on doer & leader turned an innovative thinker on 'Grand Strategy', encompassing various dimensions of geopolitics, security, governance & leadership;

- During his 26 years long career (1992-2018) as civil servant, Jitendra has handled a wide variety of complex geopolitical- security and governance scenarios both in India as well as abroad. He has engaged statesmen, leaders (political, corporate, military, intelligence, civil-society, media & administrative) and opinion shapers across genres to pursue multi-stakeholder engagements/ build peace & security in complex (including conflict) zones. He has more often succeeded as innovative solution architect. His exceptional knack of assessing evolving geopolitical-security scenarios with consistent accuracy is demonstrated even in his post-retirement public talks and write ups.

- Jitendra derives strength from his broad pre-service exposures, that include nearly a decade in student political leadership alongside brushes with civil society activism, media & even private sector. These offered him a unique vantage point in his career in intelligence/diplomacy. His deeper understanding of geopolitics & global security dynamics, alongside strategic psyche of major cultures/civilizations/states enable him offer more reliable perspectives/solutions on various facets of security, governance & geopolitics. He has backed his professional exposures & experiences with researches & reading in a wide variety of related subjects to sharpen his knowledge/expertise.

- As Head of Intelligence Academy of India, he not only led a comprehensive transformation in quality, content & infrastructure of training to make the institution future ready but also devised a series of innovative but effective programmes & games that helped his students optimize their professional/leadership skills to succeed in multiple challenging contexts.

- Jitendra is also a distinguished alumnus of National Defence College of India (56th Course) where he underwent policy planners' programme on National Security for military & civilian officers of India and its friendly nations. His thesis, captioned as: 'Governance as Bedrock of National Security' was appreciated for its innovative perspective.

- In his post-civil service innings, Jitendra writes and speaks on geopolitics, governance & security and advises on political-security risks on corporate investments in Asia and Africa. His views are sought by statesmen, think tanks & business houses to shape their own assessments & strategies.

- With research degrees (M.Phi) in "Defence & Strategic Studies" and "Diplomacy", from University of Madras and Jawaharlal Nehru University (JNU) respectively, as well as published papers/articles in his name, Jitendra has good academic exposure to reinforce his professional/intellectual erudition. He has devised a comprehensive futuristic scientific framework of democratic governance, captioned as "Indocracy". He claims that this model can optimize not only governance- security output of India (and similarly placed others) at a faster pace but also augment the quality of stability of the prevailing global order and security cover for entire mankind. The paper is yet to come out in public domain.

- Some of the lectures, talks, TV discussions, research papers & articles of Jitendra are available on web. He occasionally writes on his blog that can be accessed at: www.democracyandgovernance.com;
-

STTAL Postgraduate International Conference

Surabaya, 27 June 2024

SMART DEFENSE FOR INDONESIAN NAVY

VICE CHAIRMAN
NATIONAL RESEARCH AND INNOVATION AGENCY
THE REPUBLIC OF INDONESIA

Prof. Dr. Ir. Amarulla Octavian, M.Sc.
Vice Admiral (Retd.), Indonesian Navy

6/27/24 RESTRICTED 1/27

Curriculum Vitae

Education Background
Bachelor of Engineering, Indonesian Naval Technology College, 1998-2001
Master of Science, Université Paris 2, Panthéon-Assas, French, 2005-2006
Doctor of Sociology, University of Indonesia, 2010-2012
Indonesian National Resilience Institute, 2016

Military Education, Course, and Training
Indonesian Naval Academy, 1984-1988
OJT. PH. Jeanne d'Arc, French, 1991-1992
Anti Submarine Specialization School, 1993
Royal Australian Navy Maritime Studies Period, Australia, 1995
Good Governance and Conflict Training Course, Netherland, 2002
Indonesian Naval Command and Staff College, 2003
Collège Interarmées de Défense, French, 2006
Maritime Security Cooperation Course, Australia, 2009
Combined Force Maritime Component Commander Flag Officer Course, U.S.A., 2014
Transnational Security Cooperation Course, U.S.A., 2017

Military Accomplishment
Naval Warfare Officer (DDG, FFG, FFLG), EFC, 1988-2003
Commanding Officer of KRI Tjiptadi (FFL-881), EFC, 2003
Commandant of Naval Warfare Centre, EFC, 2003
Commandant of Naval Operation Centre, EFC, 2003-2004
Commandant of Sangatta Naval Base, EFC, 2004
Commanding Officer KRI Karel Satsuitubun (FFG-356), EFC, 2006-2007
Commander of 2nd Division, Escorta Squadron, EFC, 2006-2007
Commander of Fast Attack Squadron, EFC, 2007-2008
Commander of Sea Battle Group, WFC, 2013-2014
Chief of Staff, WFC HQ, 2014-2016
Commandant of Indonesian Naval Command and Staff College, 2018-2020
Rector of the Republic of Indonesia Defense University (RIDU), 2020-2023

Government Assignment
Vice Chairman of the Republic of Indonesia of the National Research and Innovation Agency (BRIN), 2023-Present

Academic Achievement
Naval Tactical Trainer, 1989
Naval Operational Instructor, 1995
Naval Technology Lecturer, 2003
Assistant Professor, 2013
Associate Professor, 2019
Full Professor, 2021

Permanent Professor
RIDU

Visiting Professor
Naval Command and Staff College
University of Indonesia
University of Gajah Mada

Research Expertise
Naval Technology
Maritime Security
Military Sociology
Defense Industry

Honorary Award and Medal
Star of Jalasena Nararya, 2015
Star of Yudha Dharma Nararya, 2016
Star of Jalasena Pratama, 2016
Star of Yudha Dharma Pratama, 2017
Star of Dharma, 2020
Star of Commandeur dans l'Ordre National du Merité, French Government, 2022

6/27/24 RESTRICTED

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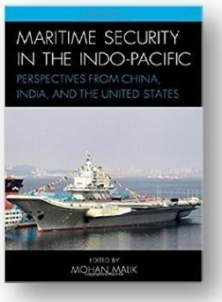
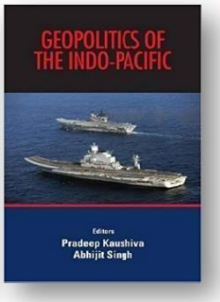
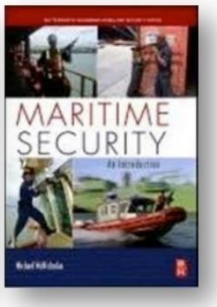






Foreword

NATO Secretary General

Anders Fogh RASMUSSEN
Munich Security Conference, 2011

Smart Defense is about building security for less money by working together and being more flexible.

Smart Defense also means encouraging multinational cooperation. Nations should work in small clusters to combine their resources and build capabilities that can benefit the alliance as a whole. NATO can act as a matchmaker, bringing nations together what they can do jointly a a lower cost, more flexibility, and with less risk.

Foreword

Smart Defense is defined by three interrelated features:

1. The main idea of pooling and sharing military goods and best practices.
2. The need to identify a common set of security priorities through which overall coherence should be maintained.
3. The requirement of establishing strategy synergies between NATO and other institutions, primarily the European Union.

Foreword

After Russia's 2022 invasion of Ukraine, NATO adopted a new "back to the future" strategic concept which returned Russia to its Cold War status of adversary and put deterrence and defense back at the heart of alliance strategy.

Many experts assess that NATO's capability to support Ukraine more than two years is supported by the implementation of Smart Defense that has been running previously. The synergy between NATO member countries is going well even though not all of them are European Union member countries.

Pooling and Sharing

Smart Defense is designed for “pooling and sharing” military capabilities, including the navy. It is to work the mechanism and scheme regionally and domestically. We could consider the System of Systems approach. Usually decision-makers are looking at their own system for optimization opportunities.

This approach could be easily implemented but one should not forget that optimization opportunities frequently reside outside the national defense system. Policy makers could find ample of opportunities in other governmental and even non-governmental agencies to better share cost and responsibilities.

Pooling and Sharing

Several countries have not clearly divided responsibilities for border control, especially at sea. In some cases different ministries or governmental departments build their own “navies” or surveillance systems, which are not connected. Better sharing of platforms or surveillance data could lead to savings.

Building a Smart Defense thinking about defense as a System of Systems. Smart defense at sea for the navy and other national agencies, such as Coast Guard, marine police, or other institutions. So, the navy’s defense system could collaborate with other national agencies security system at sea.

Pooling and Sharing

The Smart Defense approach is the possibility of creating an intermediate level of capabilities development between the navy and other national agencies.

Emphasis is being placed on three particular principles of Smart Defense, namely prioritization, specialization, and multi-agencies cooperation.

Prioritization

Prioritization deals with the order that should be given to the specific capabilities to endorse critical gaps. They should influence national defense planning in such a way that navy may choose whatever capabilities are suitable for the alignment of their maritime security requirements with those of the other national agencies to which they belong in a transparent, cooperative, and cost-effective manner.

This obviously sets the stage for each agency's specialization. Specialization under the Smart Defense means the concentration of efforts in areas that navy think they are strong and valuable for joint operation.

x

Prioritization

Prioritization can be done starting from determining assets that are common needs with a high urgency value. Priority is also directed towards assets that can be compatible for one to another. For this reason, human resources must have high competence needed that they can understand various systems from other national agencies.

Specialization

The better alternative for the navy is to consult and coordinate with other national agencies prior to making decisions on best capabilities to operate regularly and to create new operational concept. The aim is to synchronize navy's defense planning with other national agencies' security planning so that joint capabilities will be achieved.

This procedure of specialization by design, which requires cooperation between navy and other national agencies is being encouraged to respect the principle of flexibility for decisions.

Specialization

Specialization at domestic level can be implemented at the regional level as well by taking into account the scope of policies and strategies as well as the level of technological mastery owned.

Multi-agencies Cooperation

Joint operation at sea means that each national agency voluntarily participates all phases of multi-agencies cooperation that are shared by other national agencies, thus acquiring a capability it could not afford by other means. Some national agencies may form clusters of capabilities based on communalities, such as detection systems, command and control facilities, etc.

Capabilities development does not mean that every national agency must have the same equipment. Thus, special concern is being given to the interoperability of operational systems. As a means of interconnecting capabilities and forging synergies, defined as the “plug and play” approach.

Multi-agencies Cooperation

Joint operation can run well when the technology mastery by each national agency is in accordance with the established specialization.

domestic Smart Defense

The navy can provide several alternative patterns of joint operation which can become a joint agenda with other national agencies in accordance with mutually agreed priority levels.

The ultimate priority is to increase the capability of naval bases and naval air bases for receiving ships and aircraft from other national agencies. Various maintenance and logistics facilities owned by naval bases and air naval bases could be equipped according to the technology of the ships and aircraft being operated.

domestic Smart Defense

Joint operation could be conducted more effectively by utilization of command and control centers belonging to the navy and other national agencies must be prioritized for common use and manned by all participating national agencies.

The technological priority is to support the effectiveness of joint operation, such as underwater detection systems, USV and USSV, etc. Spare parts for all equipment are also adapted to the equipment technology used.

domestic Smart Defense

The navy can determine technical and tactical capacities that can be directed to other national agencies which become the specialty of each agency. The navy can provide instructors to brief its technical and tactical capacities to all other national agencies.

The specialization of each agency's capacities is always projected to always be able to cover existing weaknesses. In principle, there is an opportunity for overlapping certain specialties but not duplication.

domestic Smart Defense

Each agency with its respective specialization can function well as a complement and/or substitute for other agency specialties when carrying out joint operation.

This specialization can ultimately be used as a basis for determining what technology must be mastered for the common instrument. The technology is available in various conditions when joint operation are carried out.

domestic Smart Defense

The navy can establish a network that will be used for sharing information to support the effectiveness of joint operation. On each network, a validation method can be determined for each valuable information received.

The navy together with other national agencies can determine the assets that will be used in joint operation, both surface or sub-surface platforms and air platforms.

The navy can provide joint operation schedules according to operating areas and schedule particularly for each other national agency when participating in joint operation.

domestic Smart Defense

The navy deploy supply chains and logistics support to increase the efficiency of joint operation.

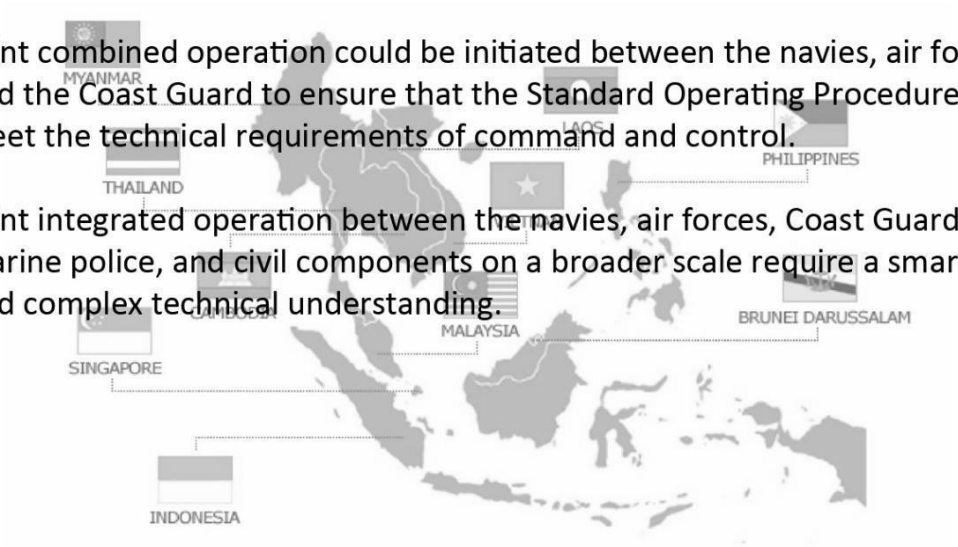
The navy invite experts from other national agencies to conduct joint research regularly to solve problems faced while carrying out various innovations.

regional Smart Defense

The Indonesian Navy can offer mutual interests that can be accepted by the navies of countries in the region so that they are willing to participate in a task force for joint operation (including marine police and civilian components). Common interests can be formulated from joint efforts to ward off and overcome common threats, such as tackling Transnational Organized Crimes, managing climate change, preventing pollution, etc.

Bilateral joint operation can be expanded into multilateral joint operation. It is very important to develop a Standard Operating Procedure that can be used by all agencies from all participating countries.

regional Smart Defense



Joint combined operation could be initiated between the navies, air forces and the Coast Guard to ensure that the Standard Operating Procedures used meet the technical requirements of command and control.

Joint integrated operation between the navies, air forces, Coast Guard, marine police, and civil components on a broader scale require a smarter and complex technical understanding.

regional Smart Defense

The Navies can carry out joint research with all experts from the Air Force, Coast Guard, marine police and civil components to ensure technology and all equipment is always up to date with needs in the field.

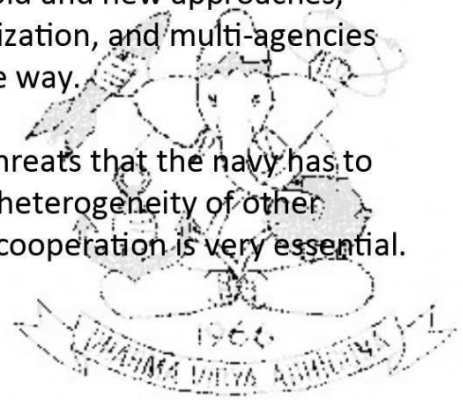
Both joint combined operation and joint integrated operation can make a positive contribution for defense diplomacy to prevent conflict escalation in the region and beyond.

Smart defense will be an important role to balance between regional interests and the national interests of each country to deescalate current conflicts.

Closing

Smart Defense is largely driven by the need to save money or to spend more wisely. Smart Defense is a combination of several methods of capabilities development and sustainability, using a mix of old and new approaches, following the principles of prioritization, specialization, and multi-agencies cooperation in a synchronized and cost effective way.

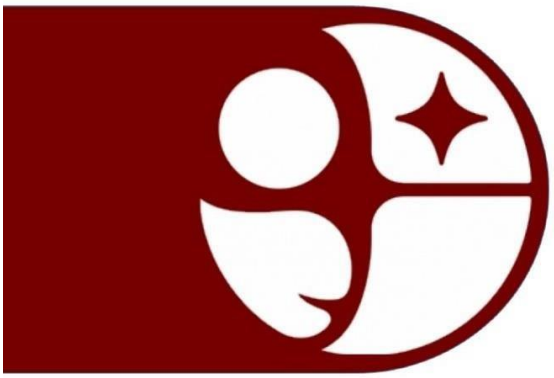
Taking into account the spectrum of maritime threats that the navy has to face, the security capabilities required, and the heterogeneity of other national agencies, some type of multi-agencies cooperation is very essential.

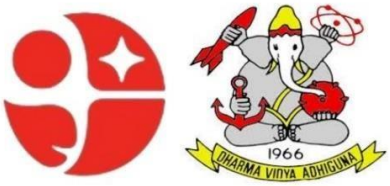


Closing

Smart Defense can be carried out domestically and regionally. Equality in the level of technology between the navy and other national agencies at the domestic level plays a very important role. Likewise, the level of technological mastery between the navies of countries in the region also plays a significant role in the sustainability of combined and/or integrated joint operation over a long period of time.

STTAL can conduct various research to produce various technological innovation needed to determine the priorities and specializations of the navy and each national agency in joint operation. Likewise for the technology needed in integrated and/or combined joint operation in the region.





Thank You

FIELD I
OPERATION RESEARCH

Indonesian Naval Technology College
Postgraduate International Conference, Vol. 8, No. 1, pp. 1-12
June, 27th 2024

IDENTIFICATION OF IMPACT FACTORS MINIMUM ESSENTIAL FORCE (MEF) ACHIEVEMENT OF INDONESIAN NAVY ON THE STRATEGIC ENVIRONMENT IN THE NORTH NATUNA MARINE AREA

Arda Widyaksa[1], Okol Sri Suharyo[2], Joko Purnomo[3],April Kukuh Susilo [4]

Indonesian Naval Technology College,
Bumimoro-Morokrembangan, Surabaya 60187, Indonesia

ABSTRACT

This research focuses on evaluating the current status of the Indonesian Navy's Minimum Essential Force (MEF) in the North Natuna Sea area. This research aims to evaluate the progress of the Indonesian Navy's Minimum Essential Force (MEF) initiative, focusing specifically on its impact within the North Natuna Sea region. Utilizing a qualitative descriptive statistical approach the research using the Delphi Method to support its analysis. The impact of achieving the MEF is dissected into three main criteria: Deterrent Effect, Bargaining Power, and Maritime Security Threat. The research identified 4 sub-factors for both Deterrent Effect and Bargaining Power, and 6 sub-factors for Maritime Security Threat, all determined through consensus among expert panelists.

Keyword : Minimum Essential Force (MEF), Impact, Delphi

1. Introduction

Territorial disputes in the South China Sea (SCS) remain a significant security challenge within the ASEAN region due to conflicting claims. The SCS spans approximately 3 million km², bordered by China and Taiwan to the north, several Southeast Asian nations to the west, the Philippines to the east, and Kalimantan, Indonesia, to the south. This maritime region is surrounded by ten countries, including Brunei Darussalam, Cambodia, China, Indonesia, Malaysia, the Philippines, Singapore, Taiwan, Thailand, and Vietnam (Schofield et al, 2016).

Since 2010. Indonesia has been increasingly involved in the SCS disputes after China extended its claim to the northern region of the Natuna Islands in the Riau Islands Province, an area within Indonesia's Exclusive Economic Zone (EEZ). China justifies its claim by citing historical fishing rights (Dugis et al, 2018). The potential for conflict in the SCS raises concerns that the Natuna Sea and its vicinity could become a battleground for contesting nations and major powers with interests in the SCS. Consequently, it is imperative for the Indonesian Navy to maintain a state of readiness to safeguard territorial sovereignty over the Natuna waters should disputes escalate into armed conflict (Utomo et al., 2017). Marsetio (2014) emphasizes the importance of consistently strengthening the Indonesian Navy in line with the national defense policy, the Minimum Essential Force (MEF), to prepare for such eventualities.

If Indonesia fails to meet the objectives of the Minimum Essential Force (MEF), the country could face several risks, including: a) Increased threats to the sovereignty and territorial integrity of the Republic of Indonesia, potentially destabilizing national security; b) Obstacles in achieving the national development goals related to national defense; c) Diminished bargaining power of the Indonesian government in international diplomacy, leading to decreased influence in the international community; d) A failure to develop the primary components of the MEF could weaken national defense deterrence capabilities in the region; e) A decline in the nation's competitiveness index, affecting its standing in the international environment; f) A reduction in the Indonesian National Armed Forces' (TNI) ability to perform its primary duties.

This research aims to evaluate the progress of the Indonesian Navy's Minimum Essential Force (MEF) initiative, focusing specifically on its impact within the North Natuna Sea region. Utilizing a qualitative methodology grounded in 3D modeling, the research seeks to scrutinize the current state of MEF achievements and strategize its future development. The significance of impact assessment in this context is underscored by its ability to grant researchers the opportunity to identify and analyze factors critical to the MEF's success. This research endeavors to contribute to the field of defense management by offering insights into the handling of territorial disputes through impact assessment. Furthermore, this research employs a qualitative descriptive statistical approach, enriched by theories on Competitive Dynamics, Deterrent Effect, and Maritime Security Threats.

This research offers multiple contributions. Firstly, it advances research on the Defense Force by evaluating the impact of Minimum Essential Force (MEF) development, analyzed through various lenses including Bargaining Power in diplomacy (Harry & Nugraha et al, 2017), Deterrence effect (Chadhafi et al, 2021), and the Capability to address maritime security threats (Andalus & Djuyandi, 2022). Secondly, it establishes Confidence-Building Measures (CBMs) as both a deterrence mechanism against threats and a strategic guide for shaping defense posture policies (Santiko & Agustien et al, 2022). Thirdly, this research acts as a follow-up on the recommendations by Kaya & Kahraman (2011), aiming to assess environmental impacts employing alternative methodologies.

2. Methodology

2.1 Competitive dynamics.

Dynamic competition theory, which emerged in the 1980s within the strategic management field, emphasizes the interplay of attack and counterattack actions among firms (Chen & Miller, 2012). Chen (2009) posits that competition forms the core of strategic considerations, encapsulating a dynamic process involving actions and reactions by companies. This interplay underscores a dependency relationship, wherein a company's competitive standing is vulnerable to its rivals' defensive or offensive strategies (Chen & Miller, 2012). Competitive dynamics encompass the entire spectrum of competitive behaviors, meaning all actions and reactions executed by firms within a market context. Importantly, the actions and reactions of firms are deeply interdependent, with their strategic moves significantly affecting their performance (Woo et al., 2021).

As outlined in the research, the theory of competitive dynamics serves as a tool for competitors to assess the ramifications of their actions and reactions within the competitive landscape. It has a notable impact on organizational activities concerning the responses of rivals and overall organizational performance. The theory suggests that the influence on organizational activities, particularly the degree to which an organization either repetitively mirrors past actions or selectively incorporates new strategies into its strategic framework, is a critical consideration (Baskoro, 2017).

2.2 Impact Assessment

Since the enactment of the National Environmental Policy Act of 1969 (NEPA) in the United States, the theory and practice of impact assessment have evolved significantly (Pope et al., 2013). Impact assessment is a systematic process designed to evaluate the effectiveness, relevance, and sustainability of an organization's current and future actions and initiatives. Its primary goal is to delineate the relationships among an organization's inputs, outputs, and outcomes, aiding organizations in making well-informed programmatic and institutional choices.

The International Association for Impact Assessment (IAIA) outlines four key objectives of impact assessments: a) To comprehend the potential impacts of proposed actions, changes, or interventions, and to prepare for addressing both positive and negative consequences; b) To foster accountability towards a wide rangeof stakeholders, including shareholders, employees, donors, partners, customers, volunteers, and beneficiaries; c) To identify necessary procedures and methodologies for future policy development, planning, and project cycles; d) To facilitate decisions that are environmentally, socially, and economically sustainable, thereby supporting organizational growth and development (Bond & Pope, 2012).

Expanding on these foundations, our paper introduces varied perspectives on the current state and future directions of impact assessment within the context of defense management strategy. We present our insights into the current advancements in impact assessment, the forthcoming challenges, and potential research directions aimed at enhancing the role of impact assessment in fostering sustainable development through informed decision-making. This research specifically addresses the impact of achieving Minimum Essential Force (MEF) based on three impact criteria: Deterrent effect (D), Bargaining power (B), and Threat to maritime security (T).

2.3 Minimum Essential Force (MEF)

Indonesia initiated the Minimum Essential Force (MEF) target as a strategic response to its defense requirements, constrained by a limited defense budget (Kennedy et al, 2023). The MEF is aligned with the government's Nawacita vision and mission, which focuses on ensuring national security and contributing to global peace. It aims to enhance Indonesia's defense capabilities to effectively address the evolving strategic environment and to deter both internal and external, as well as traditional and non-traditional threats (Santiko & Agustien, 2022).

The MEF development was structured into three phases: Phase I from 2010 to 2014. Phase II from 2014 to 2019, and Phase III from 2019 to 2024. The completion rates of the MEF development programs and activities were recorded at 52.33% for Phase I, 59.69% for Phase II, and 68.9% for Phase III. The primary goal of the MEF initiative is not to incite an arms race or to achieve superiority for total warfare. Instead, it is meticulously designed to elevate the country's defense forces to a more optimal standard, ensuring they are capable of exerting a deterrent effect, thus contributing to national and regional stability (Ervin et al, 2022).

2.4 Delphi Method

The Delphi method was developed by Derlkey and his associates at the Rand Corporation, California in the 1960s. The Delphi method is a method that harmonizes the communication process of a group so that an effective process is achieved in obtaining solutions to complex problems. The Delphi method in another definition is the process of involving a group in an interaction between researchers and experts who are selected based on background and criteria that are relevant to a special topic of discussion using a questionnaire (Yousuf, 2007).

The Delphi method aims to reach consensus from a series of information mining processes. In carrying out the Delphi method, opinions and judgment from experts and practitioners are needed (Widiasih et al, 2015). In carrying out the Delphi method, opinions and judgment from experts and practitioners are needed. Some characteristics of the Delphi method (Yousuf, 2007):

a. Anonymous use of questionnaires or other communications i.e. responses are otherwise not identified as being from a particular member of the panel which allows for anonymity.

b. Control feedback from interaction (controlled feedback), control feedback allows interaction with reduced disagreement between panel members. Interactions that occur are possible from interactions

between group members in several stages with the results of the previous stage being summarized and group members asked to evaluate their answers compared to groupthink.

c. Statistical group response, group opinion is defined as the statistical average of the final opinions of each member with the opinion of each group member reflected in the final group response.

The Delphi method is designed to achieve consensus through a systematic process of gathering and distilling the opinions and judgments of experts and practitioners (Widiasih et al, 2015). It is particularly valued in decision-making processes for its ability to solicit and refine the most credible insights among a group of decision-makers or experts. The method aims to facilitate a convergence of opinions by narrowing down the spectrum of judgments, importantly doing so in a manner that avoids the biases and errors typically associated with direct, face-to-face interactions (Ahmad et al., 2021; Zio & Maretti, 2015). In this study, a panel of 15 experts was engaged to oversee and participate in the rounds of Delphi questionnaires (Flostrand et al., 2020; Ribeiro et al., 2021).

The feedback process for each round of questionnaires usually requires two to three iterations to gather comprehensive feedback from the panel, with each round spanning an average of two weeks. The process is concluded once consensus among the panel members is achieved. This consensus is determined based on statistical measures such as mean, median, standard deviation, and interquartile range aligning with the predetermined objectives of the Delphi method (Widiasih et al., 2015). According to Karakikes & Nathanail (2020), the Delphi process comprises three primary steps:

The first questionnaire was sent to the expert panelists to ask for some opinions (from experience or judgment), some predictions and recommendations. In the second round, a recap of the results of the first questionnaire was sent to each expert panelist to be able to re-evaluate their first assessment on the questionnaire using the set criteria. In the third round, the questionnaire was sent back with information on the panelists' ratings and the consensus results. The panelists were again asked to revise their opinions or explain the reasons for disagreeing with the group consensus.

The use of the Delphi method preceded the AHP approach for the following reasons: 1) The Delphi method is based on the subjective opinions of respondents, so that it can formulate the overall objective or criteria that are revealed more flexibly; 2) The results of the Delphi approach have not been tested for consistency of answers, so the AHP method complements the proposed procedure for testing the consistency of individual and group opinions and weighting the priority of the importance of each criterion/objective.

In this study, the Delphi method was used to identify factors related to the impact of MEF achievement. In the identification of factors, the Delphi method was used for up to three rounds.

2.5 Content Validity Indeks (CVI)

The Content Validity Index (CVI) stands as a pivotal method for assessing the validity of an instrument's content, widely recognized for its application in various research domains. It quantifies the degree to which experts agree on the relevance or representativeness of an instrument's items, offering insights into its content validity both at the item level (Item-level CVI or I-CVI) and across the entire instrument (Instrument-level CVI). The calculation of CVI is underpinned by expert evaluations of each item, based on its content relevance or representativeness (Almanasreh et al., 2018).

In exploring factors that influence a panel's consensus on Minimum Essential Force (MEF) attainment in a given domain (during a Delphi round), both means and standard deviations are computed to gauge factor

convergence. The assessment of each objective's importance by an expert panel is facilitated through a 5-point Likert scale (Stancine et al., 2019). To assess content validity, the research employs both the item-level content validity index (I-CVI) and the scale-level average content validity index (S-CVI/Ave). The S-CVI/Ave is determined by dividing the sum of I-CVI scores by the number of items. An S-CVI/Ave of ≥0.8 is considered acceptable, whereas an S-CVI/Ave of ≥0.90 denotes excellent overall content validity. The I-CVI, on the other hand, is calculated as the number of experts rating an item ≥3 divided by the total number of experts, with an I-CVI of ≥0.78 being acceptable (Almohanna et al., 2022). Literature suggests that for a new assessment instrument to be considered valid, it should achieve a total CVI of ≥0.90 or 90% and an I-CVI of ≥0.78 or 78% (Marisa, 2021).

In this particular instance, the S-CVI/Universe method was not employed due to the large size of the expert panel, which could potentially skew results towards unacceptable levels. Additionally, this approach does not account for the possibility of chance agreement among experts (Roya & Behrooz, 2017) emphasizing the method's reliance on expert consensus without adjustments for randomness in responses.

3. Result and Discussion

In this section, the Delphi Methodology is applied in assessing the impact of achieving MEF. The Delphi method is a method that harmonizes the communication process of a group so that an effective process is achieved in obtaining solutions to complex problems. The Delphi method in another definition is the process of involving a group in an interaction between researchers and experts who are selected based on background and criteria that are relevant to a special topic of discussion using a questionnaire (Yousuf, 2007).

3.1 Result

The Delphi survey questionnaire needs to be designed in such a way as to obtain information regarding the objectives or criteria for each round of the survey. All panelists acted in high-level leadership or professional positions of expertise, which may increase the internal validity of the study (Toppinen et al., 2018). The number of panels is kept simple to reduce complexity, this is because the purpose of the Delphi method is not to explain phenomena based on statistical variance, but to offer a fairly broad and varied quality of responses and allow management to categorize and consolidate responses (Nyström & Kaartemo, 2022). None of them suggested changing any themes or indicators (Lakmini et al., 2023).

This section elaborates on the systematic approach undertaken to finalize the impact factors from three principal aspects: Deterrence Effect, Bargaining Power, and Threat to Maritime Security. Given the stringent criteria, this research engaged a panel of 15 maritime field experts to partake in a Delphi survey. The design of the Delphi survey questionnaire was critical to garner insights about the objectives or criteria in each survey round. All panelists, comprising 12 practitioners at the maritime manager level and 3 academics specializing in maritime defense, completed three survey rounds. The result of this stage is the identification of key impact assessment factors.

Round 1: The initial round involved distributing a Google Form questionnaire to the 15 expert panelists. This questionnaire outlined the research and its objectives and included three variable dimensions: 8 items on the deterrence effect, 8 on bargaining power, and 19 on maritime security threats. Utilizing a Likert scale of 1-5 for assessments, the estimated completion time was between 10-15 minutes. The analysis revealed that all dimensions were crucial for constructing the assessment tool, as evidenced by the average importance rating of each dimension being above 3 (mean). Item-CVI scores ranged from 0.40 to 1. validating all items. The set

achieved an S-CVI of 85% (≥0.8 is acceptable) and an I-CVI of 87% (I-CVI ≥0.78 is acceptable), with no suggestions for theme or indicator modifications (Lakmini et al., 2023). The first round led to the elimination of 3 deterrence effect items, 2 bargaining power items, and 3 maritime security threat items, narrowing down from 25 to 18 items.

Round 2: Two weeks later, the second round asked experts to assess the CVI of the remaining 18 items across the three dimensions. Item-CVI ranged from 0.67 to 1. again validating all items with a 1-5 Likert scale and maintaining the 10-15 minute completion estimate. This round achieved an S-CVI of 85% and an I-CVI of 81%, reaffirming the fundamental nature of all dimensions, as the average importance rating of each remained above 3. This round resulted in the removal of 4 items related to sub-factors (Economic Resources, Population Size and Market Potential, Wealth of Natural Resources, Geopolitical Dynamics), reducing the item count to 14.

Round 3: After reformulating, the instrument underwent a third evaluation round to assess final validity. The consensus was nearly unanimous, with the I-CVI value at 1 for almost all items, indicating 100% agreement among experts. This resulted in an impressive S-CVI of 98%. Given the very good I-CVI values, this round effectively completed the instrument's overall validity phase, negating the need for further evaluation. All items fell into valid or very valid categories, achieving consensus in the Delphi process.

Table 6 Summarizes the progression and outcomes of expert opinions across rounds 1. 2. and 3. detailing the methodical refinement and validation of the instrument items through expert consensus.

Tabel 1. Results of collecting expert opinions in rounds 1,2 and 3

No	Dimension	Item	Round 1			Round 2			Round 3		
			Mean	CVI	Result	Mean	CVI	Result	Mean	CVI	Result
1	**Deterrencce Effect**	Military Capability	4,40	0,93	Acceptep	4,40	0,93	Acceptep	4,47	1,00	Acceptep
2		Nuclear Deterrence	3,80	0,80	Acceptep	3,80	0,80	Acceptep	4,00	1,00	Acceptep
3		Effective Communication	3,60	0,60	Rejected						
4		Credible Leadership	4,33	0,93	Acceptep	4,33	0,93	Acceptep	4,33	1,00	Acceptep
5		Alliances and Coalitions	4,67	0,93	Acceptep	4,67	0,93	Acceptep	4,73	0,93	Acceptep
6		Negotiation	3,73	0,73	Rejected						
7		Enemy Perceptions and Calculations	3,93	0,67	Rejected						
8		Economic Resources	3,80	0,80	Acceptep						
9	**Bargaining Power**	Economic power	3,80	0,80	Acceptep	3,73	0,73	Rejected			
10		Political Influence	4,20	0,93	Acceptep	3,80	0,80	Acceptep	0,40	1,00	Acceptep
11		Aliances International	4,47	0,93	Acceptep	4,20	0,93	Acceptep	0,54	1,00	Acceptep
12		Diplomatic Skills	4,40	0,93	Acceptep	4,47	0,93	Acceptep	0,50	0,93	Acceptep
13		International Laws and Norms	3,20	0,47	Rejected						
14		Population Size and Market Potential	3,80	0,80	Acceptep	4,40	0,93	Acceptep	0,61	0,93	Acceptep
15		Geopolitical Significance	3,60	0,60	Rejected	3,73	0,73	Rejected			

No	Dimension	Item	Round 1			Round 2			Round 3		
			Mean	CVI	Result	Mean	CVI	Result	Mean	CVI	Result
16		Wealth Natural Resources	4,13	0,80	Acceptep	4,00	0,73	Rejected			
17	**Threat Maritime Security**	Territorial Disputes	4,27	1,00	Acceptep	4,27	1,00	Acceptep	4,27	1,00	Acceptep
18		Piracy	4,33	1,00	Acceptep	4,33	1,00	Acceptep	4,33	1,00	Acceptep
19		Terrorism	4,27	1,00	Acceptep	4,27	1,00	Acceptep	4,27	1,00	Acceptep
20		Illegal Fishing	4,13	1,00	Acceptep	4,13	1,00	Acceptep	4,13	1,00	Acceptep
21		Smuggling	4,40	1,00	Acceptep	4,40	1,00	Acceptep	4,40	1,00	Acceptep
22		Geopolitical dynamics	4,20	0,80	Acceptep	4,00	0,67	Rejected			
23		Cybersecurity Risks	3,80	0,73	Rejected						
24		Competition for maritime resources	4,07	0,80	Acceptep	4,07	0,80	Acceptep	4,33	0,93	Acceptep
25		Environmental Damage	3,53	0,60	Rejected						

3.2 Discussion

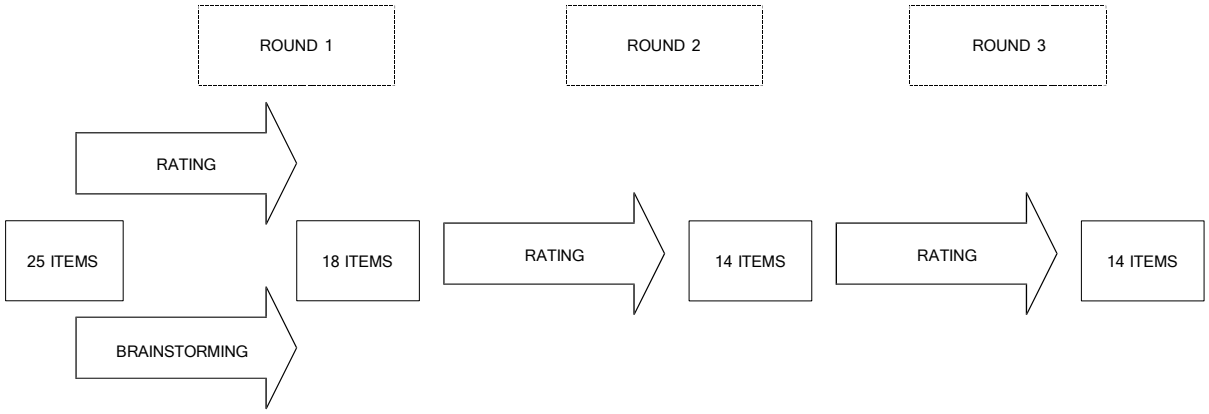


Fig 1. Overview of various rounds and number of indicators

The model for determining the impact factors on the achievement of MEF on the Strategic environment in the North Natuna Sea area is quite complex, because it has many characteristics in each aspect of the Deterrence Effect, Bargainning Power and Threat Maritime Security Criteria. The results of the 25 items of impact factors from 3 (three) main aspects in round 1 became 18 items where there were 7 factors released in the deterrence effect aspect, there were 3 factors: Effective Communication, Negotiation, Enemy Perceptions and Calculations, in the Bargainning power aspect there were 2 factors: International Laws and Norms and Geopolitical Significance, in the Threat Maritime Security aspect there are 2 factors: Cybersecurity Risks and Environmental Damage. Meanwhile, in the second round, 4 items were issued, namely: Economic power, Geopolitical Significance, Wealth Natural Resources and Geopolitical dynamics.

There are four sub-criteria in the deterrence effect aspect, four sub-criteria in the bargaining power criteria aspect and nine sub-criteria in the threat maritime security criteria aspect which were identified through a literature survey and consensus opinion of experts using the Delphi method, where 11 items were identified as not in

accordance with expert consensus, according to the experts, these 11 items are not in accordance with the research locus, geostrategic and geopolitical conditions that currently exist in the South China Sea region.

3.3 Implications.

Theoretical Implications: This research sheds light on the qualitative aspects of managing defense strategies within the maritime sphere of Indonesia, an area witnessing annual technological advancements and shifts in the stability of its strategic environment, alongside evolving threats to maritime security. It offers a foundational step for stakeholders aiming to evaluate and develop framework for impact MEF achievement. This tool is pivotal for policy strategy formulation, leveraging the solutions identified through this research. The proposed framework facilitates a self-assessment of capabilities by state actors, enabling them to benchmark against competitors and strategize for enhancing their regional defense competitiveness.

Practical and Managerial Contributions: This research stands to benefit practitioners and decision-makers by acquainting them with novel methodologies. It introduces a conceptual model for assessing the minimum base force, aimed at aiding policymakers in defense capability development. The anticipated outcome is to guide stakeholders in shaping future policies for Minimum Essential Force (MEF) enhancement. Furthermore, from a governmental standpoint, the proposed model is expected to play a significant role in managing territorial disputes, thus aiding in the preservation of national and regional stability. It positions itself as a strategic tool for negotiation, offering leverage in the context of the South China Sea disputes. Additionally, it encourages policymakers and academic institutions to explore non-military avenues for addressing security concerns through a systematic approach. Consequently, this research is poised to enrich the body of knowledge, particularly in the realm of Indonesian maritime strategy.

4. Conclusion

The Department of Education's method-based impact identification approach is a practical and efficient tool for identifying impact factors for achieving MEF. This framework makes it possible to balance and compare the impacts associated with maritime defense capability elements, as well as create a database, supplementing it with factual figures to arrive at several subfactors (14 subfactors in total). In this research there are study limitations that offer opportunities for future research. This research acknowledges several limitations that pave the way for future research avenues. Firstly, while the research successfully identifies key factors influencing maritime security threats, there is a pressing need to develop a comprehensive framework that encompasses both tangible and intangible threat factors.

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Indonesian Naval Technology College
Postgraduate International Conference, Vol. 8, No. 1, pp. 13-23
June, 27th 2024

SUBMARINE CAPABILITY ASSESSMENT TO INCREASE DETERRENCE EFFECT IN THE ALKI II REGION

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ABSTRACT

Regional dynamics marked by an increase in submarine operations by several countries need to be balanced with an increase in Indonesia's capabilities in underwater warfare and contribute to increasing the country's defence system at sea. herefore, the purpose of this study is to consider the competitive dimension of submarine capability development on a country's deterrence effect and assess the extent of the literature review. This research is a statement that there is no instrument for assessing the capability and sustainability of submarines in an effort to increase the deterrence effect in the ALKI II region associated with the development of current dynamics so that this research is expected to contribute to getting an instrument for assessing submarine capability and submarine deterrence effect in the ALKI II region.

Keywords: Deterrence Effect, Capability, Submarine, Submarine Capability, ALKII

1. Introduction

After determining Indonesia's identity as an archipelagic state, the country ratified UNCLOS 1982. The Indonesian Navy (TNI AL) has a submarine unit that is an important part of the defence equipment and strategic weapons. A discussion of modern conventional submarine capabilities, and some possible future developments, in Australia and in ASEAN countries. The transformation of a country's security strategy and system is strongly influenced by the dynamics of an evolving and changing strategic environment. The dynamics of the region are characterized by an increase in submarine operations. This research is expected to provide the acquisition of an assessment model that can measure submarine capability and submarine deterrence effect.

The evolution of a country's security strategy and system is strongly influenced by the dynamics of the evolving and changing strategic environment. A defence must be able to retaliate in the event of an attack, either directly at the time of any indication of an attack from an opponent having the ability to strike back safely from submarine missiles (Andersson, 2015). In the international environment, the security dimension is a top priority so that every country will try to strengthen security by increasing military expenditure When a country increases its military strength, other countries will do the same (Nugraha, 2017).

The dynamics of the region, marked by an increase in submarine operations by several countries, need to be matched by Indonesia's improved capabilities in underwater warfare (Defence, 2014). Indonesia's Defence Strategic Plan 2024 to develop a submarine fleet (Andersson, 2015). Analyzing the relationship between external, internal and operational factors of submarines to the country's defence system's deterrence explains that submarines can contribute to increasing the country's defence system's deterrence at sea (Haryanto AR et al., 2021). The purpose of this study is therefore to consider the competitive dimension of submarine capability development to analyze capability against deterrence effect in the ALKI II region.

This research is in line with previous research conducted by Timbul Haryanto AR (2022). From the existing literature, there is no submarine capability assessment instrument to increase the deterrence effect in the ALKI II region associated with the development of the dynamics of changes in the ALKI II environment regarding the transfer of the country's capital. In Addition to this, the rapid development of submarine technology owned by neighbouring countries, the Navy needs to keep pace with these changes to defend and increase the deterrence effect of Navy submarines. This research is expected to provide the acquisition of an instrument that can measure the capability of submarines and the deterrence effect of submarines in the ALKI II region.

As an analytical approach, this research adopts a statistical descriptive qualitative method to provide an overview of the research subject to create a researcher's foundation for more comprehensive data collection using AHP-Dynamic System. This research project can describe and provide new insights into the hierarchical model between submarine capability factors and submarine deterrence effect as a key to knowledge development in determining submarine capability assessment instruments. This research is focused on ASEAN countries that have interests in the

ALKI II region, this research is also supported by 7 expert panels as a target for distributing questionnaires. As such, the upgrade of submarine capabilities will contribute to the renewal of the Navy's deterrence and striking power. Deterrence theory states that extended deterrence threats tend to be more effective when potential challengers perceive them as capable and trustworthy (Johnson et al., 2015). To have more information about capabilities at the individual level, a capability approach can be used by developing a survey instrument (Anand et al., 2009).

2. Literature Review

Military deterrence strategy is dynamic, through the preparedness of defence forces to face actual threats in the form of war or other forms of military threats. In peacetime, the presence of submarines has a major deterrence impact on other parties so as to strengthen the diplomacy efforts undertaken by the government. (Defence, 2014). On this section The theoretical review includes several related theories, namely: a) Seapower theory. b) Capability theory.

2.1. Seapower theory.

Alfred Thayer Mahan, his perspective became the basis for great nations in achieving the greatness of being an ideal maritime nation. Mahan emphasised the importance of great powers building sea power evenly across strategic regions. Furthermore, Mahan also emphasised the great emphasis on the role of countries in building a sustainable maritime infrastructure. Mahan explained about six characteristics that a country must have in developing its seapower to the greatest extent in order to achieve the progress and glory of a country.

2.2. Capability theory

Capability theory is an important construct in understanding an individual's potential and opportunities. Capabilities are an opportunity set and are specific to a person, which can significantly affect their lives. In the application of this theory, it is important to recognised that capabilities are not only limited to the physical aspects or technical skills of a person, but also involve psychological, social, and even emotional aspects. Capabilities are also influenced by external factors such as the social environment, culture, and public policy.Teori deterrence.

In the concept of strategy, deterrence is always aligned with defence and focuses more on military capabilities. This theory states that actors seek to increase their capabilities and strengths to ward off attacks from opponents, or at least suppress and force opponents to rethink attacks. The purpose of using the military is to make the opponent realise the risks they face if they attack. The instruments used to implement deterrence policies can be the use of weapons of mass destruction (WMDs), the power of conventional weapons, increasing military capabilities in general, forming alliances, economic sanctions or embargoes, and threats of retaliation.

3. Methods

The stages of the research method that will be used in this research include the stages of literature review, weighting criteria using the AHP method and scoring criteria and sub criteria using Likert and then simulated using a dynamic system.

3.1. Literature Review

To obtain literature reviews of international journals, researchers used Harzing's Publish or Perish 8 application software using keywords capabilities, submarine capabilities, deterrence effect. in the range of years of publication ranging from 2012 to 2023. The criteria and sub criteria obtained were validated using Content validation index (CVI) by distributing questionnaires to expert personnel. The formula for calculating CVI (Lawshe, 1975) is:

$$CVI = \frac{ne - \frac{N}{2}}{\frac{N}{2}}$$

The conceptual design of this method is described as follows.

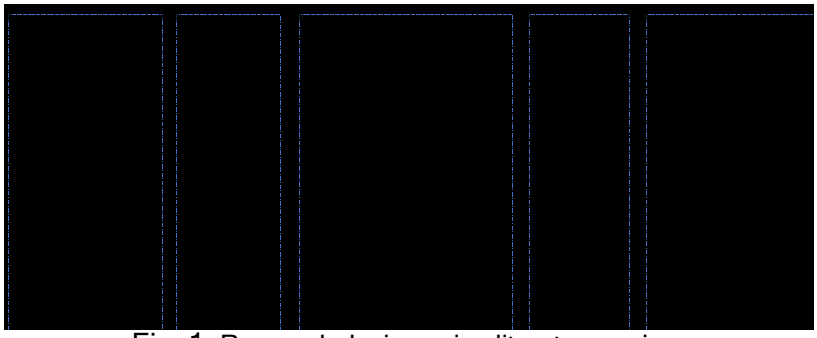

Fig. 1. Research design using literature review

3.2. AHP-LIKERT

Analytical Hierarchy Process (AHP) analyses complex multi-factor or multi-criteria problems into a hierarchy, according to Saaty hierarchy is defined as a representation of a complex problem in a multi-level structure, where the first level is the goal, followed by the level of factors, criteria, sub-criteria and so on down to the last level of alternatives with a hierarchy of a complex problem can be described in groups which are then arranged into a hierarchy as the problem will appear more structured systematically (Improta et al., 2018). This method uses the criteria and sub criteria from the CVI literature review into a hierarchy diagram.

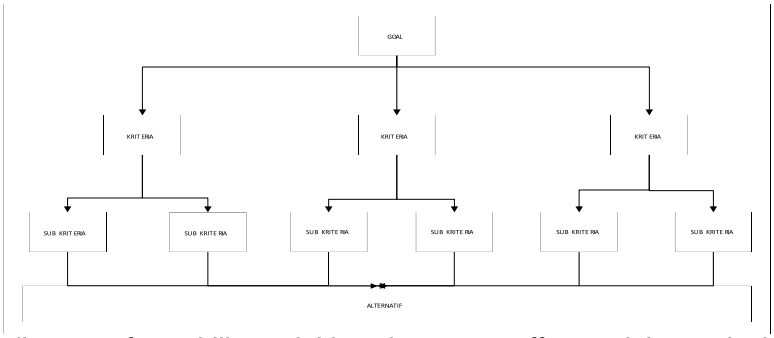

Fig. 1. Hierarchy diagram of capability variables, deterrence effect and threats in the ALKI II region

Validation of AHP results was tested using Consistency Index (CI) and Consistency Ratio (CR) assessments using the formulas:

$$CI = \frac{\lambda maks - n}{n};$$

$$CR = \frac{CI}{RI}$$

If the CR ratio is 0.1 (i.e. 10%), the matrix is considered consistent and the decision W is accepted. Instead a CR of more than that implies too more contradictions in the matrix. The precaution for the latter situation is to review the matrix. Desain model pada metode ini digambarkan sebagai berikut. The simulation design for this method is described as follows.

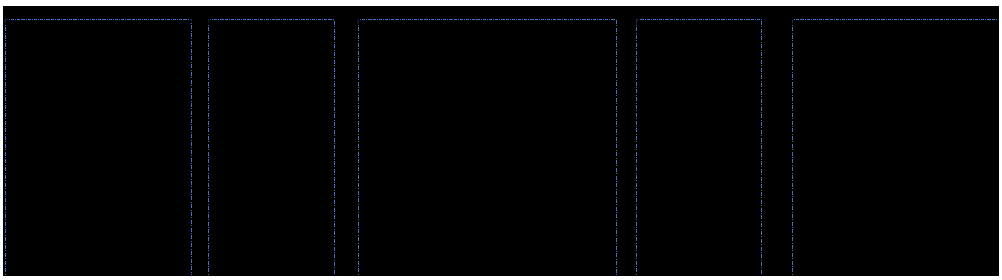

Fig. 2. research design using AHP-Likert method

3.3. System Dynamic

Modelling is a way to solve problems that appear in the real world. Modelling involves the process of mapping real-world problems and modelling them into a world model (abstraction process) as well as the process of analysis and optimisation to obtain solutions that can be implemented in the real world (Sterman, 2018). In the decade since its publication, the range of practical applications has expanded to include research management (Richardson, 2019). A simulation is the operation of a system model used before changes are made to an existing system to reduce the impact of failures, eliminate unforeseen bottlenecks, prevent overuse of resources, and optimise system performance.(Forrester, 2009). However, each capability procurement must identify and understand the basic needs of the strategic requirements for the capability, and what will happen over the lifetime of the capability in the decades of strategy that define strategic trends in Asia (Kopp, n.d. 2012).

System Dynamics model types that represent the structure of feedback diagrams can be in the form of causal diagrams or commonly called Causative Loop Diagrams (CLD). Such a diagram shows the direction of modification of the variable flow and its polarity. The flow polarity as mentioned above is divided into positive and negative. An additional form of diagram that collectively illustrates the structure of a system dynamics model is the flowchart. Flowcharts represented the connections to variables made during a cause and impact diagram additionally with clear and exploitative bound symbols for the various related variables (Forrester, 2010).

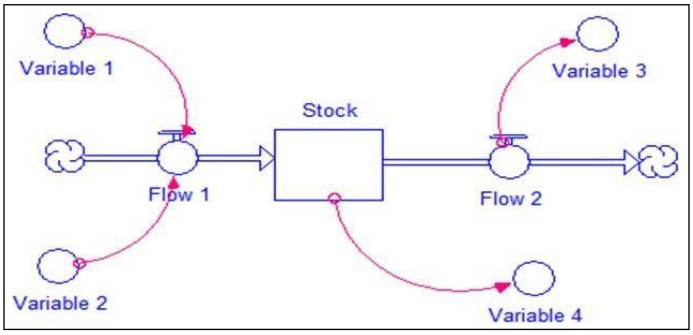

Fig. 3. stock flow diagram

In this method, causal loop diagrams and stock flow diagrams are made, then the results of AHP weighting and Likert scoring are included in the simulation of a dynamic system model with a 10-year time period so as to obtain an overview of the submarine capability value in the next 10-year period. The design of model in this method is described as follows.

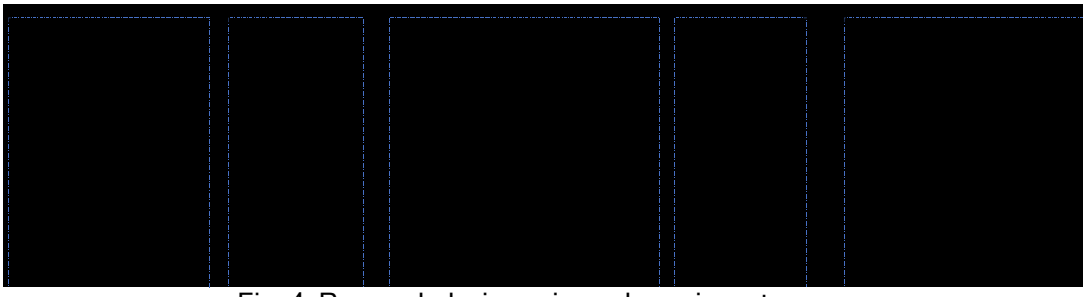

Fig. 4. Research design using a dynamic system

4. Results and discussion

In order to obtain the research objectives, data were collected through observations, interviews and literature review. To obtain data on the object of research, researchers used interview techniques then the answers were returned to the researcher. The next step was to pilot test the questionnaire using Aiken's V technique (Monge-Rogel et al., 2022).

The most straightforward process of comparison is to compare two things with an accuracy that can be accounted for. For this the quantitative scales of 1 to 9 were established to assess the comparative importance of one element to another. System Dynamics Society provides a definition of how to solve complex problems that arise due to trends, reasons, and influences of various variables in a device.

Submarine capability assessment model is obtained using literature review to determine the criteria and sub criteria that make up submarine capability, then the criteria and sub criteria are

weighted using ahp and scoring criteria and sub criteria using likert scale, then included in the dynamic system scenario to get the scale of submarine capability in the next 10 years.

4.1. Literature review analysis

This study analyses data from review literature of several journals that discuss submarine capabilities which are then taken as references in determining criteria and sub-criteria related to the assessment of submarine capabilities and the influence on the deterrence effect of submarines in the ALKI II region. Furthermore, it was validated using the Content Validation Index (CVI) by distributing questionnaires to 7 expert personnel to provide responses and assessments of the content used so as to obtain the following results:

Table 1. Content Validity Index (CVI)

SUM OF I-CVI	**36.857**	**Sum UA**	**36**
S-CVI/Ave	**0.996**	**S-CVI/UA**	**0.973**
Result	Accepted		Accepted

The result analysis of CVI stated that the content was accepted and then the list of variables was used as criteria and sub-criteria/sub-sub-criteria in the research.

4.2. Analisa Hierarcy Process-Likert (AHP-LIKERT)

4.2.1. AHP

The accepted list of variables from the CVI results is then made into an AHP hierarchy model as follows:

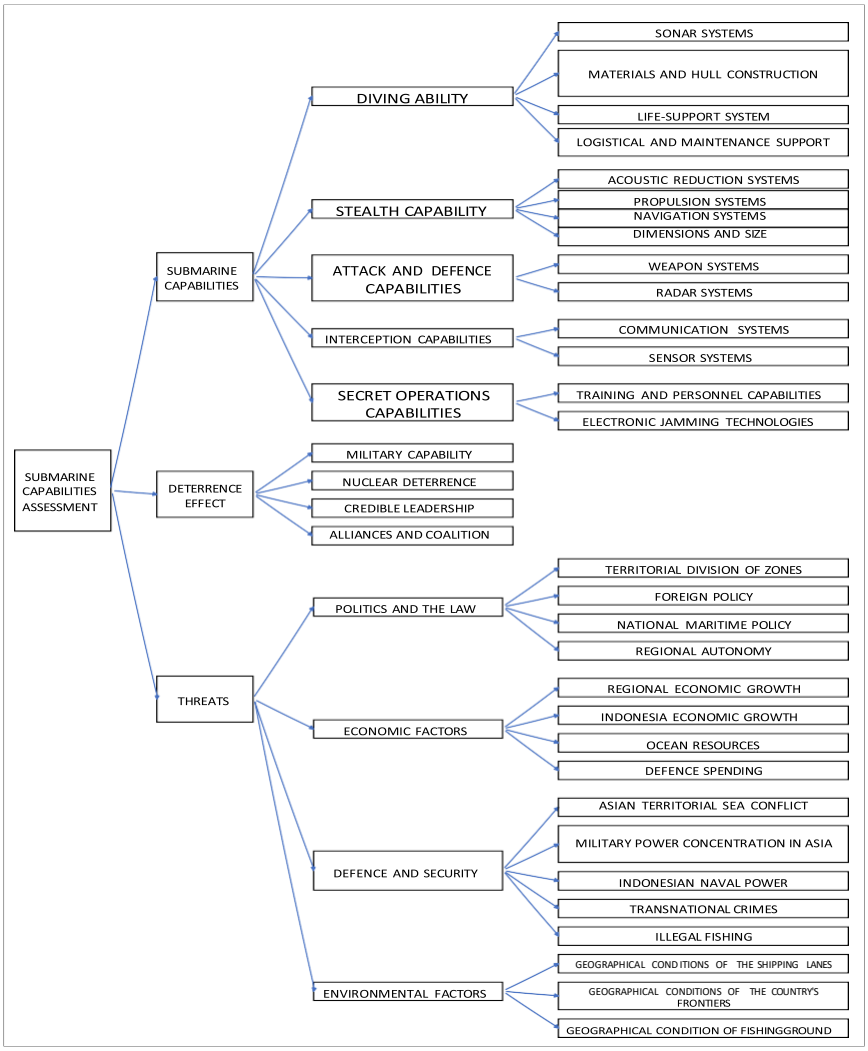

Fig. 5. Submarine Capability Assessment Hierarchy Diagram.

The hierarchical criteria and sub-criteria variables that are responsible for the assessment of submarine capability in increasing the deterrence effect of submarines in the ALKI II region are then carried out to assess the weight of the criteria and sub-criteria through expert assessment by distributing questionnaires so that the weight value of each criterion and sub-criteria is obtained as presented in Table 2 below:

Table 2. Assessment of submarine capability criteria.

CODE	DESCRIPTION	Assessment (AVE)
K-1	SUBMARINE CAPABILITIES	
K-1.1	Diving Capability	0.22
K-1.2	Stealth Capability	0.23
K-1.3	Attack and Defence Capabilities	0.21
K-1.4	Interception Capabilities	0.18
K-1.5	Secret Operations Capabilities	0.15

Table 3. Deterrence effect criteria assessment.

CODE	DESCRIPTION	Assessment (AVE)
K-2	**DETERRENCE EFFECT**	
K-2.1	Military Capability	0.29
K-2.2	Nuclear Deterrence	0.27
K-2.3	Credible Leadership	0.26
K-2.4	Alliances and Coalitions	0.18

Table 4 .Threat criteria assessment

CODE	DESCRIPTION	Assessment (AVE)
K-3	ANCAMAN	
K-3.1	Politics and Law	0.25
K-3.2	Economic Factors	0.29
K-3.3	Defence and Security	0.29
K-3.4	Environmental Factors	0.18

The AHP obtained the weight value of each criterion and sub-criteria, which then in the next step carried out the score assessment of each criterion and sub-criteria.

4.2.2. Assessment Analysis Using A Likert Scale

In the assessment analysis using Likert aims to get a value for each criterion and sub-criteria which is then used as a factor determining the value of the capability level with the result of multiplying the AHP weight with the Likert score. This assessment uses a questionnaire instrument distributed to expert personnel with a rating scale of 1-5 with the results of the score weight assessment presented in the following tables 5-7:

Table 5. Scoring of submarine capability criteria.

CODE	QUESTIONNAIRE ASPECT	AVE
K-1.1	Diving Capability	2.286
K-1.2	Stealth Capability	3.429
K-1.3	Attack and Defence Capabilities	3.286
K-1.4	Interception Capabilities	2.714
K-1.5	Secret Operations Capabilities	2.571

Table 6. Deterrence Effect Criteria score assessment.

CODE	QUESTIONNAIRE ASPECT	AVE

CODE	QUESTIONNAIRE ASPECT	AVE
K-2.1	*Military Capability*	2.714
K-2.2	*Nuclear Deterrence*	2.286
K-2.3	*Credible Leadership*	2.714
K-2.4	*Alliances and Coalitions*	2.429

Table 7.Threat criteria score assessment

CODE	QUESTIONNAIRE ASPECT	AVE
K-3.1	Politics and Law	2.571
K-3.2	Economic Factors	2.286
K-3.3	Defence and Security	2.429
K-3.4	Environmental Factors	2.286

4.2.3. AHP-Likert processing

Table 8. Submarine capability score-weighting assessment

CODE	DESKRIPTION	Assess. (AVE)	Score	Assess. * Score
K-1	**Submarine Capabilities**			
K-1.1	Diving Capability	0.22	2.29	51%
K-1.2	Stealth Capability	0.23	3.43	80%
K-1.3	Attack and Defence Capabilities	0.21	3.29	69%
K-1.4	Interception Capabilities	0.18	2.71	48%
K-1.5	Secret Operations Capabilities	0.15	2.57	40%

Table 9. Deterrence effect assessment score-weighting

CODE	DESKRIPTION	Assess.(AVE)	Score	Assess. * score
K-2	**DETERRENCE EFFECT**			
K-2.1	Military Capability	0.29	2.71	79%
K-2.2	Nuclear Deterrence	0.27	2.29	62%
K-2.3	Credible Leadership	0.26	2.71	70%
K-2.4	Alliances and Coalitions	0.18	2.43	45%

Table 10. Threat weight-score assessment

CODE	DESKRIPSI	Assess. (AVE)	Score	Assess * Score
K-3	THREATS			
K-3.1	Politics and Law	0.25	2.57	64%
K-3.2	Economic Factors	0.29	2.29	66%
K-3.3	Defence and Security	0.29	2.57	74%
K-3.4	Environmental Factors	0.18	2.29	40%

4.3. Dynamic system analysis and simulation

The next step is to create a causal loop diagram with a stock-flow diagram modelling with a dynamic system using Stella software. A causal loop diagram illustrating the systemic relationship between submarine capability, threat and deterrence effect of submarines in ALKI II is depicted in Figure 7 below:

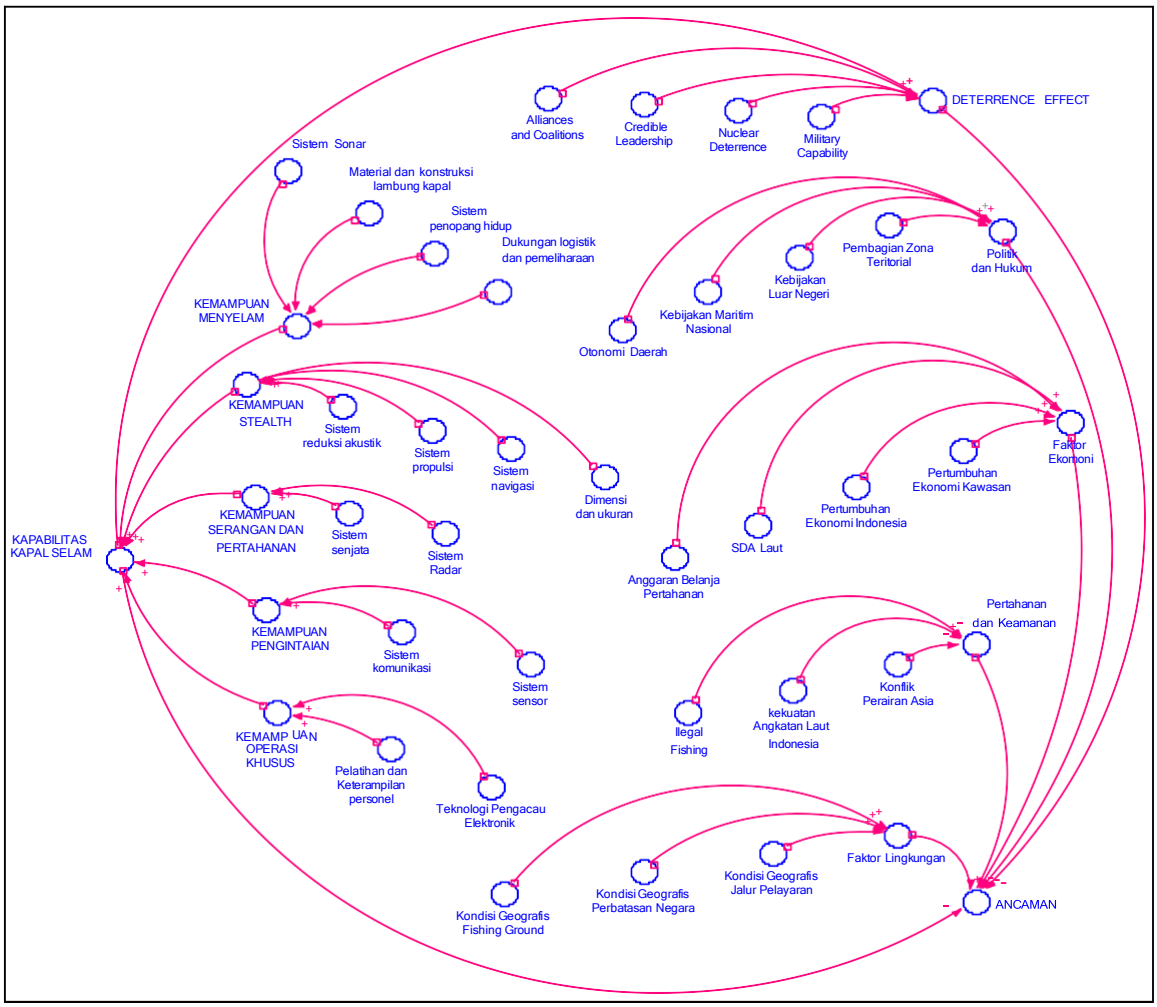

Fig. 6 . Causal Loop Diagram Of Submarine Capability Assessment

4.3.1. Verification and Validity Test of System Dynamics Model

In the dynamic system model, verification and validation of the submarine capability assessment model in providing deterrence effects in the ALKI II region are carried out, to find out the factors/criteria and sub-criteria that have a relationship to the verification of this model to check whether there are errors in the model and ensure that the model functions according to the logic of the observed system. In addition, verification is done by checking the formulations (equations), models and checking the units of the model variables. If of course there is no error in the model, then it can be said that the model has been verified. In this research, verification was carried out using Stella software and the results obtained were that all model formulations (equations) and units (units) of model variables were consistent as shown in Figure 8.

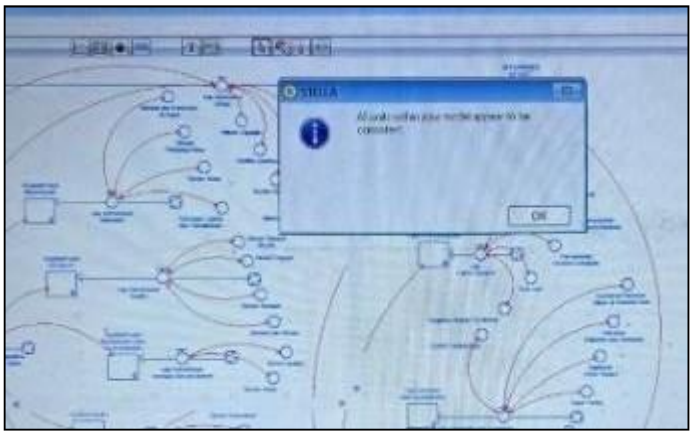

Fig. 7.. Dynamic System Model Verification

The next step after the model verification test is to test the validity of the dynamic system model simulation by distributing questionnaires to 3 experts with doctoral qualifications with the results of the simulation model being declared valid.

The next step is to simulate the CLD model to the following stock flow diagram:

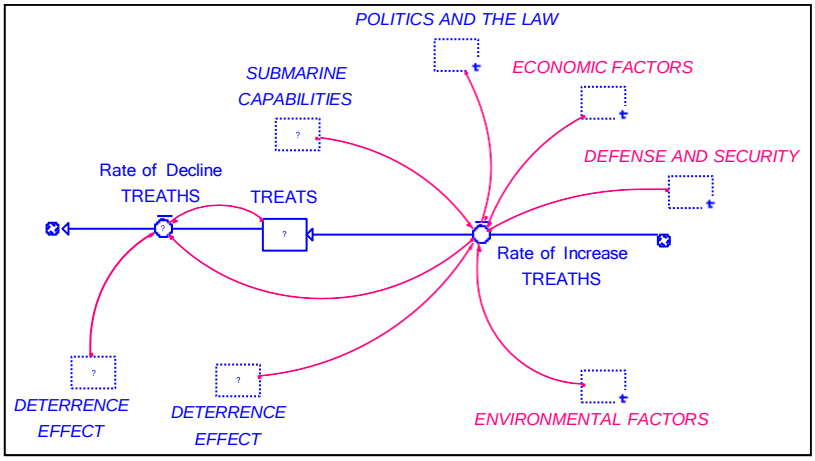

Fig. 8. stock flow diagram of submarine capability assessment

Table 4.12 Simulation of the Dynamic System of Submarine Capability Assessment in the Next 10 Years.

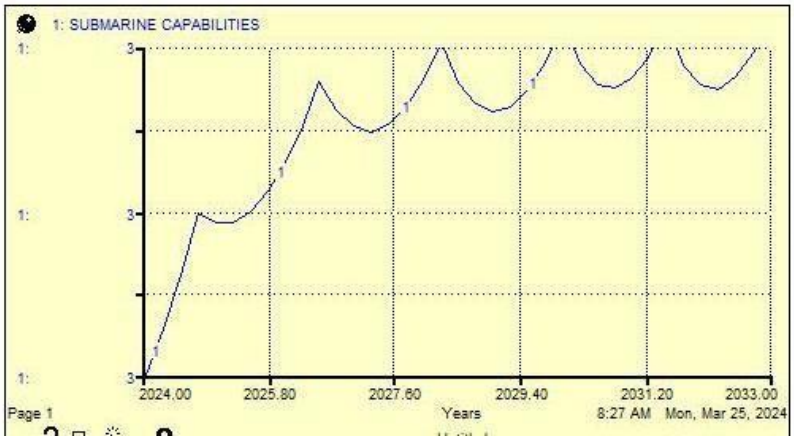

Fig. 9. Simulation Graph of Dynamic System of Submarine Capability Assessment in the Next 10 Years Period.

Table 4.13. Dynamic System Simulation Of Submarine Capability Assessment.

8:27 AM 3/25/2024 Table 1 (PENILAIAN KAPABILITAS)

Years	SUBMARINE	DETERRENC	THREATS			
2024.00	2.86	2.54	2.57			
2024.25	2.90	2.68	2.80			
2024.50	2.96	2.79	3.04			
2024.75	3.02	2.89	3.26			
2025.00	3.01	3.02	3.48			
2025.25	3.01	3.13	3.71			
2025.50	3.02	3.27	3.94			
2025.75	3.04	3.40	4.18			
2026.00	3.07	3.52	4.42			
2026.25	3.10	3.65	4.66			
2026.50	3.15	3.76	4.90			
2026.75	3.12	3.87	5.14			
2027.00	3.10	3.99	5.39			

5. Conclusions and recommendations

5.1. Conclusion

As a result of the analysis and series of data processing, scenario modelling and research results, the following conclusions can be drawn:

a. The assessment of current submarine capability in providing deterrence effect in the ALKI II region at level IV (High).

b. Submarine capability value at the time of this study (first trimester 2024). Will last until the next 8-year period (2033).

c. The assessment of submarine capability for deterrence effect in the ALKI II region will decrease in the next 9 years (2033) and will lower the capability level.5.

5.2. Recommendation.

After researchers conducted research on Submarine Capability Assessment in Efforts to Increase Deterrence Effect in the ALKI II Region, there are several suggestions and input in order to improve this research:

a. This research only discusses the assessment of submarine capabilities in the ALKI II area so that in the future it is necessary to develop the range of assessments throughout the archipelagic waters of the Republic of Indonesia.

b. The use of capability assessment instruments can be applied to other military organisations (Army and Air Force), because they have similarities in threat and deterrence effect variables/criteria.

5.3. Research limitations

This research presents a submarine capability assessment instrument in the ALKI II region while the sea sovereignty area is divided into ALKI I, II and III a,b so that this instrument still has assessment limitations and it is hoped that the next research can present assessment variables with a wider range so as to be able to provide input and suggestions for submarine development policies in creating deterrence effet in the Indonesian sea sovereignty area.

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Indonesian Naval Technology College
Postgraduate International Conference, Vol. 8, No. 1, pp.25-34
June, 27th 2024

APPLICATION OF ANALYTIC NETWORK PROCESS (ANP) METHOD BASED ON ESTABLISHED CRITERIA IN THE SELECTION OF THE LOCATION OF MAKO LANTAMAL VI

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ABSTRACT

This study discusses the degradation condition of the Makassar VI Naval Base which has experienced a decline in its function as an operational support center for the Indonesian Navy. So that it has an impact on the optimality of the implementation of base duties. Through the application of the Analytic Network Process (ANP) method, this study aims to determine the best alternative in choosing the location of Mako Lantamal VI. The alternative involves Lanal Mamuju, Lanal Kendari, Lanal Baubau, and Lanal Palu which are work units under Lantamal VI Makassar which are located in the Sea Route of the Islands II (ALKI II). Criteria and subcriteria in determining the best alternative include, geography, resources, and socio-cultural aspects. As a result, this research is expected to be a strategic foundation in preparing a plan for projecting the strength of the Indonesian Navy in the future. Where is the urgency in this research, so that the function of the base according to its principles can still be carried out. This study intends to select the location of Mako Lantamal VI due to the degradation of the base function which results in the main functions and tasks of the base being constrained, The solution of this study will use the Analytical Network Process (ANP) method where the results of data processing are obtained by the weight of geography criteria (0.47433), socio-cultural (0.13536), and resource criteria (0.237890).

Keywords : *Decision making, Multi Citeria Decision Making (MCDM), ANP-MOORA Naval Base.*

1. INTRODUCTION

The Main Base of the Indonesian Navy VI Makassar in carrying out its duties to support the operations of the Indonesian Navy is currently experiencing a decline in its basic function, this condition occurs, especially related to the impact of the Makassar New Port (MNP) development reclamation project (Kamaruddin et al., 2020). Although Lantamal VI has an important responsibility in providing administrative and logistical support, its condition is not optimal due to various factors such as budget limitations, inadequate pier facilities, and lack of human resources. The impact of economic growth and the MNP project also includes changes in the morphology of the surrounding region (ACHSAN, 2015), resulting in problems such as limited ship maneuvering space and acceleration of siltation in the Lantamal VI pier pool (Kamaruddin et al., 2020).

The plan to build the TNI Navy's strength in the future has a significant impact on the Lantamal VI berth facilities, especially related to the lego anchor area. In addition, the dense population settlement around Lantamal VI is also a factor that affects the existence and development of the base (Musbawati et al., 2022). The importance of maintaining the function of the Naval Base as a point for resupplying the KRI, safeguarding the stability of state integration, and deterring threats from other countries through the sea and coast (Mardhani et al., 2020). To determine alternative locations that consider potential vulnerabilities in the region, the *Anlitic Network Proces* (ANP) (Hondro, 2018).

The urgency in this study is to continue to maintain the role and function of the Base according to its basic function as a place for the development of sea power to the area of operation or *"deployment forces position"* will have an important meaning in supporting the operational tasks of the Indonesian Navy as a security operation unit at sea (Suharyo, 2017). In addition, the base as *"Home Base"* has functional criteria in accordance with the 5 R's, namely: *Rest, Refresh, Refuel,*

Repair and Replenishment, In addition, the role of the Base as a waiting point and a place for the development of forces to the sea is very much needed, besides that Lantamal VI is located in the Indonesian Archipelago Sea (ALKI) II channel including the Sulawesi Sea, Makassar Strait, Lombok Strait, and Flores Sea, which connects shipping routes, international trade from Africa to Southeast Asia and Japan, and from Australia to Singapore, China, and Japan, so it is highly expected that the existence and function of the Base will be optimal. (Suharjo & Suharyo, 2019).

Where the results are, this study aims to provide strategic input in compiling the projection of the strength of the Indonesian Navy in the future by considering the impact of environmental conditions, and changes in the use of the defensive area around Lantamal VI. This method ANP is used to be able to solve the problem of decision-making in determining the location of Mako Lantamal VI (Singh, 2017) in maintaining the function and strategic role of the TNI Navy Main Base (Puspitasari & Pradoto, 2013).

2. MATERIAL AND METHOD

2.1. Multi Citeria Decision Making (MCDM)

In daily life, humans are often faced with various problems and challenges. One of the challenges that is commonly faced is how to make the right decision in the midst of many options (alternatives) and criteria (attributes) that must be considered (Muanley et al., 2022). Humans are always looking for the best way or solution to solve this problem, and as a result, various methods and solutions have been developed. One of the methods that is often used to overcome this decision-making challenge is the Decision-Making Method with Multiple Criteria *(Multiple Criteria Decision Making* - MCDM) (Purnomo et al., 2020). This method helps humans to detail and understand in various factors that need to be considered when facing complex decisions. With MCDM, we can conduct a better and more informed analysis to choose the alternative that best suits our goals and needs (Ardielli, 2020).

2.2. Method *Analytic Network Process* (ANP)

Analytic Network Process Method (ANP) is a development of the *Analytical Hierarchy Process* (AHP) (Tuzkaya et al., 2008). The ANP method is able to correct structural differences in AHP in the form of the ability to accommodate the relationship between criteria or alternatives. There are two types of linkages in the ANP method, namely linkages in a set of elements (*inner dependence*) and the interconnection between different elements (*outerdependence*) (Pane & Erwansyah, 2020). The basic principle of the *Analytic Network Process* (ANP) is to think analytically, in order to make a decision in a methodology *Analytic Network Process* (ANP) based on the following principles:

a. Preparation of network structure

Network preparation is a step to define complex problems into clusters and their elements, as well as identify the relationships of interaction and dependency that exist in them. This structure is prepared based on the views of parties who have expertise and knowledge in the relevant field.

b. Prioritization

Prioritization consists of criteria elements that can be seen as the weight or contribution of these elements to the decision-making objectives. ANP conducts element priority analysis using the paired comparison method between two elements. This priority is determined based on the views of experts and interested parties on the decision, either directly (interview) or indirectly (questionnaire).

c. Logical Consistency

The consistency of the respondents' answers in determining the priority of the elements is a basic principle that will determine the validity of the data and the results of decision-making. In general, respondents should have consistency in the comparison of elements.

The *Analytic Network Process* (ANP) method in the decision-making process has stages or steps in making ANP. The following are the steps to make an ANP according to Saaty (1999):

a. Step One: Model construction and problem structuring. The construction of the model is made based on the existing problem, so it is necessary to clearly describe the problem, and form it into a network.

b. Step Two: A paired comparison matrix showing the linkages. The pairwise comparison of ANP was carried out by comparing the level of importance of each element to its control criteria. The scale used for comparison according to Saaty (1999) with the assessment as shown in Table 2.1.

c. Step Three: Calculate the weight of the element (Eigenvector Value). After the paired comparison matrix is carried out, the eigenvalue of the matrix is then determined. The eigenvector calculation is by summing the values of each column from the matrix then dividing each column cell value by the total column and summing the values from each row and dividing by n. The eigenvector value is calculated by equation 1.

$$Xi = \frac{\sum_{j=1}^{n} \left(\frac{Wij}{\sum w j}\right)}{n} \quad \text{.....} \quad (1)$$

Information:

X : eigenvector (weight) line i
i; j :line; column
Wij : value in a single line i (j = 1.2, ... n)
ΣWj : the total number of columns j (j = 1,2, ... n)
n : size of the order matrix

e. Step Four: Calculate the Consistency Ratio.After getting the eigen, then check the consistency ratio, the consistency ratio is a ratio that states whether the assessment given by the experts is consistent or not. The first step is to find the value λmax using the 2nd (two) equation.

$$\lambda max = \sum_{ij=1}^{n} (\sum \; Wj \; * \; X1) \quad \text{.....} \quad (2)$$

Information:

wj : the total number of columns j (j = 1, 2, ... n)
Xi : eigenvector (weight) line i

After obtaining the maximum lambda, then the Consistency Index (CI) of a comparison matrix is calculated by the third equation:

$$C1 = \frac{\lambda \max - n}{n-1} \quad \text{.....} \quad (3)$$

The consistency ratio (CR) can be obtained by comparing the value of the consistency index with the value of the random consistency index (RI) in equation 4 (four).

$$C1 \quad \underline{\quad} = \frac{CI}{RI} \quad \text{.....} \quad (4)$$

Information:

λmax : The largest eigenvalue of the paired comparison matrix n x n: The number of items being compared (matrix size)
C*I* : Consistency Index
RI: Random Index

Table 2.1 Nialai Random Index Table

N	1	2	3	4	5	6	7	8	9
RI	0	0	0,58	0.9	1,12	1,24	1,32	1,41	1,45

f. Fifth Step: Super matrix formation. A super matrix is a matrix consisting of sub-sub-matrices that are composed of a set of relationships between two levels contained in the model. There are three levels of super matrix that must be completed in the ANP model, namely:

1). Unweighted super matrix Each column in an unweighted super matrix contains one vector eigen, so in total, a single column will have more than 1 vector eigen.

2). The weighted super matrix is obtained by multiplying all vector eigens in the unweighted super matrix by the weights of their respective clusters.

3). *Limit super matrix* The limit contains global priority weights in a weighted super matrix that has converged and is stable. The value is obtained by weighted super matrix multiplied by 2k + 1, where k is a large number. Selection of the Best Alternatives.

After obtaining the value of each element in the limit matrix, the next step is to perform a calculation on the value of these elements according to the ANP model created. The alternative with the highest global priority is the best alternative.

2.3 Methodology

In the design stage of data collection and processing methods, the following activities are carried out:

a. Primary and secondary data sources

Primary Data; The data is in the form of a multi-level assessment questionnaire regarding the distribution transformer insertion program. Secondary Data; Secondary data is existing data regarding the condition of a base, customer potential, and ease of execution as a complement to data to support decision-making. Data collection of the Management Questionnaire, Determination of alternative criteria by conducting discussions with experts in the fields of Operational Staff, planning, and logistics staff at Lantamal VI Makassar through the Group Discussion Forum (FGD) followed by primary data collection. The primary data was obtained by providing a questionnaire assessment of the multi-level comparison criteria regarding decision-making in determining the prioritization of the location of transformer inserts. The expert respondents were selected based on the following qualifications: a) Are TNI Navy officers serving in Lantamal VI Makassar.

b. Carrying out duties in the Planning section, the field of logistics and engineering.

c. Employees with a working experience of more than 15 years with the rank of Lieutenant Colonel and above.

d. Experienced in Base location, distribution and maritime potential.

3. RESULT AND DISCUSSION.

3.1 Criteria Data

In this study, the ANP method is used in describing the relationship that occurs between the criteria obtained by Referring to the Decree of the Naval Base Number: Skep/1771/XII/2013 concerning the standardization of the TNI Navy Base, the base as part of the SSAT component must be able to perform its function optimally to provide the logistical support needed in the operation of other SSAT components, such as ships or KRI, aircraft, and Marines. Then collect data with questionnaires for experts/experts (Nurjanah et al., 125 C.E.). The assessment carried out is a pair comparison with a scale to describe the influence of the relationship between one criterion and the other criteria and obtain the weight value of the criterion by the ANP method to obtain the ranking value of the alternative that has been determined (Arsita et al., 2021). The existing criteria and sub-criteria that have been considered in this study are as seen in Table 1.2 (one) as follows.

Table 3.1 Criteria and subcriteria

NO	CRITERION	SUB CRITERIA	DEFINITION
1	**GEOGRAPHY**	**Cruise Flow**	Explain the condition and situation of the waters heading to a port area where it will later be used as a reference for shipping routes from ships and it is hoped that the route is a safe area from all forms of navigation hazards.
		Shipping Navigation Aids (SBNP)	It is a means and facility that can help in shipping activities in the shipping channel, either in the form of beacon signs, flare buoys or other signs that help ships to be able to carry out activities safely.
		Types of seabed	It is a state and condition that explains the type of material that exists on the seabed in a certain area.
		Coastal Morphology	A condition that explains a condition around the beach and explains the relief of the beach itself, be it a beach formation such as a sandy beach, coral or a stretch of mangroves, including there also the relief of the beach itself which concerns the steepness or slope of the beach.
		Sea Depth	A condition that describes how deep the seabed in the Gulf is an alternative choice, which is related to the ship's ability to dock.
		Landing Area	It is an area/land that can be used as a landing place for amphibious ships and amphibi camps to be used as a coastal support area in a sea operation.
		Military Training Area	It is an area/location that can be used as a military training area for both water ship training activities, submarines or marine forces.
2	**RESOURCES**	**Land availability**	Explain about a condition of the land/area available to be used as a dock and mako lanal location.
		Staples Support Facilities	The available facilities include facilities and base supports such as foodstuffs, fuel, fresh water and the existence of traditional markets and building materials or materials.
		Maritime Industry Support Facilities	It is a condition for facilities that allow the availability of support for the maritime industry, be it in the form of opportunities for dock development, the availability of ship spare parts, workshop facilities and even the availability of experts/technicians in the maritime and shipping sectors.
3	**SOCIO-CULTURE**	**Educational Facilities**	It is about something related to the condition of educational institutions, school facilities
		Health Facilities	Explaining health support facilities, both from the Puskesmas to the hospital level and explaining the ability to provide services in the health sector itself.

		Socio-Cultural Conditions	It is a community environment that reflects the local social conditions of settlements, government centers, development efforts in the near future, and the existence of locations with military institutions and the National Police
		Political Conditions	It is a location that is prone to conflict or safe, and reflects the living situation of the community and the state of the community.
		Transportation	It is a means of supporting transportation in an area, be it land, sea or air transportation facilities there.
		Means of Communication	It is a means of supporting communication both between regions and between islands, in this case it also concerns telephone networks, the internet and radio communication.

In the criteria obtained by Referring to the Decree of the Naval Base Number: Skep/1771/XII/2013 concerning the standardization of the TNI Naval Base , a weighting questionnaire was carried out using the ANP (Analytical Network Process) multiple comparison method (Rizaldi, Yunita, & Rodiah, 2020).

3.2 Weighting Criteria

The assessment of the criteria in the ANP is calculated through a double or pairwise comparison questionnaire filled out by 6 (six) experts who are currently serving as Commanders, deputy commanders of operational staff, planning staff, logistics staff, and the Head of the Lantamal VI Makassar base facilities office. As seen in Table 3.2 below.

Table 3.2 Criterion Weighting Questionnaire.

Criterion (A)	Intensity of Interest																	Criterion (B)
Geography	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Insecurity
Geography	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Social Culture
Geography	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Source power
Insecurity	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Social Culture
Insecurity	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Source power
Social Culture	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Source power

3.3 Data Processing

At this stage, to get the weighting of the ANP, a questionnaire was conducted on 6 (six) respondents. The answers from the questionnaire filled out by the respondents are then normalized with the geomaen formula a = which will be $\sqrt[n]{a1 * a2 * an}$ input in the super decision software of the ANP method. Respondents will be asked to choose a comparison of values from 1 to 9 where the

value of 1 has the same meaning and the greater the value of filling, the greater the value of importance according to the Saaty scale. As seen in figure 3.1 below.

Figure 3.1 Comparison of Alternative Clusters with Criteria using Super Decision Software

Each pairwise comparison consistency ratio value of each comparison must be less than 0.1. If the overall paired comparison on all nodes is consistent (the consistency ratio is below 0.1), then a weight will be obtained for each criterion. As shown in figure 3.2.

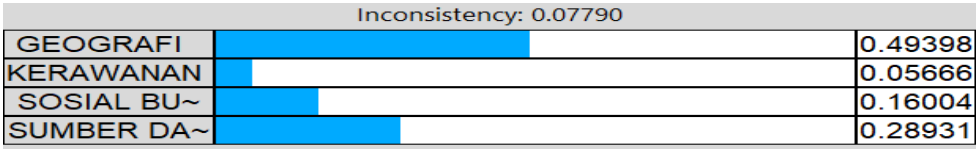

Figure 3.2 Normalized weighting results using *Super Decision*

As seen in the figure above, the inconsistency value of the paired comparison on all nodes is consistent (the consistency ratio is below 0.1) where the value is (0.07790).

3.4. Weighting Criteria

At this stage, to get the ANP weighting, a questionnaire was carried out on the calculation of the double comparison weighting in this study assisted by using the Expert Choice application by entering the questionnaire scores from 6 (six) expert respondents.

NO	CRITERION	PRIORITY WEIGHT
1	Geography	0,47433
2	Socio-Cultural	0,13536
3	Resources	0,23780
4	Cruise Flow	0,09676
5	Training District	0,03504
6	Landing Area	0,02710
7	Types of seabed	0,02325
8	Sea Depth	0,10638
9	Coastal Morphology	0,11615
10	Means of Navigation	0,69533

11	Health Facilities	0,28610
12	Educational Facilities	0,28545
13	Political Conditions	0,07841
14	Socio-Cultural Conditions	0,14147
15	Means of Communication	0,19374
16	Transportation	0,01484
17	Maritime Industry Facilities	0,14763
18	Logistics Facilities	0,34110
19	Land Availability	0,51127

3.5. Criterion Weighting Analysis with the AHP Method

In this study, a limit of 4 (four) Mako Lantamal VI location plans was given as an alternative option. The initial stage in determining location priority is to conduct an FGD (Focus Group Discussion) to determine criteria, alternatives and continue with a questionnaire to 6 (six) expert respondents in the field of Base to compare the criteria calculated with the ANP method. The results of the respondent questionnaire were found to be inconsistent below 10%, which means that it can be used for the next stage.

Based on the data from the results of the ANP Weighting Prioritization Order, it was found that the Geography criterion (0.47433) was the most dominant criterion to be considered in the selection of the location of Mako Lantamal VI, then the criteria with a weight of (0.23780) and Socio-cultural with a weight (0.13536) where all of these need to be considered in making a decision in obtaining the best solution.

3.6. Sensitivity Analysis

Sensitivity analysis was carried out in this study with the aim of ansicipating the possibility of a change in criteria that resulted in a change in the order of prioritization of alternatives, a change in the ranking of alternative priorities did not occur when a change was made in 10% and in the priority alternatives did not have a significant change in the ranking order. Changes will occur if the increase or decrease in the criteria is above 50%. Thus, it can be concluded that the results of the weight increase sensitivity analysis in the ANP method can be used as a reference.

4. CONCLUSION

From the results of data collection and processing, as well as the analysis and interpretation of data processing results from the previous chapter that has been carried out, the conclusions that can be drawn in this study are: where the results of processing using a decision-making model using the *Analytic Network Process* (ANP) method using *Super Decision Software* then the weight of the criteria is obtained, namely geography (0.47433), socio-cultural (0.13536), and resource criteria (0.237890). while the sensitivity analysis was carried out in this study with the aim of anticipating the possibility of a change in criteria that resulted in a change in the order of prioritization of alternatives, changes in the ranking of alternative priorities did not occur when a

change was made in 10% and in the priority alternatives did not have a significant change in the ranking order. Changes will occur if the increase or decrease in the criteria is above 50%. Thus, it can be concluded that the results of the weight increase sensitivity analysis in the ANP method can be used as a reference.

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Indonesian Naval Technology College
Postgraduate International Conference, Vol. 8, No. 1, pp. 35-51
June, 27th 2024

SUBMARINE OPERATIONAL RISK MANAGEMENT DESIGN IN SUPPORTING TNI AL'S DUTIES

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ABSTRACT

This research discusses risk management faced by submarines and their crews. One of the risks that can occur is that the submarine cannot surface because the steering and propulsion system is not functioning properly. With the submarine unable to surface, it will cause the ship to sit on the seabed. A submarine that experiences an emergency so that it cannot surface is called a Distressed Submarine (DISSUB). Through the FMEA method the author identifies risks and aims to prioritize different causes based on their priority. FMEA itself is a systematic method, so it can find out the root of the problem that actually occurs. By knowing how urgent the priority is, the author can focus on problems that have a big impact on ship operational risks. It is hoped that the research results can be used as recommendations for mitigating risks that occur on submarines, providing a risk management framework for submarines.

Keywords: Risk, Distressed Submarine (DISSUB). Failure Mode and Effects Analysis (FMEA)

1. INTRODUCTION

Submarines, as strategic weapon systems, are designed to operate both on and below the sea surface, facing significant risks, including the inability to surface due to malfunctioning steering and propulsion systems. When a submarine cannot surface and sits on the seabed, it is termed a Distressed Submarine (DISSUB). There are two primary rescue methods: the rescue method, relying on external rescue forces, and the escape method, which depends on the crew's knowledge and decision-making abilities. Critical factors influencing the waiting time in a DISSUB include carbon dioxide (CO2) levels, pressure, and oxygen (O2) levels (KOARMADA II Submarine Unit Standing Procedure Book, 2020).

If the escape method is chosen, two techniques are used: Rush or Compartment Escape and Tower Escape, both employing Submarine Escape Immersion Equipment (SEIE). Post-escape, the crew must survive on the surface while awaiting rescue. The development of escape capabilities, mastery of safety equipment, and rigorous training are essential for crew preparedness and submarine safety.

Geographically, Indonesia, an archipelagic country with 17,504 islands and a coastline of 108,000 km, covers a land area of 1.9 million km² and a water area of 6.4 million km². The enactment of the United Nations Convention on the Law of the Sea (UNCLOS) 1982 further defines these areas (Kasal Decree No Kep-503-V-2018, May 22, 2018, Concerning Indonesian Navy Submarines, No. 302, 2018).

Indonesia's strategic maritime territory stretches between the Asian and Australian continents and lies between the Indian and Pacific Oceans, making it a key international shipping route (Wiranto, 2020). This positioning provides significant benefits and poses sovereignty threats. Indonesia's waters vary from shallow seas to depths of thousands of meters, encompassing seas, straits, and bays with diverse seabeds like mud,

sand, rocks, and coral.

The territorial waters include deep regions like the Banda Sea, Flores Sea, Makassar Strait, Maluku Sea, and parts of the Arafuru Sea, and shallow regions such as the Java Sea, Karimata Strait, and Sunda Strait. Indonesia's maritime defense must cover internal waters, archipelagic waters, and outer jurisdictions, requiring robust naval power and comprehensive sea power to control international trade and marine resources, implement sea control, sea denial, blockades, and power projection.

Indonesia's marine area is divided into five zones: littoral, epineritic, neritic, batial (200-2,000 meters deep), and abisal (over 2,000 meters deep) (Marsetio, 2015). Effective maritime defense strategy, supported by reliable sea and air power, is crucial for Indonesia to protect its territory, control outer islands, landing beaches, strategic sea funnels, and airspace, thereby ensuring national security.

Figure 1.1.
Indonesian Archipelago Sea Lanes
Source: www.ruangguru.com (2023)

The TNI AL's capabilities can be realized through planning and building within the framework of an Integrated Fleet Weapons System (SSAT). Submarines, as part of the SSAT component, have reconnaissance and infiltration capabilities with low detection levels by opponents, as well as ambush and high destructive power, providing the necessary deterrence effect. To maximize this effect and uphold sovereignty, it is essential to develop submarine strength and deployment patterns supported by advanced infrastructure and base facilities tailored to the Submarine Operating Area (SOA) (Defense White Paper, Indonesian Ministry of Defense, Jakarta, 2015). This aligns with the Indonesian National Army (TNI) Commander's Regulation No. 26/V/2008, which emphasizes national defense at sea as part of the Archipelago Maritime Defense Strategy (SPLN). This strategy ensures the sovereignty and law enforcement within Indonesia's national jurisdiction through sea control and various maritime operations (TNI Commander Regulation No. 26/V/2008).

The Indonesian Navy relies on the SSAT, consisting of Ships, Aircraft, Marines, and Bases, to conduct maritime operations. Submarines play a vital role, with the current fleet including the Cakra class and the Nagapasa class. The Cakra class, specifically Cakra-401, was built in Germany in 1980, while the Nagapasa class includes three units made in South Korea as part of a technology transfer cooperation. Both classes are

based on the German Type 209 submarine design, ensuring similar capabilities and dimensions. Type 209 submarines, diesel-electric models from HDW Germany, have been in service since 1971, with 61 units operated by 13 countries. Their mission has evolved from traditional blue water operations to littoral operations, reflecting the changing strategic environment post-Cold War.

The Cakra class features a length of 59.9m, a surface displacement of 1300 tons, and a diving capability up to 300m, with an endurance of 53 days. The Nagapasa class is slightly larger, with a length of 61.3m, a surface displacement of 1442 tons, and similar endurance. The Nanggala-402, another Type 209 submarine, tragically sank on April 21, 2021, in Bali waters, highlighting the risks associated with submarine operations. This incident underscores the importance of risk management in submarine operations to prevent such losses.

Operational risks, divided into financial and operational risks, must be managed. Financial risks involve economic factors, while operational risks stem from human error, natural, and technological factors. Submarines face emergencies due to various causes, such as loss of propulsion, steering gear malfunction, and fire hazards. Understanding these risks and implementing preventive measures are crucial for maintaining buoyancy and operational stability (Kountur, 2004). The stability of a submarine relies on the center of gravity, center of buoyancy, and metacenter. Factors like loss of propulsion, steering gear issues, and fire hazards can compromise stability. Effective risk management involves addressing these factors to ensure submarine safety and operational readiness.

Figure 1.2 Causes of Fire

Solid fuel, when exposed to sufficient heat, produces vapors that are easily ignitable. The position of the solid fuel affects the combustion rate. Liquid fuel vaporizes when heated, producing flammable gas. It has a fire point, flash point, and auto-ignition temperature. The fire point is the minimum temperature at which fuel vapors ignite and burn for at least five seconds when exposed to an external source. The flash point is the minimum temperature at which fuel vapors continuously ignite with an external source. The auto-ignition temperature is the minimum temperature at which the fuel ignites spontaneously in normal atmospheric conditions without an external source. When liquid fuel absorbs heat, it reaches the flash point and burns continuously if an external flame is present. At the auto-ignition temperature, the fuel ignites on its own.

Gas fuels are the most dangerous due to their natural ignitability. Submarine air contains various substances (oxygen, hydrogen, carbon, arsenic, water particles, etc.). Oxygen concentration is about 21%, but only 16% is needed to start a fire. Heat is energy transferred due to a temperature difference, while temperature

measures how hot or cold something is. Common heat sources on a ship include open flames and electrical currents.

Fire classification by the National Fire Protection Association (NFPA) in America helps determine effective firefighting methods and safety levels based on the fire's source. Leakage in submarines can increase weight, reduce buoyancy, and risk sinking. Quick actions are essential to maintain buoyancy, such as using high-pressure air systems. Toxic gas poisoning, especially from lead-acid batteries in diesel-electric submarines, is a critical concern. These batteries contain sulfuric acid, producing flammable hydrogen gas during charging. Submarine operations include various roles and activities like warming up systems, preparing for sailing and combat, conducting watertight tests, steering trials, navigating underwater, responding to alarms, and surfacing.

Operational risk management is essential for achieving organizational objectives, identifying potential obstacles, and ensuring successful assignments. It involves recognizing losses from operational failures, internal factors, personnel errors, system failures, external events, and violations (Kaho, 2018). Effective operational risk management ensures the achievement of objectives, job security, and minimizes losses. The risk management process includes risk identification, analysis, evaluation, handling, monitoring, and review. Risk identification uses brainstorming, analysis with a risk matrix, evaluation with Failure Mode and Effect Analysis (FMEA), and risk treatment through manual recommendations. The House of Risk (HOR) method, developed by Pujawan and Geraldin in 2011, is relevant for designing submarine risk management. HOR combines FMEA and the House of Quality (HOQ) methods to prioritize risk triggers and select effective actions. HOR's two stages are risk identification, which develops HOQ based on Indonesia's maritime needs, and risk treatment, which uses FMEA to reduce risk events.

The risk identification step involves identifying, measuring, and prioritizing risk events and triggers, calculating their correlation. The risk handling step selects high-priority risk agents and formulates actions based on preventive action relationships. The final stage designs preventive activities for risk mitigation. Based on the explanation above, it is necessary to design operational risk management for submarines to support the duties of the Indonesian Navy. Therefore, the author will conduct research with the title "Submarine Operational Risk Management Design in Supporting the Tasks of the Indonesian Navy". The objectives of this research are to identify operational risks on submarines in supporting the Indonesian Navy's missions, assess and evaluate risk events on submarines in supporting the Indonesian Navy's missions, and determine risk mitigation or management strategies to support the Indonesian Navy's missions.

2. MATERIAL AND METHOD

2.1. Understanding Risk

Risk is defined as "the adverse impact on probability of several distinct sources of uncertainty". Risk is defined as uncertainty caused by change. Risk is a deviation from something that is expected (Joel Bessis, 2010).

2.2. Operational Risk

Chrouhy, Galai and Mark (2001) define operational risk as the risk of operating a business. This risk is divided into two components, namely operational failure risk and operational strategic risk. Operational failure risk arises from potential failures in people, processes or technology in business units that can cause losses to

the company. Operational strategic risk arises from environmental factors such as the presence of new competitors. Marshall (1964) stated that operational risks are all possibilities that cause disruption to the company's operational processes. Operational risks can arise due to errors or negligence in all operational activities within the company and lack of accuracy or lack of control of the employees involved.

2.3. Risk management

Risk management is defined as directed and coordinated organizational activities related to the risks that exist in the organization. Risk management has several components consisting of principles, frameworks and processes. These components are inseparable from one another and inherent in an organization. Principles are the main reference that guides the implementation of risk management in all areas of the organization. The framework is the foundation and organization of the organization. Meanwhile, the risk management process is a series of risk management activities that handle risks one by one and in groups according to the type of target affected. Thus, the risk management process is the core of overall risk management (Kaho, 2018).

2.4. Risk management

Risk management or risk mitigation requires planning and consideration of various alternative solutions in order to obtain effective and efficient mitigation results.

2.5. Monitoring and Review

Monitoring and review are carried out on all risk management activities including the context (organization, strategy, stakeholders, environment, processes, etc.). Monitoring results records are then stored as reports that the activities have been implemented and as input for the existing Risk Management Framework.

2.6. Failure Mode and Effects Analysis (FMEA)

FMEA is a method for identifying the risk of failure and carrying out calculations to obtain the Risk Priority Number (RPN) as the main factor for the risk of failure. The aim is to identify risks of failure that have undesirable impacts by identifying each form of failure from a sequence of events related to the risk. How it works is by identifying problems and collecting data in the field, calculating the scale of each Severity, Occurrence, Detection table to get the highest RPN value. Activities that have the highest RPN values are the main failure risks that must be provided with solutions to reduce the possibility of risks arising during the work process. FMEA can be used in various fields, from systems, product design, work processes, etc. (Idham & Fahmi, 2014).

2.7. Main Duties of the Indonesian Navy

Internal reform within the TNI, namely to reorganize the TNI according to its new paradigm, is consistently outlined in TNI Law No. 34 and was enacted in 2004. This law regulates all duties, functions and roles of the TNI in the future, including the TNI AL. The TNI AL is an integral part of the TNI which participates in determining the success of Defense and Security efforts, and in itself cannot be separated from the demand for a Defense and Security system that is able to ward off and overcome all threats, especially the threat of maritime terrorism with the available national strength and potential. It is clearly written that the TNI AL, as one of the main components of the TNI, has the main task of supporting Indonesia's foreign policy as a political decision as outlined in the law.

2.8. Submarine

A submarine is a ship that moves under the surface of the water, generally used for military purposes

and purposes. Apart from being used for military purposes, submarines are also used for marine and freshwater science and for work at depths unsuitable for human divers. In supporting these maritime operations, the Indonesian Navy has prepared various forms of administration and logistics systems. One of the equipment owned by the Indonesian Navy is a submarine, which is a ship that moves below the surface of the water, generally used for military purposes and purposes. Apart from being used for military purposes, submarines are also used for marine and freshwater science and for work at depths unsuitable for human divers.

3. RESULTS AND DISCUSSION

The history of the Navy began with the formation of the People's Security Agency (BKR) at the PPKI session on 22 August 1945. The BKR then developed into several divisions, where the Marine BKR, one of the initial divisions, covered maritime/ocean areas. The formation of the Maritime People's Security Agency (BKR Laut) on 10 September 1945 by Soekarno's initial cabinet administration became an important milestone for the presence of the Navy in the Unitary State of the Republic of Indonesia which was proclaimed on 17 August 1945. The formation of the BKR Laut was spearheaded by veteran maritime figures who had served in the Koninklijke Marine ranks during the Dutch colonial period and was a Kaigun veteran during the Japanese occupation. Another factor that encouraged the formation of this agency was the potential to carry out Navy functions such as ships and bases, even though at that time the Indonesian Armed Forces had not yet been formed. The formation of the Indonesian military organization known as the People's Security Army (TKR) also spurred the existence of the Marine TKR, which was later better known as the Republic of Indonesia Navy (ALRI), with all the strength and capabilities it possessed.

3.1 Submarine Operational Risk Analysis using the FMEA Method

This FMEA method is carried out to analyze submarine operational risk planning and identify the causes and impacts that occur on each risk of submarine operational readiness. This FMEA method prioritizes completion based on level Severity (Impact), Occurance (Frequency of Events), and Detection (Detection Capability). Thus, the results allow controlling each basic cause of the failure.

When distributing the risk assessment questionnaire which was filled in by several respondents, the researcher included a risk assessment scale to assist respondents in assessing the risk in each variable of submarine operational readiness, namely: (1) Ship Losing Bouyancy, (2) Fire, (3) Leak, and (4) Noxious Gas Poisoning.

3.2 Analyzing Levels Severity (Impact)

Level Severity (Impact) aims to understand the impact of each risk that arises in submarine operations to support the duties of the Indonesian Navy. Severity This is evaluated based on the impact caused by each risk assessment in each submarine operational readiness variable, namely: (1) Ship Losing Bouyancy, (2) Fire, (3) Leak, and (4) Toxic Gas Poisoning. In the previous chapter, a severity scale from 1 to 10 was explained. However, to make it easier for respondents to fill out the questionnaire, in this chapter a scale is used. severity, as follows :

Table 1 Scale Severity

Skor Severity	1	2 - 3	4 - 5	6 – 7	8 - 9	10
Description	Very low	Low	Currentl y	Heigh t	Very high	Extreme

Source: Data scores processed by the Author (2024)

Score Severity from the results of the assessment of 7 experts on each risk variable for submarine operational readiness, namely: (1) Ship Losing Bouyancy, (2) Fire, (3) Leaks, and (4) Toxic Gas Poisoning, can be seen in Table 4.4, as follows :

Table 2 Severity Score on Research Operational Risk Variables

Operational Risk	Sub Causes	Severity (S)	Information
Ship Loses Bouyancy	Thrust Stopped	7.80	Very high
	Steering Jammed	8.00	Very high
	Density of Sea Water	8.40	Very high
	Internal Solitary Wave	9.00	Very high
Fire	Class A fire	5.40	Currently
	Class B fire	4.70	Currently
	Class C fire	4.80	Currently
	Class D fire	4.40	Currently
	Class E fire	4.30	Currently
	Class K fire	4.50	Currently
Leakage	Water Pipe & Valve Systems	3.70	Currently
	Sea Water System Pump House	4.20	Currently
Toxic Gas Poisoning	Hydrogen	5.30	Currently
	Lead Acid Battery	6.00	Height

Source: Appendix 2 Expert Data Tabulation (2024)

Table 2 shows that the highest severity score is 9.00 for the operational risk of ship loss bouyancy sub cause internal solitary wave in the very high category, meaning that Loss of buoyancy on the submarine due to Internal Solitary Wave is an operational risk with a very high level of severity. Buoyancy is the ability of a submarine to float and control its depth in the water. Lost buoyancy occurs when a submarine cannot maintain a balance between the weight of the ship and the volume of water it displaces. ISW can cause sudden changes in the pressure distribution and water currents around the submarine, which can disrupt this balance. Here are some potential scenarios: (1) Sudden Depth Change: ISW can cause the submarine to move vertically without control from the crew. This could result in the submarine descending to dangerous depths or rising too quickly to the surface, risking structural damage or dangerous decompression for the crew; (2) Navigation System Disturbance: Strong currents and pressure fluctuations caused by ISW can disrupt a submarine's navigation and control systems. Hydraulic systems, sonar, and other navigation instruments may not function properly, increasing the risk of accidents; and (3) Structural Damage: Uneven water pressure can place excessive loads on the submarine's structure, causing cracks or damage to the hull. This is especially dangerous at greater depths where the water pressure is very high.

In risk assessment using FMEA, the severity level (Severity) describes the potential impact of failure on operations and safety. In the case of loss of buoyancy due to ISW, the severity level can be considered very high for the following reasons: (1) Personnel Safety: Sudden loss of buoyancy can result in an emergency situation that endangers the lives of the crew. The potential for sudden decompression, violent impact with the seabed, or even drowning, places this risk at the highest level of severity; (2) Material Loss: Damage to a submarine can be very expensive and take a long time to repair. This includes damage to the hull, navigation systems, and other equipment vital to submarine operations; (3) Mission Failure: Loss of buoyancy can disrupt or even derail the mission in progress. In military situations, this can mean loss of strategic initiative, failure to

gather important intelligence, or inability to provide necessary support; and (4) Strategic Impact: Loss or damage to a submarine has broad strategic implications, including damage to naval power and diplomatic influence. This could also weaken the national defense and security position.

Therefore, it can be said that the impact on personnel safety, material losses, mission success and strategic position is very significant. So a comprehensive and proactive approach is needed to manage this risk. By implementing advanced detection technology, intensively training crews, improving navigation systems, implementing strict operational protocols, and collaborating with international institutions, the Indonesian Navy can increase the operational readiness of submarines and ensure effective support for its strategic tasks.

3.3 Analyzing Levels Occurance (Frequency of Occurrence)

The frequency of events aims to determine how often failures occur in each operational risk faced by the submarine. This frequency level is based on each risk assessment variable for submarine operational readiness, namely: (1) Ship Loss Buoyancy, (2) Fire, (3) Leak, and (4) Toxic Gas Poisoning. In the previous chapter, a frequency scale from 1 to 10 was explained. However, in this chapter a scale is used Occurance in Table 4.5 to make it easier for respondents to fill out the questionnaire. The following are the frequency scale (occurrence) criteria for each risk of submarine operational incidents.

Table 3 Skala Occurance

Skor Occurrence	1	2 - 3	4 - 5	6 - 7	8 - 9	10
Description	Very rarely	Seldom	Currently	Often	Very often	Almost Sure

Source: Data scores processed by the Author (2024)

Score Occurance from the results of the assessment of 7 experts on each risk variable for submarine operational readiness, namely: (1) Ship Losing Bouyancy, (2) Fire, (3) Leaks, and (4) Toxic Gas Poisoning, can be seen in Table 4.6, as follows :

Table 4 Score Occurance on Research Operational Risk Variables

Operational Risk	Sub Causes	Occurance (O)	Information
Ship Loses Bouyancy	Thrust Stopped	3.70	Currently
	Steering Jammed	3.70	Currently
	Density of Sea Water	3.70	Currently
	Internal Solitary Wave	4.00	Currently
Fire	Class A fire	3.60	Currently
	Class B fire	3.60	Currently
	Class C fire	3.70	Currently
	Class D fire	3.50	Often
	Class E fire	3.40	Seldom
	Class K fire	2.70	Seldom
Leakage	Water Pipe & Valve Systems	3.60	Currently
	Sea Water System Pump House	3.40	netting
Toxic Gas Poisoning	Hydrogen	3.80	Currently
	Lead Acid Battery	3.20	Seldom

Source: Appendix 2 Expert Data Tabulation (2024)

Table 4 shows that score Occurance The highest is 4.00 on the operational risk of ship loss bouyancy sub cause internal solitary wave in the Medium category, meaning an occurrence score of 4.00 for the risk of

loss of buoyancy due to internal solitary waves shows that even though this event is in the moderate category, the impact can be very dangerous and requires serious attention. In the FMEA analysis, this means that submarine operations must always be prepared to encounter ISW through constant monitoring, intensive training, and the implementation of advanced detection technology. In this way, the Indonesian Navy can minimize risks and ensure mission success and the safety of submarine crews.

3.4 Analyzing Levels Detection (Detection)

The level of ability to detect submarine operational risks aims to assess how well operational risks can be detected through various submarine operational readiness risk variables, namely: (1) Ship Losing Buoyancy, (2) Fire, (3) Leaks, and (4) Gas Poisoning Poisonous. In the previous chapter, the detection scale from 1 to 10 was explained. However, in this chapter a scale is used detection in Table 4.7 to make it easier for respondents to fill out the questionnaire. The following are the criteria for the detection ability scale (Detection) from any risk of submarine operational incidents.

Table 5 Scale Detection

Score Detection	1	2 - 3	4 - 5	6 - 7	8 - 9	10
Description	Very easy	Easy	Currentl y	Diffi cult	Very difficult	Almost impossible

Source: Data scores processed by the Author (2024)

Score Detection from the results of the assessment of 7 experts on each risk variable for submarine operational readiness, namely: (1) Ship Losing Bouyancy, (2) Fire, (3) Leaks, and (4) Toxic Gas Poisoning, can be seen in Table 4.8, as follows :

Table 6 Score Detection on Research Operational Risk Variables

Operational Risk	Sub Causes	Detection (D)	Information
Ship Loses Bouyancy	Thrust Stopped	3.80	Currently
	Steering Jammed	3.80	Currently
	Density of Sea Water	4.10	Currently
	Internal Solitary Wave	4.20	Currently
Fire	Class A fire	3.60	Currently
	Class B fire	3.40	Easy
	Class C fire	3.60	Currently
	Class D fire	3.30	Easy
	Class E fire	3.30	Easy
	Class K fire	3.00	Easy
Leakage	Water Pipe & Valve Systems	3.80	Currently
	Sea Water System Pump House	3.60	Currently
Toxic Gas Poisoning	Hydrogen	3.90	Currently
	Lead Acid Battery	3.90	Currently

Source: Appendix 2 Expert Data Tabulation (2024)

Table 7 shows that score Detection The highest is 4.00 on the operational risk of ship loss bouyancy sub cause internal solitary wave in the ability category detection moderate, meaning a detection score of 4.00 on the risk of buoyancy loss due to internal solitary waves indicates that even though there are detection systems and procedures, the detection capability is still at a moderate level and requires improvement, in other words that the ability to detect ISW is still at a moderate level . This means that although there are some detection systems available, they may not be effective enough to always provide the necessary early warning.

Linking this to the Standard Operational Procedures for Implementing Emergency Management for Nagapasa Class Submarines, it is important to improve detection technology, strengthen crew training and readiness, and revise SOPs to be more effective. With these steps, the Indonesian Navy can improve its risk detection and mitigation capabilities, thereby ensuring safer and more efficient submarine operations.

3.5 Analyzing RPN (Risk Priority Number) value calculations

Knowing the most critical risk level by paying attention to various risk scales can be done using the RPN (Risk Priority Number) method. The RPN value is obtained from multiplying the severity, occurrence and detection scales.

$$RPN = severity\ x\ occurance\ x\ detection$$

The most critical RPN value will be identified as the source of the cause of each risk variable: (1) Ship Loses Buoyancy, (2) Fire, (3) Leak, and (4) Poisoning by Toxic Gas. The RPN value for each risk variable can be seen in Table 4.9 to Table 4.12 as follows:

Table 8 RPN of Ship Losing Bouyancy

Operational Risk	Sub Causes	Severity (S)	Occurance (O)	Detection (D)	RPN
Lost Ship *Bouyancy*	Thrust Stopped	7.80	3.70	3.80	109.7
	Steering Jammed	8.00	3.70	3.80	112.5
	Density of Sea Water	8.40	3.70	4.10	127.4
	Internal Solitary Wave	9.00	4.00	4.20	151.2
Mean		**8.30**	**3.78**	**3.98**	**124.5**

Source: Appendix 2 Expert Data Tabulation (2024)

Based on Table 8 RPN of Lost Ship Bouyancy value can be known risk priority submarine lost buoyancy above, it is found that repair priorities must take precedence over the operational risk of losing the submarine Bouyancy is Internal Solitary Wave, this is due to the RPN value Internal Solitary Wave highest, compared to Stuck Thruster, Stuck Rudder, and Sea Water Density.

Table 9 Fire RPN

Operational Risk	Sub Causes	Severity (S)	Occurance (O)	Detection (D)	RPN
Fire	Class A fire	5.40	3.60	3.60	70.0
	Class B fire	4.70	3.60	3.40	57.5
	Class C fire	4.80	3.70	3.60	63.9
	Class D fire	4.40	3.50	3.30	50.8
	Class E fire	4.30	3.40	3.30	48.2
	Class K fire	4.50	2.70	3.00	36.5
Mean		**4.68**	**3.42**	**3.37**	**53.9**

Source: Appendix 2 Expert Data Tabulation (2024)

Based on Table 9, the RPN for Fire values can be determined risk priority above from submarine fires, it was found that the repair priority that must come first from the operational risk of submarine fires is Class A fires, this is because the RPN value for class A fires is the highest, compared to Class B fires, Class C fires, Class D fires, Class A fires. E and Class K Fires.

Table 10 RPN Leaks

Operational Risk	Sub Causes	Severity (S)	Occurance (O)	Detection (D)	RPN
Leakage	Water Pipe & Valve Systems	3.70	3.60	3.80	50.6
	Sea Water System Pump House	4.20	3.40	3.60	51.4
Mean		**3.95**	**3.50**	**3.70**	**51.2**

Source: Appendix 2 Expert Data Tabulation (2024)

Based on Table 10 RPN Leakage, the value can be determined risk priority Above, from submarine leaks, it was found that the repair priority that must come first from the operational risks of submarine leaks is the sea water system pump house, this is because the RPN value of the sea water system pump house is the highest, compared to pipe and water valve system leaks.

Table 11 RPN of Toxic Gas Poisoning

Operational Risk	Sub Causes	Severity (S)	Occurance (O)	Detection (D)	RPN
Toxic Gas Poisoning	Hydrogen	5.30	3.80	3.90	78.5
	Lead Acid Battery	6.00	3.20	3.90	74.9
Mean		**3.95**	**5.65**	**3.50**	**3.90**

Source: Appendix 2 Expert Data Tabulation (2024)

Based on Table 11 RPN for Toxic Gas Poisoning, the value can be determined risk priority Above, from toxic gas poisoning in submarines, it was found that the priority for improvement that must first be the operational risk of Toxic Gas Poisoning in Submarines is the emergence of hydrogen gas (H2) from lead-acid batteries during processing. charging, this is due to the RPN value of the emergence of hydrogen gas (H2) from the lead-acid battery during the process charging highest, compared to the emergence of toxic gases from lead acid battery electrolyte materials.

Based on value risk priority it is found that repair priorities must come first from ship operational risks as long as the four causes are ship loss. Bouyancy RPN 124.5, compared to Toxic Gas Poisoning RPN 77.1, Fire RPN 53.9 and Leak RPN 51.2. This RPN value will be connected in the FTA method (Fault Tree Analysis)

3.6 Submarine Operational Risk Analysis using the FTA Method

Based on the Failure Mode and Effect Analysis (FMEA) carried out, the highest risk of a ship losing buoyancy is due to a phenomenon internal solitary wave. This phenomenon is explained by oceanography experts as strong underwater waves that can pull objects vertically. This internal solitary wave is produced by a combination of strong tidal interactions, temperature differences between warmer and colder sea layers, and underwater geographic conditions.

Furthermore, interviews with experts have identified 14 potential underlying causes (basic event) from the risk of loss of buoyancy in submarines due to internal solitary waves. These potential causes are divided based on human factors, environment and methods. Based on interviews with experts, there are 14 potential causes which are item basic, namely:

No.	Ship Incident Loss of Buoyancy	Item Basic Event
1	**Internal Solitary Wave**	**1. Lack of Crew Knowledge and Experience**: Lack of understanding of the internal solitary wave phenomenon and how to deal with it.
2		**2. Non-compliance with Operational Procedures**: Crew does not comply with

No.	Ship Incident Loss of Buoyancy	Item Basic Event
		established standard operating procedures.
3		**3. Fatigue and Stress**: Crew experiences fatigue or stress which can affect decisions taken.
4		**4. Poor Communication**: Lack of communication between crew in emergency situations.
5		**5. Inadequate Training**: The training provided is not sufficient to deal with critical situations such as internal solitary waves.
6		**6. Rapid Changes in Sea Conditions**: A sudden and unexpected change in sea conditions.
7		**7. Influence of Climate and Weather**: Extreme weather conditions that worsen the situation at sea.
8		**8. Diversity of Underwater Geography**: A complex underwater structure that amplifies the effects of internal solitary waves.
9		**9. Ocean Current Conditions**: Strong and unpredictable ocean currents.
10		**10. Errors in Navigation**: An error in navigation that causes a ship to enter a high-risk area.
11		**11. Deficiencies in the Detection and Monitoring System**: Detection and monitoring system that cannot detect internal solitary waves effectively.
12		**12. Ineffective Evacuation Procedures**: Evacuation procedures that cannot be carried out quickly and efficiently.
13		**13. Lack of Alarm and Early Warning Systems**: The absence or malfunction of an alarm system that can warn the crew of approaching danger.
14		**14. Obsolete Ship Technology**: Ship technology is outdated and unable to deal with extreme sea conditions.

Source: Interview with Expert (2024)

3.7 **Tree diagram** Proposed Improvements**Fault Tree Analysis (FTA)**

Tree diagram Fault Tree Analysis (FTA) for the event of a ship losing buoyancy due to the internal solitary wave phenomenon which has been discussed with experts. This diagram shows the flow from top events to intermediate events and then to basic events, using AND gate and OR gate symbols to describe the relationship between events.

Detailed explanation of Diagram 4.1 FTA, below:

Top Event: Ship Loses Buoyancy Due to Internal Solitary Wave

- OR Gate: Top event occurs if one of the intermediate events occurs.

Intermediate Event 1: Crew Not Ready to Face Internal Solitary Wave

- OR Gate: Intermediate Event 1 occurs if one of the following basic events occurs:
    1. BE1: Lack of Crew Knowledge and Experience
    2. BE2: Non-Compliance with Operational Procedures
    3. BE3: Fatigue and Stress in Crew
    4. BE4: Poor Communication between Crew
    5. BE5: Inadequate Training

Intermediate Event 2: Extreme Marine Environmental Conditions

- OR Gate: Intermediate Event 2 occurs if one of the following basic events occurs:
    1. BE6: Rapid Changes in Ocean Conditions
    2. BE7: Effects of Climate and Extreme Weather
    3. BE8: Diversity of Undersea Geography
    4. BE9: Strong and Unpredictable Ocean Current Conditions

Intermediate Event 3: Errors or Deficiencies in Ship Methods and Systems

- OR Gate: Intermediate Event 3 occurs if one of the following basic events occurs:
    1. BE10: Error in Navigation
    2. BE11: Deficiencies in Detection and Monitoring Systems
    3. BE12: Ineffective Evacuation Procedures
    4. BE13: Lack of Alarm and Early Warning Systems
    5. BE14: Obsolete Ship Technology

3.8 Proposed Improvements

Enhance crew knowledge through regular training on internal solitary waves and emergency response. Enforce compliance with operational procedures, and provide support to reduce fatigue and stress. Improve communication and develop a comprehensive training curriculum. Upgrade navigation and detection systems with advanced technology. Implement effective evacuation procedures and maintain alarm and early warning systems. Modernize submarine technology to handle extreme conditions.

Utilize weather prediction and oceanography technology to monitor ocean conditions. Prepare contingency plans for extreme weather and adjust travel routes based on underwater geography and ocean currents. Conduct regular audits and inspections to ensure compliance and effectiveness. Collect feedback for continuous improvement and collaborate with research institutions and experts to enhance understanding and mitigation strategies.

3.9 Discussion of Research Findings

Based on Failure Mode and Effect Analysis (FMEA) and Fault Tree Analysis (FTA), this research identified that the main factor causing submarines to lose buoyancy is the internal solitary wave (ISW) phenomenon. In the FMEA analysis, ISW has the most dominant Risk Priority Number (RPN) value, indicating that this threat is a significant operational risk for submarines. The Fault Tree Analysis (FTA) diagram shows the flow relationship from top event, namely the ship losing buoyancy, to intermediate events and basic events, with the use of AND gates and OR gates to describe the relationship between events.

Study by Wang, et al. (2022) provide strong support for these findings by analyzing the characteristics and impacts of ISWs in the Bali Sea and linking them to the KRI Nanggala-402 accident. Some key points from the study of Wang et al. relevant to the findings from FMEA and FTA include the identification of active ISWs in the Bali Sea with a peak length of close to 200 km, which moves from the Lombok Strait to the northwest across the Bali deep sea basin. This analysis reinforces the finding that ISWs are a significant real threat to submarine navigation, especially in areas identified as high risk areas. In addition, the study of Wang et al. linked the KRI Nanggala-402 accident to ISWs that had large amplitudes and high propagation speeds in the area where the submarine sank, confirming that ISWs can cause sudden changes in buoyancy, which was identified as a major risk factor in the FMEA and described in the FTA as intermediate event that leads to loss of buoyancy.

Combining these findings provides a comprehensive understanding of the threat posed by ISWs to

submarine operations in Indonesian territory, particularly in the Bali Sea. Some points of this integration include the theory of ISWs which explains that ISWs are non-linear internal waves that can move through layers of water at quite large speeds and amplitudes, capable of affecting the stability of submarines. Understanding these mechanisms helps develop effective mitigation strategies to reduce risk. Specific observations in the Indonesian region using data from satellite imagery enable real-time identification and monitoring of ISWs. Observations in the Bali Sea show that ISWs in this region have characteristics that can cause submarine accidents, such as what happened to the KRI Nanggala-402. The case study of KRI Nanggala-402 provides practical insight into how ISWs can cause buoyancy loss in submarines.

By combining theory about ISWs, specific observations in the Indonesian region, and analysis of the impact of ISWs on submarine navigation, this study provides a comprehensive understanding of the threat posed by ISWs to submarine operations in the Bali Sea. The findings from the FMEA and FTA analyzes indicating ISWs as a major risk factor were strengthened by an empirical study by Wang et al. (2022), provides a strong basis for the development of effective mitigation strategies in supporting the duties of the Indonesian Navy. This mitigation strategy includes increasing crew training and education, strengthening ship systems and technology, as well as comprehensively handling environmental factors. By implementing these mitigation measures, the risk of loss of buoyancy on submarines due to internal solitary waves can be minimized, thereby supporting the smooth and safe operation of the Indonesian Navy.

4. CONCLUSION

Based on the Failure Mode and Effect Analysis (FMEA) and Fault Tree Analysis (FTA) analysis, the following conclusions can be drawn Identification of operational risks on submarines can be done using the Failure Mode and Effect Analysis (FMEA) and Fault Tree Analysis (FTA) approaches. Through FMEA, various potential failures are identified and analyzed to determine the Risk Priority Number (RPN) value, which indicates the severity level, probability of occurrence, and detection ability of each risk. The internal solitary wave (ISW) phenomenon was identified as the main factor causing loss of buoyancy in submarines, having the most dominant RPN value. In FTA, this risk is analyzed further by describing the flow relationship from top event, intermediate event, to basic event, using AND gate and OR gate symbols to show how various factors contribute to this significant operational risk. The assessment and evaluation of risk events on submarines involves in-depth analysis using FMEA and FTA. In FMEA, each potential failure is scored based on severity, likelihood of occurrence, and detectability, resulting in an RPN value that helps identify priority risks that need to be addressed. The analysis results show that ISW is the main operational threat to submarines. FTA completes this evaluation by mapping the flow of events from top events (the ship loses buoyancy) through intermediate events (such as crew unpreparedness and extreme environmental conditions) to basic events (such as lack of crew knowledge and experience, rapid changes in sea conditions, and errors in navigation). . This allows a more comprehensive understanding of how and why these risks occur. Determining mitigation or handling of submarine risks requires a strategy based on findings from FMEA and FTA. By identifying ISW as a key risk factor, effective mitigation measures can be designed and implemented. Recommended mitigation strategies include increasing training and education for crew to deal with ISW, strengthening submarine systems and technology for real-time ISW detection and response, as well as developing better operational procedures. Apart from that, implementing an alarm and early warning system that can detect ISW effectively, as well as

improving ship technology to be able to face extreme sea conditions, is also very important. This comprehensive approach aims to minimize the risk of loss of buoyancy on submarines, thereby supporting the Indonesian Navy's operational tasks more safely and effectively.

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Indonesian Naval Technology College
Postgraduate International Conference, Vol. 8, No. 1, pp52-64
June, 27th 2024

SUSTAINABLE ENERGY FOR RADAR SYSTEMS IN INDONESIA'S OUTERMOST ISLANDS: A COOPERATIVE GAME THEORY ANALYSIS

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ABSTRACT

Indonesia's vast territorial waters, essential for natural wealth and strategic trade routes, face significant security challenges, including smuggling, illegal fishing, marine pollution, and maritime terrorism. To address these threats, Indonesia has implemented the Integrated Maritime Surveillance System (IMSS), primarily powered by diesel generators and, in some cases, supplemented by solar cells. This study explores the potential of transitioning IMSS to sustainable energy sources, specifically solar cells, to enhance environmental sustainability and operational independence. Utilizing cooperative game theory, we analyze the compromise values of using solar cells, diesel generators, and PLN (state electricity) to determine the optimal energy mix that balances cost-efficiency and renewable energy utilization. Through cooperative game theory, we evaluate the total costs and net present values (NPV) of each energy source under different usage scenarios (100%, 75%, 50%, and 25%). The NPV method is applied to assess the profitability and cost-effectiveness of each energy source over a 10-year period, discounting future cash flows to present value to account for the time value of money. This analysis shows that while solar cells require high initial investment, they offer significant long-term operational cost savings and environmental benefits. Conversely, diesel generators, despite lower initial costs, incur high operational and maintenance expenses. PLN electricity, though reliable in certain areas, faces limitations in remote regions. By determining the payoff matrix and eliminating dominant strategies, we identify the optimal compromise strategy that maximizes the use of renewable energy while minimizing costs. This approach not only supports Indonesia's green economy initiatives but also ensures reliable and efficient maritime surveillance. The findings advocate for a strategic shift towards greater reliance on solar energy for IMSS, promoting environmental sustainability and enhancing the system's overall effectiveness in securing Indonesia's maritime domain. This study contributes to the broader discourse on sustainable energy transitions in critical infrastructure and highlights the applicability of cooperative game theory in resource management.

Keywords: Cooperative Game Theory, NPV, IMSS, Green Energy

1. INTRODUCTION

Indonesia's seas have historically served as a wellspring of natural wealth and vital strategic trade routes for the nation. The country's vast territorial waters, while holding immense economic promise, also present formidable security challenges. The presence of an expansive maritime domain, studded with thousands of islands and intersected by bustling trade routes, renders Indonesia susceptible to a wide array of threats. These encompass activities like smuggling, which can range from the illicit trade of goods to narcotics trafficking, putting the nation's economic stability at risk. Moreover, the lure of Indonesia's rich fishing grounds has attracted illegal fishing operations that not only deplete marine resources but also undermine the livelihoods of local fishermen. Environmental issues, such as marine pollution and habitat degradation, pose further concerns, endangering the ecological integrity of these precious waters. Beyond these challenges, Indonesia faces the persistent menace of maritime terrorism, as its strategic sea lanes may be targeted by extremist groups seeking to disrupt global trade and stability. Lastly, the country must grapple with the issue of people smuggling, as its vast coastlines and numerous islands can be exploited by human traffickers, necessitating efforts to safeguard human rights and maintain the nation's security. Balancing the economic potential of its seas with the imperative of security remains

a significant and ongoing challenge for Indonesia.

Indonesia's largely poorly monitored territorial waters, compared to the close surveillance at airports and land travel lanes, provide an opening for foreign vessels to easily pass through Indonesian waters, as long as they comply with applicable regulations. This condition increases the level of vulnerability to various threats, which threaten not only economic interests but also territorial sovereignty, as well as national security and defense. In recent years, Indonesia has sought to improve water security by implementing a coastal surveillance radar-based security system, known as the Integrated Maritime Surveillance System (IMSS), especially in the northern border, especially in the Strait of Malacca (Ariantoko, 2023) and the Indonesian archipelago can be seen in figure 1.

IMSS plays an important role in monitoring the movement of ships entering and leaving Indonesian territorial waters, in addition to monitoring ships crossing the Indonesian coastal area the radar is also to monitor if there is an accident at sea or the piracy of commercial ships in the Indonesian sea area. So further efforts are needed to strengthen and maximize the use of this system, especially in areas that are the outer boundaries of the Indonesian archipelago. (Dotulung, 2020)

Fig.1 IMSS Location

Currently, IMSS Radar uses electricity from PLN in areas covered by the national electricity network (PLN). However, obstacles arise when the area where IMSS is located is outside the reach of PLN's network, so it uses diesel generator resources as the main power source and solar cells as supporting power (Gunawan, 2023).

On the other hand, to support the achievement of the Government's main target in overcoming global climate problems through the implementation of the green economy to date. This effort is shown by the Government through its commitment to encourage the provision of optimal resources to accelerate the sustainable energy transition. In the International Seminar on Leveraging Performance Audit Impact Towards Green Economy, the Coordinating Ministry for Economic Affairs is committed to supporting sustainable renewable energy development to increase the target of reducing Greenhouse Gas emissions to minimize the negative impact of emissions produced. The phenomenon of greenhouse gases occurs due to the increasing amount of carbon in the air which causes heat from sunlight to be trapped which will increase temperatures globally (Fadzil, 2022). The Indonesian Navy leadership also supports the government program by considering the potential use

of renewable energy as the main power source for IMSS radars.

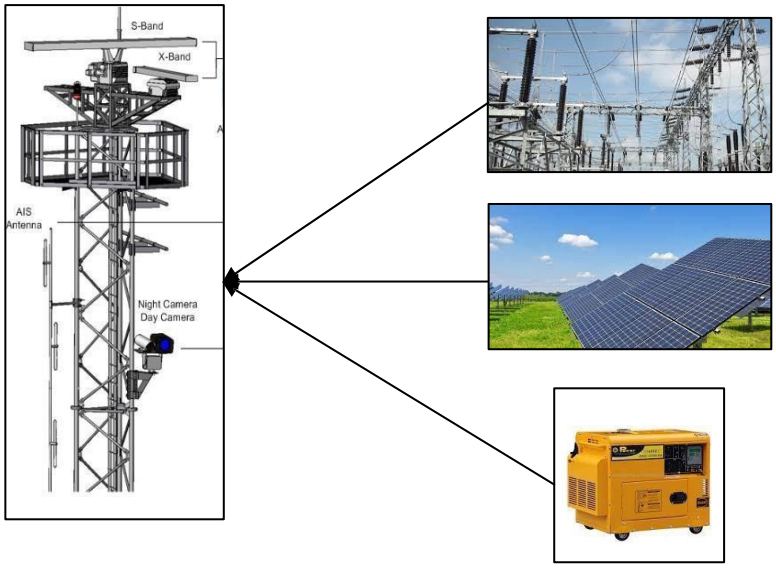

Fig.2 Power supply for IMSS

In addition to contributing positively to environmental sustainability, the use of solar cells also provides advantages in terms of independence, where the system can operate independently without being too dependent on outside resources. The move towards the use of renewable energy such as solar cells for IMSS Radar is a strategic step in the effort to reduce environmental impact and improve the efficiency of maritime surveillance systems. In addition, independence in power supply will improve the reliability of surveillance systems, given the lower dependence on outside resources. With this change, it is expected that IMSS Radar will be able to operate more efficiently, effectively, and environmentally friendly so that it can be more effective in carrying out its duties in maintaining the security of Indonesian waters. Here is the architecture of the power supply on the IMSS radar.

In the Figure 2, it can be seen how the IMSS radar obtains power supply, namely from PLN from solar cells and diesel generators. In areas that have a reliable PLN electricity network, the main source of power comes from PLN, followed by solar cells as a backup power source. In addition, there is also a generator that acts as an emergency power source. However, the use of these resources still depends on fossil energy, namely from coal-fired power plants, the main fuel of which is coal.

The existing literature has put forth a substantial amount of research on sustainable energy that utilizes cooperative game theory. This section will introduce the most pertinent studies and highlight the key distinctions when compared to our proposed model. Research conducted by (Bo-Li, 2022) integrates solar PV energy sources, wind turbines and diesel generators based on multi-energy with deep merging between electricity and gas grids. Four possible game planning models are proposed using game theory analysis methods. development of interval optimization-based coordinated operating strategies for gas-electric integrated energy (IES) systems that consider wind power demand and uncertainty responses (Bai, 2016).

Traditional energy generation using diesel generators is not easily disturbed by external factors and the energy supply is stable. However, high operating costs, slow response rates, and serious air pollution are certain to make diesel generators no longer follow future development trends. Hence, the use rate of diesel generators

gradually decreases. On the other hand, distributed energy represented by wind and solar energy has a good level of safety and flexibility, as well as lower environmental pollution, but it is strongly influenced by weather factors, with a high degree of uncertainty, fluctuation, and time variation. (Barelli L, 2015).

In this study, researchers will look for compromise values from the results of each resource using cooperative game theory so that the best composition of the use of resources used by IMSS radar is obtained so that the use of solar cells as renewable energy is expected to be more dominant to support renewable energy but at a cost that is not too expensive. So, it is expected that the results obtained can be environmentally friendly and reduce the amount of carbon that exists as expected by the government (Presiden, 2021). This study aims to find the compromise point of the use of these three resources using cooperative game theory.

2. MATERIAL AND METHOD

2.1 Game Theory

Game theory is a mathematical approach used to formulate and analyze situations in which there is competition and conflict between various players in decision-making involving interactions. In decision-making with game theory, there is more than one decision-maker, often referred to as a player, who has different goals. The decisions taken by each player have an impact on the outcome obtained by all players involved. The peculiarity of game theory is the presence of interaction between players, which differs from conventional decision-making theory which involves only one decision-maker. To achieve their goals, each player has a wide choice of strategies that they can apply. The goal of game theory is to understand and predict how players will behave in situations involving these interactions, hoping to achieve their respective goals (Maschler, 2013). One of the fundamental assumptions in game theory is that all players are rational. Players in game theory can be divided into two types: two-person games, in which the game involves two players, and N-person games, in which more than two players are involved in the game. Players always choose the decision that will give the best result according to their goals, and their decision is not influenced by personal preference.

While a cooperative game is a type of game where all players can coordinate or work together to determine a mutually beneficial strategy, the strategy produced in this game may not always be the best choice optimally for one of the players, because it is based on an agreement reached by both parties that will benefit all parties or will not harm one party after cooperation and coordination (Melati, 2017).

Cooperative Game Theory is a branch of game theory that studies how groups of players (coalitions) can cooperate to achieve mutual benefits. In this theory, a group of cooperating players is called a coalition, which can range from small groups to large ones encompassing all players in the game. The main focus of this theory is on how the benefits obtained from cooperation can be distributed, regulated through a characteristic function that assigns value or benefits to each coalition. There are two types of cooperative games: transferable utility games, where benefits can be distributed in measurable forms such as money, and non-transferable utility games, where benefits cannot be easily measured, like contributions in a sports team.

Key concepts in cooperative game theory include the Core, which is a set of allocations ensuring that no coalition would gain more by breaking away; Shapley Value, a method for distributing benefits fairly based on each player's contribution; Nucleolus, a solution that minimizes player dissatisfaction with their allocation; and the Bargaining Set, a set of allocations where no player has a legitimate reason to reject the allocation. Cooperative game theory is applied in various fields such as economics, management, and political science, for business

cooperation, international negotiations, and resource allocation, helping create better solutions through cooperation rather than individual actions.

2.2 IMSS Radar

The establishment of the Regional Maritime Security Information Center (IMSS) by the Indonesian Navy involves several stages and cooperation with the US Government. In 2005, the development of the IMSS radar began and continued to expand until 2014. The construction of IMSS I commenced in 2005, followed by Phase II. In April 2006, the U.S. Embassy in Jakarta expressed the U.S. Government's interest in assisting with the implementation of the IMSS development, demonstrating a commitment to enhancing maritime security in the region. By 2012, the Indonesian Navy had held a meeting with the U.S. Embassy to further discuss maritime security, emphasizing the ongoing cooperation between the two nations. The IMSS is equipped with a 2D surface radar with an X band that can observe the sea surface up to 40 miles or 70 km, an Automatic Identification System (AIS) to monitor the movement of commercial ships, and radio and satellite communications to send data to the control center located at the TNI AL Headquarters. This robust setup underscores the strategic importance of IMSS in maintaining maritime security.

The IMSS operates continuously, 24 hours a day, 7 days a week, with no downtime for observations. This necessitates a reliable and uninterrupted power supply to support its operations. The power for IMSS is sourced from PLN (Perusahaan Listrik Negara), diesel generators, and solar panels, each with its distinct advantages and limitations. In the outermost areas, the reach of PLN resources is often limited. Many IMSS radar locations are on the outermost borders of Indonesian islands where PLN's electricity network is either non-existent or unreliable due to frequent outages, making it an unreliable primary power source.

2.3 Diesel Generator

Diesel generators are the main power source for IMSS. An IMSS system requires 20Kw of power according to the specifications provided by the (Operator, 2023) those in charge of operating and maintaining the equipment. So, it requires a power source from a generator with a minimum power of 25Kw. Because for safety the maximum generator power is 80% of the required power. In this study, the diesel generator applies as a player and is notated with Dg. Dg in this study has values, namely operational costs, investment costs and maintenance costs.

$$\text{Total Cost Dg} = Bi + Bo + Bhar \quad (1)$$

Bi: Investment or purchase costs
Bo: operational costs i.e., fuel usage
Bh: maintenance costs

The investment cost of a diesel generator with a capacity of 25 kW is between 80 to 100 million or the middle value of 90 million. The value is the value of the initial investment cost. Next is operational costs, namely the use of diesel fuel needed by diesel generators in one month. According to (Hayatullah, 2021) in finding diesel fuel consumption is as a berry.

$$S=K\times P\times T \quad (2)$$

S: Required amount of diesel

K: 0,2 (Fuel consumption constant required per kilowatt per hour)

T: generator usage time

By using the formula above, the fuel consumption needed in one day is 120 litres, while the consumption for one month is 3,600 litres. If the fuel used is for industrial marine at a price of 20,100 / litre. So the operational cost for a 25Kw generator for one month is Rp 72,360,000, and the operational cost for one year is Rp 868,320,000. As for maintenance costs according to (Yudiono, 2018) maintenance costs for generators per year is Rp. 94,539,600. So to find equation 1) can be done because all the variables needed are known.

Total Cost Dg: Bi+Bo+Bh

: 95.000.000 + 880.380.000 +94.539.600

: Rp1.057.320.000

Bi : Rp 95.000.000

Bo : Rp 880.380.000

Bh : Rp 94.539.600

From the calculation above, the total cost of the diesel generator is Rp1,057,320,000. The cost is the cost of using a 100% diesel generator or all IMSS power supplied by the diesel generator.

2.4 Solar Cell

Currently, solar cells are used to back up diesel generators. Currently, there is no division between when to use the flow generator and when to use the flow from the solar cell. So, the use of these two energy sources is not optimal. The following is the value of the costs required to support an IMSS system.

$$\text{Total cost Pv} = Pvi+Pvo+Pvh \quad (3)$$

Pvi: Investment in Solar Cell Development

Pvo: Operating costs

Pvh: Maintenance costs

According to the (ESDM, n.d.) the cost of installing solar cells is 20 million per Kw. At IMSS the power required is 20Kwh. If solar panels will be used as the main power source, then in a day 24 hours. So that the power needed is 20x24, so the power needed is 480Kw.

So, the Pvi is:

Pvi = 480x20jt

= Rp 9.600.000.000

Solar panels do not require operational costs. Because energy utilizes sunlight to generate electricity. So Pvo is 0. As for Pvh, the maintenance cost required is battery replacement. Battery replacement is carried out every 10 years. So that the equation can be solved as follows.

Total Cost Pv = Pvi+Pvo+Pvhar

= 9.600.000+0+0

= Rp9.600.000.000

From the calculation above, the cost is obtained for the installation of solar panels to support IMSS operations. In this calculation, IMSS uses 100% of the power from solar panels.

2.5 PLN electricity flow

Electric current from PLN (Perusahaan Listrik Negara) plays an important role in ensuring the continuous operation of IMSS (Maritime Security Information System) radars located in Indonesia's outer islands. The state-owned power company is providing the necessary power supply to keep the radar system in place for its essential functions in monitoring and securing maritime activity in the region. The condition in the field is that electricity supply from PLN is not used as the main power source because the conditions that exist on the outer island are many obstacles, both from stability, conditions that often die and there are some areas where there is no electricity supply from PLN. However, in this study, researchers assume PLN can reach all areas on the outer islands of Indonesia. For the cost required by electricity, PLN supplies 100% for IMSS in one year is 253,000,000 and installation costs are 20,000,000. on electricity, PLN does not require maintenance, because maintenance is borne by PLN.

2.6 NPV

The NPV (Net Present Value) approach emphasizes that a Euro received in the future carries more uncertainty and is thus less valuable compared to a certain Euro received today. As a result, the projected cash flows in the future are discounted each year. The discount rate used takes into account the opportunity cost of the capital being used, and this cost increases as the perceived risk associated with the innovation opportunity rises. In essence, projects with greater levels of risk are expected to yield higher returns. This means that the NPV approach adjusts for risk, which sets it apart from other metrics like ROI or IRR, as noted by (Gailly, 2011)

In its fundamental application, the discount rate is determined by evaluating the actual cost of the capital invested in the innovation. This involves calculating the weighted average cost of both equity and debt utilized to fund the project. In instances where small projects make it challenging to identify the specific proportions of equity and debt financing, the cost of capital, often referred to as WACC (Weighted Average Cost of Capital), is typically assumed to be equivalent to the company's overall cost of capital. This calculation is based on data from annual reports that consider the company's total equity and liabilities, as noted (Chiesa, 2009).

$$\sum_{t=0}^{n} \frac{NCFt}{(1+r)^t} \qquad (4)$$

Where NPV = net present value.

NCFt = net cash flow generated by innovation project

t = in year

r = discount rate

Commonly used discount rates for corporate projects typically range from 10 per cent to 15 per cent.

However, investors in high-tech start-ups may use rates as high as 25 per cent to 30 per cent, reflecting the intrinsically risky nature of such ventures. The second core principle of the NPV approach involves considering all future net cash flows associated with the innovation opportunity. In contrast, other metrics like the payback period or initial investments focus solely on the initial cash flow. The NPV approach necessitates, on the one hand, the discounting and aggregation of all future net cash flows, where reasonable assumptions can be made. On the other hand, it requires estimating and discounting the ultimate value of any remaining cash flows, often referred to as the "final" value. The value of innovation projects is then the sum of the discounted cash flows, inclusive of the final value. This final value can be estimated as either zero (in cases of innovations facing complete obsolescence), negative (for innovations involving rehabilitation or recycling costs, as seen in the energy sector, for instance), or as an approximation of future cash flows based on factors such as resale value, balance-sheet metrics, or a perpetual value concept.

3. RESULTS AND DISCUSSION

3.1 NPV Energy Sources Cost

The following is carried out the calculation of the net present value of energy sources over 10 years. NPV calculation will be carried out with 100% usage, 75% usage, 50% usage and 25% usage. Here is a table of calculations of NPV 100% use for 7 years.

Table.1 NPV 100% Use of Energy Sources

Source	Invest	Ops1	Ops2	Ops3	Ops4	Ops5	Ops6	Ops7	NPV Value
PLN	20	253	253	253	253	253	253	253	1.351
Generator	95	975	975	975	975	975	975	975	5.244
Solar Cell	9.600	0	0	0	0	0	0	0	9.060

In the table above is the cost required for each energy source to supply IMSS 100%. PLN has the smallest investment costs and operational costs tend to remain not the most expensive and not the cheapest. Diesel generators have slightly greater investment costs than PLN but have the highest operational and maintenance costs. The latter are Solar panels which have the largest investment costs but have the most operational costs small, it cost nothing because energy takes sunlight to generate electricity. After calculating the NPV of 100% of energy use, then calculate the NPV of 75% of the energy use of each Source. The calculation results can be seen in the table below.

Table.2 NPV 75% Use of Energy Sources

Source	Invest	Ops1	Ops2	Ops3	Ops4	Ops5	Ops6	Ops7	NPV Value
PLN	20	190	190	190	190	190	190	190	1.019
Generator	95	650	650	650	650	650	650	650	3.512
Solar Cell	7.200	0	0	0	0	0	0	0	6.790

In the NPV calculation of 75% of energy use from each source, there has been no significant change from the results that previously PLN had the smallest investment value, but there was a change in operational costs which were previously 253 million to 190 million. In diesel generators, there is a difference in operational costs from 975 million to 650 million. While in solar cells there is a change from the previous 9.6 M to 7.2 M, while

operational and maintenance costs on solar cells do not yet exist.

Table.3 NPV 50% Use of Energy Sources

Source	Invest	Ops1	Ops2	Ops3	Ops4	Ops5	Ops6	Ops7	NPV Value
PLN	20	125	125	125	125	125	125	125	677
Generator	95	575	575	575	575	575	575	575	3.117
Solar Cell	4.800	0	0	0	0	0	0	0	4.530

In the table above, the results of the NPV calculation of the cost of using 50% energy sources for IMSS, PLN generators and solar panels. Every source of cost decreases.

Table.4 NPV 25% Use of Energy Sources

Source	Invest	Ops1	Ops2	Ops3	Ops4	Ops5	Ops6	Ops7	NPV Value
PLN	20	79	79	79	79	79	79	79	435
Generator	95	220	220	220	220	220	220	220	1.248
Solar Cell	2.400	0	0	0	0	0	0	0	2.260

In the table above is the calculation of the NPV of each source supplying 25% of the power required by the IMSS radar. from the results of the NPV calculation, it can be seen the cost of each source.

3.2 Game Theory

The next step is to address the issue of sharing energy sources using cooperative game theory. With this approach, we can achieve optimal results in the utilization of renewable energy while reducing high costs. Cooperative game theory enables stakeholders in the energy system to collaborate and efficiently share energy resources. Therefore, this will help achieve a better balance between environmental sustainability and economic efficiency in the use of renewable energy sources. By applying cooperative game theory principles, we can allocate energy resources more equitably and minimize waste, leading to a more sustainable and cost-effective energy system. This not only benefits the environment by promoting the use of clean, renewable energy sources but also offers economic advantages by streamlining the energy production and distribution process, ultimately making renewable energy a more accessible and viable option for the future. It is a promising approach that has the potential to revolutionize the energy sector and contribute to a greener and more sustainable world.

3.3 Payoff Matrix Determination

In this game theory, three main players have a central role in the management of energy resources, namely PLN, diesel generators, and solar panels. Each of these players has a unique strategy relating to the energy resources they control. PLN, as the largest provider of electrical energy in Indonesia, must consider cost efficiency and reliability of energy supply. On the other hand, diesel generators consider operational flexibility and fuel availability. Meanwhile, solar panel owners can focus more on environmental aspects and the utilization of renewable energy.

When all these players are involved in this game, the results of each previous move are recorded in a matrix

that includes various possible situations or scenarios. This can include how much energy is produced, costs incurred, or the environmental impact of each strategic choice. With the bimatrix composed, the players can perform analysis to determine the best strategy that will give them the most favourable results.

In a broader context, this approach helps create a better balance between economic, environmental, and energy availability. It also reflects the importance of using renewable energy in reducing negative environmental impacts and ensuring the availability of reliable energy in the future. By integrating game theory into energy-related decision-making, we can achieve more sustainable and optimal solutions for managing energy resources in Indonesia. This is the bimatric table of cooperative game theory.

Table.5 Payoff Matrix

PLN \ Diesel generator Solar Panel	25% Usage	50% Usage	75% Usage	100% Usage
25% Usage	2.260,1.248, 677	2.260, 3.117, 435	2.260, 3.512, 0	2.260, 3.512, 0
50% Usage	4.530, 1.248, 435	4.530, 3.117, 0	4.530, 3.117, 0	4.530, 3.117, 0
75% Usage	6.790, 1.248, 0	6.790, 1.248, 0	6.790, 1.248, 0	6.790, 1.248, 0
100% Usage	9.060, 0, 0	9.060, 0, 0	9.060, 0, 0	9.060, 0, 0

In the bimatric above, there are three players, namely player 1 is a panel prayer, player 2 is a diesel generator, and player 3 is PLN. In the payoff value, there are three values, namely payoff from player 1, payoff from player 2, and payoff from player 3. The purpose of this cooperative game is to divide energy sources so that energy sources can be shared that can maximize the use of renewable energy, namely solar panels, but minimize the costs incurred, by dividing the use of owned sources.

3.4 Compromise Strategy Selection

A compromise strategy is a strategy that does not harm all players, guided by common goals. Unlike noncooperative games that pit each other's best strategy. The strategy that produces the biggest profit for player 1 and gets the smallest loss is the best strategy. The strategy that has the biggest loss impact on the opponent is the best strategy, depending on the purpose of the strategy user.

To facilitate the selection of strategies will use the elimination approach as manifested by (Hillier, 2001). In this elimination approach, it will eliminate from the dominant payoff value. In the matrix above, the dominant payoff value is the one with the largest value from player 1. So that player 1 strategy 100% usage can be eliminated. Eliminating the most dominant payoff, it will make it easier for decision-makers to determine strategy choices that do not benefit one of the players. The results of the first elimination can be seen in the following table 6.

Table.6 Dominant Payoff Elimination Results Player 1

PLN \ Diesel generator Solar Panel	25% Usage	50% Usage	75% Usage	100% Usage
25% Usage	2.260,1.248, 677	2.260, 3.117, 435	2.260, 3.512, 0	2.260, 3.512, 0
50% Usage	4.530, 1.248, 435	4.530, 3.117, 0	4.530, 3.117, 0	4.530, 3.117, 0
75% Usage	6.790, 1.248, 0	6.790, 1.248, 0	6.790, 1.248, 0	6.790, 1.248, 0

After making the first elimination that eliminates one strategy from player 1, then look again at the payoff table whether there is still a dominant value in the matrix table above. In the table, there is the smallest dominant value found in player 3, which is a zero value in all strategies of 75% and 100% usage. So that these two strategies can be eliminated. The results of the elimination matrix can be seen in the following table 7.

Table.7 Dominant Payoff Elimination Results Player 3

PLN \ Diesel generator Solar Panel	25% Usage	50% Usage
25% Usage	2.260,1.248, 677	2.260, 3.117, 435
50% Usage	4.530, 1.248, 435	4.530, 3.117, 0
75% Usage	6.790, 1.248, 0	6.790, 1.248, 0

After carrying out elimination in the player 3 strategy, the player 2 strategy has two strategies, namely 25% usage and 50% usage. After carrying out the final elimination, look again at whether there is a dominant pay off value. In table 7, there is still the smallest dominant value in player 3 in strategy 3. Next, carry out elimination in the strategy. So that leaves the following strategy that does not have a dominant value.

Table 8 Dominant Payoff Elimination Results Player 3

PLN \ Diesel generator Solar Panel	25% Usage	50% Usage
25% Usage	2.260,1.248, 677	2.260, 3.117, 435
50% Usage	4.530, 1.248, 435	4.530, 3.117, 0

Table 8 presents a scenario where each player—solar panel, diesel generator, and PLN—has two remaining strategies, specifically 25% and 50% usage. This results in a total of four possible payoffs:

a. Solar Panel 25% Usage, Diesel Generator 25% Usage
b. Solar Panel 25% Usage, Diesel Generator 50% Usage
c. Solar Panel 50% Usage, Diesel Generator 25% Usage
d. Solar Panel 50% Usage, Diesel Generator 50% Usage

These four payoffs represent the combined outcomes of the different strategy pairings between the players. By reducing the number of strategies to two for each player, the complexity of the decision-making process is significantly minimized. This streamlined approach allows researchers to more easily analyze the interactions and trade-offs between different energy sources.

Furthermore, focusing on these specific payoffs facilitates the identification of the optimal compromise strategy. Researchers can now examine which combination of solar panel and diesel generator usage best balances the goals of cost efficiency and green energy utilization, ensuring that no single player dominates the outcome and that the overall strategy supports sustainable and economical energy management for the IMSS system.

4. CONCLUSION

The compromise strategy selection process successfully identifies strategies that are beneficial to all players and do not disadvantage any single party, adhering to common goals. Using Hillier's (2001) elimination approach, dominant strategies are systematically removed, making it easier to determine equitable decisions. The initial elimination of player 1's 100% usage strategy, followed by the removal of player 3's 75% and 100% usage strategies due to zero value payoffs, narrows down the choices. After these eliminations, the analysis focuses on the remaining strategies to ensure they are not dominated by any other. The final selection leaves two strategies for each player, simplifying the determination of a compromise payoff value. The identified strategies effectively balance cost and green energy utilization, with the four remaining payoffs highlighting scenarios of 25% and 50% green energy usage. These scenarios align with the objectives of cost efficiency and environmental sustainability.

This method demonstrates the effectiveness of cooperative game theory in harmonizing diverse interests and optimizing resource use in complex systems. By ensuring no single player's interests dominate, the approach fosters collaboration and supports the sustainable transition to renewable energy sources for Indonesia's Integrated Maritime Surveillance System (IMSS). The findings highlight the potential of cooperative strategies to improve both economic and environmental outcomes in the management of critical infrastructure. However, this research has certain limitations. One primary weakness is the reliance on static data and assumptions, which may not accurately reflect real-world variability and dynamics. The model does not account for potential fluctuations in energy prices, technological advancements, or changes in policy that could affect the feasibility and cost-effectiveness of the proposed strategies. Additionally, the cooperative game theory approach assumes rational behavior and perfect cooperation among all players, which may not always be achievable in practice due to conflicting interests or external pressures. These limitations suggest that while the findings provide a solid foundation, further research incorporating dynamic and real-time data, as well as consideration of practical implementation challenges, is necessary to validate and refine the proposed strategies.

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THE ANALYSIS OF THE OUTPATIENT PHARMACY INSTALLATION SERVICES SYSTEM IN HOSPITAL USING ARENA SIMULATION METHOD

(Case Study in ABC Hospital)

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ABSTRACT

ABC Hospital is a type A hospital. ABC Hospital is one of the referral centers for both TNI agencies in the eastern region and regional hospitals in Surabaya and its surroundings. For this reason, the services provided must be able to provide a level of satisfaction to the patients who seek treatment. To support this implementation, it must be supported by all parts related to the patient service process. One important part that supports the running of a good service process is the pharmaceutical installation, especially the outpatient pharmacy installation. Where the entire service process in the hospital will end at the pharmacy installation. Outpatient pharmacy installations are special because this process is carried out by the patient or their family, which is different from inpatient treatment where drugs or processes in the pharmacy installation are usually carried out by the nurse on duty in the inpatient room. The author uses arena simulation to analyze and obtain results both for existing conditions and results from experimental scenarios. Where the process begins by determining the distribution model from data observed in the field using analyzer input and then carrying out simulations, validation tests, and verification tests. Then carry out several experimental scenarios using the process analyzer. From the experimental results, we obtained better results than the existing conditions in the non-mixed (+1) and packaging (+1) scenarios, resulting in an improvement in the response variable of 15.2%.

Keywords: Outpatient Pharmacy Installation System, ABS Hospital, Arena Simulation Method.

1. Introduction.

Hospitals are one of the service industries in the health sector. So, to maintain its existence, we must pay attention to the quality of services produced by the wishes of customers in particular and society in general. To increase patient satisfaction in terms of service, hospitals are always required to provide good facilities and services. Service delays will result in long queues and longer waiting times. If this happens, you can be sure that customer satisfaction will not be met properly.

Based on initial observations at the outpatient pharmacy installation at ABC Hospital on Monday 22 April 2024 at 09.00 - 09.30 WIB, many patients started waiting for the outpatient pharmacy service to get the medicines listed on the doctor's prescription. On this occasion, the researcher also had a chance to chat (question and answer) with one of the visitors, where the service at the outpatient pharmacy installation was very disappointing because the process of taking the medicine took quite a long time. The experience he experienced was finished in the poly examination room at +10.00 WIB and immediately entered the prescription into the outpatient pharmacy installation but he only received the medicine at +14.00 WIB.

By the background above, what will be raised as a problem in this final assignment is "What is the patient queue for taking medicine at the outpatient pharmacy installation of ABC Hospital does not experience buildup," Therefore, research needs to be carried out to find out how long the average time it takes for officers, what the repair scenario is, how the repair scenario compares with the existing conditions.

2. LITERATURE REVIEW

2.1 Queuing Theory

Queuing is a process related to the arrival of a customer at a service facility and then waiting in a queue if all services are busy providing service to other customers. In general, queuing systems can be classified into different systems where queuing theory and simulation are often applied widely (Prihati, 2012).

Three components make up a queuing system, namely:

a. Customer (customer).

A customer is a person or a machine waiting to receive service.

b. Server (waiter).

A server is a person or machine that provides services.

c. Queue

A queue is a group of customers waiting to be served. In the queue the customer requests service but the server is busy.

2.2 Queue Process.

According to Bronson (1996: 310), the queuing process is a process related to the arrival of a customer at a service facility, waiting for a call in the queue if they have not received service, and finally leaving the service facility after receiving service. This process begins when customers who need service begin to arrive. They come from a population called an input source.

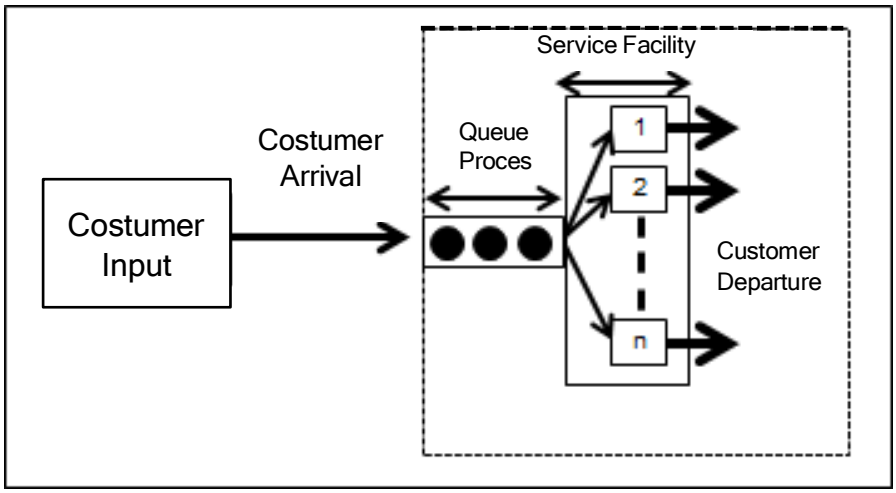

Figure 1. Queuing System

The basic components of the queuing process are described as follows:

a. Arrival Pattern, according to (Wagner, 1972), the arrival pattern is the pattern of queue formation due to the arrival of customers within a certain time interval.

b. Travel Pattern, is the number of customer departures during a certain period. The departure pattern is usually characterized by service time, namely the time required by a waiter to serve a customer. Service time can be deterministic and can be a random variable with a certain probability distribution (Bronson, 1996).

c. System Capacity, according to (Bronson, 1996), system capacity is the maximum number of customers, both customers currently in service and in queues, that can be accommodated by service facilities at the same time.

d. Service Design, according to (Sinalungga, 2008), service facility designs can be classified into channels and phases which will form different queue structures. The channel shows the number of paths to

enter the service system. Phase means the number of service stations, which subscribers must go through before the service is declared complete. Four basic queue structure models are common in all queuing systems as shown in Figure 2

1. Single Channel – Single Phase, Single channel means there is only one path entering the service system or there is one service facility. A single phase means there is only one service.
2. Single Channel – Multi-Phase, the term Multi Phase indicates that there are two or more services carried out sequentially (in phase phase), for example, car washing.
3. Multi-Channel – Single Phase, occurs at any time where two or more service facilities are being supplied by a single queue, for example, the queue at a bank teller.
4. Multi-Channel - Multi-Phase, each existing system has several service facilities at each stage, for example, services in hospitals starting from registration, diagnosis, and treatment process, to payment.

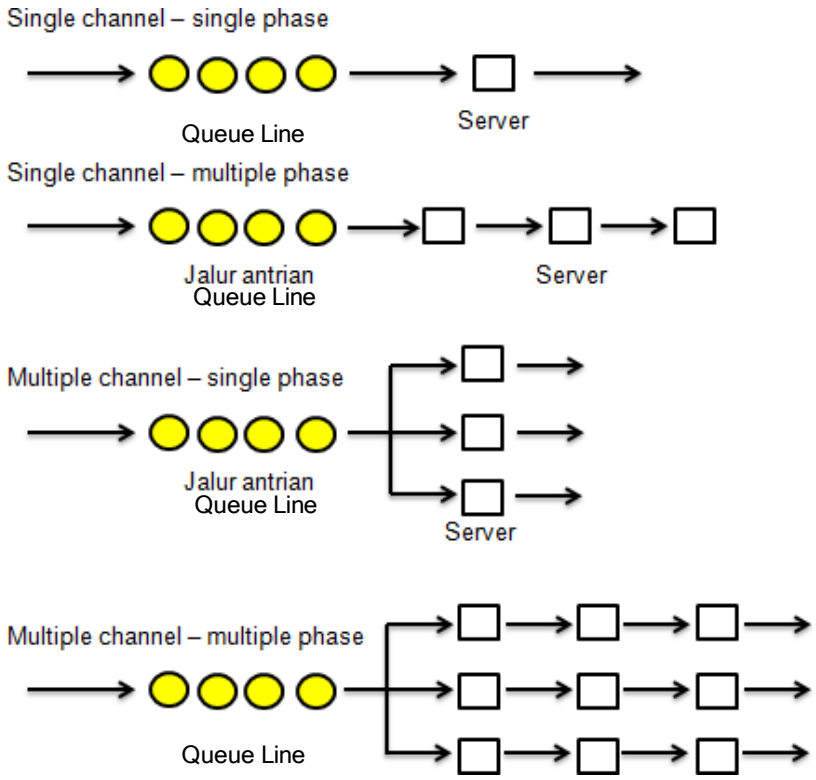

Figure 2. Basic Structure of a Queue (Aminudin, 2002)

e. Service Discipline, according to (Sinalungga, 2008), service discipline is a rule that is introduced in selecting customers from the queue to be served immediately. The division of service disciplines is:

1. First come first served (FCFS) or first in first out (FIFO), a rule where those who will be served are the customers who arrive first. For example, the queue at a supermarket cashier.
2. Last come first served (LCFS) or last in first out (LIFO) is a queue where the person who arrives last is the one who is served first or first. For example, in a queue in a pile of goods in a warehouse, the last goods to enter will be stacked at the top, so they will be taken first.
3. Service in random order (SIRO) or service in random order often known as random selection for services (RSS), meaning that service or calls are based on random chance, it doesn't matter who

arrives first. For example the lottery papers that are waiting to be drawn the winner is determined, who is drawn at random.

4. Priority service (PS), meaning that service priority is given to those who have the highest priority compared to those who have the lowest priority, even though the latter has arrived in the waiting line first. An incident like this can be caused by several things, for example, someone who has a more serious illness than other people in a hospital.

f. Calling Sources, according to (Taha, 1997), the size of calling sources is the number of populations that require service in a queuing system. The size of the calling source can be finite or infinite.

g. Human Behaviour, according to (Gross, D, & Harris, C. M, 1998), human behaviour in a queuing system when acting as a customer is as follows.

1. Reneging describes a situation where someone enters the queue, but has not received service, and then leaves the queue.

2. Balking describes people who do not enter the queue and immediately leave the queue.

3. Jockeying describes the situation if in the system there are two or more queue lines then people can move queues from one line to another.

2.3 Birth and Death Processes (Birth - Death Processes)

According to (Winston, 1994), the process of birth and death is an addition process in a system where the state of the system always produces n positive integers. The state of the system at time t is defined as the difference between the number of births and deaths at time t. Thus, the state of the system at time t in a queuing system, denoted by N(t), is the difference between the number of arrivals and departures at time t.

2.4 Simulation

According to (Kelton, WD, Sadowski, RP & Sadowski, D. A, 2002) simulation is the process of forming a model of a real system for experimentation to understand the behavior of the system and evaluate the strategy or performance of the system. Analytical models are used when:

a. Not all assumptions in the analytical model are valid.

b. Mathematical models are very complex and difficult to run.

c. When a good solution is enough.

2.5 System

In the simulation system, there are several system elements used, namely:

a. Entity, Player in the system, is something that will be processed in the system, move, change status, and influence and affect other entities. Examples of entities are people, materials, consumers, documents, patients, and so on.

b. Attributes, entity characteristics that are attached to entities to describe and differentiate between entities. These attributes can be identity, time, sequence, and so on.

c. Resources, something that will carry out the process. These resources are usually realized in operators, facilities, equipment, and other things that carry out activities.

d. Controls, show where the simulation is carried out, the simulation time, and maintains the sequence, logic, and rules of the system.

e. Variable, something that is attached to the system

2.6 Arena Software

ARENA software is a simulation software published by System Modelling Corp. ARENA software is object-oriented, which provides alternative and interchangeable templates for graphical simulation models and analytical simulation models which can be combined to create quite extensive and varied simulation models. Some of the advantages include being specialized in solving discrete system simulation problems and having statistical data processing capabilities, although not very complete.

2.7 Hospital Pharmacy Installation

A Hospital Pharmacy Installation is a department unit or section in a hospital that is under the leadership of a pharmacist and assisted by several pharmacists who meet the requirements of applicable laws and regulations and are professionally competent and is a place or facility that is responsible for administering responsible for all pharmaceutical work and services intended for the needs of the hospital itself (Siregar, Amalia, 2004)

3. RESEARCH METHODS

3.1 Data source

The data used for the final assignment research entitled Queuing Analysis of the ABC Hospital Pharmacy Installation Service System is the primary data. Direct data collection was carried out on drug takers who came during the hours and days of the week when the observation was carried out. Namely Monday to Friday from 08.00 to 14.00 WIB. Except on Fridays, observations are only carried out until 11.30 WIB. This was done because outside of these hours there were no long queues at the outpatient pharmacy installation at ABC Hospital.

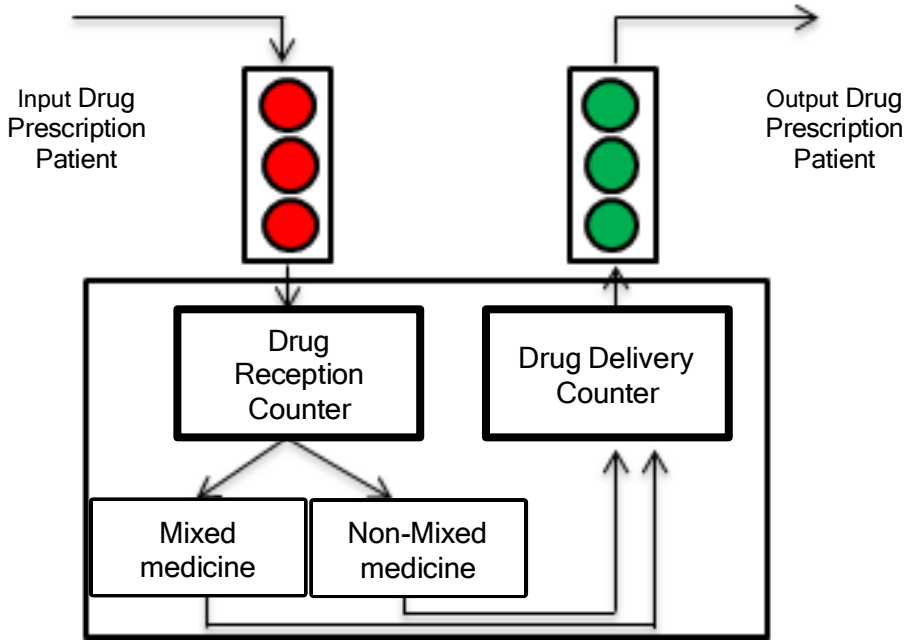

Figure 3. Drug Prescription Service Process

Figure 3. depicts the service system at the outpatient pharmacy installation at ABC Hospital, where incoming prescriptions must wait at the prescription reception counter. Then the officers will separate prescriptions containing compounded medicines from non-mixed medicines. The prescription will be given for taking and compounding the medicine. Once completed, the medicines will be given to the patient.

This research is a descriptive study using qualitative methods, where data and information related to research problems obtained through literature studies and field interviews are analyzed quantitatively, and then interpreted according to the meaning contained in the data and information. Data collection techniques are carried out through library research and in-depth interviews with parties who are considered competent and have information and data related to research problems.

4. Result and Discussion

4.1 Existing System Condition

ABC Hospital Outpatient Pharmacy Installation is an important facility that functions to serve drug requests from the community. This facility looks very busy in serving its customers every day, which is shown by the quite long queue in the waiting room. In general, the pharmaceutical installation system is divided into four main parts, namely the customer reception section, the drug production section, the drug packaging section, and the drug inspection section.

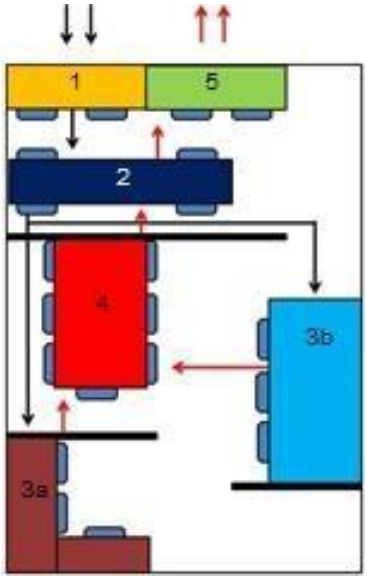

Figure 4. Plan of the processing room in the Outpatient Pharmacy Installation ABC Hospital

a. Customer Reception Department

This section is represented by a team of counter staff consisting of three workers. Each counter officer can only serve one order/customer at a time and the division of work is carried out alternately (cyclical).

b. Medicine Production Department

This section is handled by two drug manufacturing teams, namely the compounded drug manufacturing team and the non-concocted drug manufacturing team. The team for making compound medicines consists of three workers, while the team for making non-mixed medicines consists of two workers. The capabilities and rules for dividing workload in this section are the same as in the customer reception section.

c. Medicine Packaging Department

This section is handled by a drug packaging team consisting of three workers. The capabilities and rules for dividing workload in this section are the same as in the customer reception section.

d. Drug Inspection Department

This section is handled by a drug inspection team consisting of two pharmacists. The capabilities and rules for dividing workload in this section are the same as in the customer reception section.

4.2 Data collection

Data was collected using direct field observation methods at the ABC Hospital Outpatient Pharmacy Installation. From the observations made, data was obtained regarding the arrival time of the prescription, the handover time and analysis of the prescription by the counter staff, the processing time for giving the queue number by the counter staff, the processing time for preparing compounded medicines, the processing time for preparing non-mixed medicines, the time for the drug packaging process, the time inspection of customer medicines by the pharmacist, time for delivery of the medicine along with consultation, time the prescription is received and the medicine is ready to be handed over to the customer, data on the number of prescriptions received in one working day, as well as data on the number of compounded and non-mixed medicines in one working day.

4.3 Simulation of Existing Conditions

The existing model simulation was carried out using the Arena simulation model. The simulation model is built from the logic of the conceptual model and the observational data that has been obtained. Observation data in the form of process time needs to be processed first to obtain data distribution and parameters that can simulate the real performance of each process in the system. The observation data processing was carried out using the input analyzer in Arena. In the data distribution fitting process, the type of data distribution selected is a distribution that is capable of producing low squared error and is by the data distribution for similar processes or properties. Figure 4 is the result of fitting the distribution of time data for each system process using the Arena analyzer input.

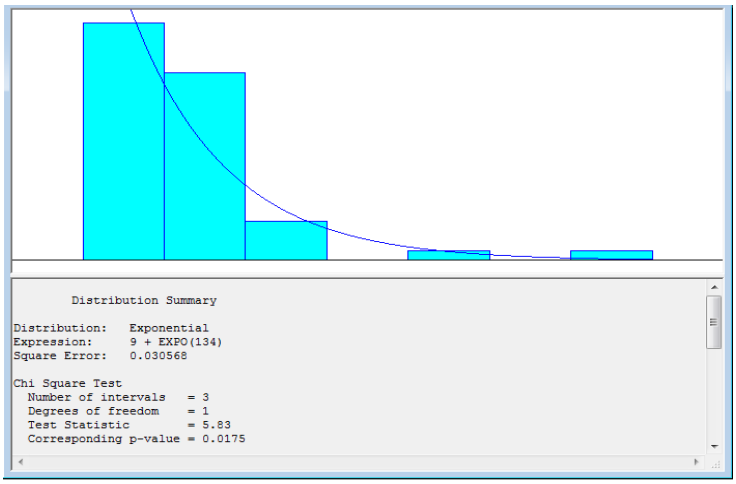

Figure 5. Chart Fitting Data Distribution of Time Between Customer Arrivals

4.4 Verification and Validation

4.4.1 Verification

Verification is the process of testing the suitability of the simulation model with the conceptual model that has been created. Practically, verification can be done by ensuring the model runs well and correctly according to the logic of the model structure. In this research, verification is carried out by checking for errors

in the simulation model (errors) using the check model feature in the Arena software which looks like in Figure 6.

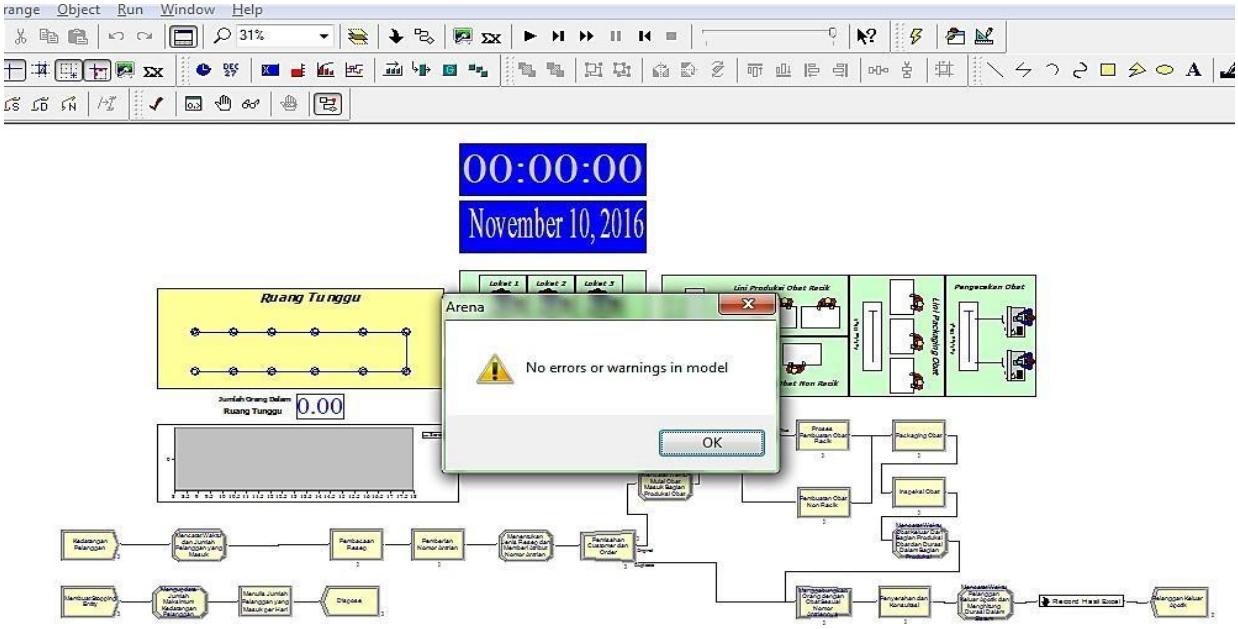

Figure 6. Simulation Model Verification Output

4.4.2 Validation

Validation is a process to test whether the conceptual model that is built is by the conditions of the real observed system. In the simulation of the ABC Hospital Outpatient Pharmacy Installation system., validation is measured by the accuracy of a verified simulation model in producing output that matches the observation data (black box validation). The model is said to be valid if the comparison results show that the simulation model output and observation data do not differ significantly from a statistical point of view. The output data used in model validation must have a relatively small error rate (less than the 0.05 significance level).

The minimum number of replications of the simulation model that must be carried out can be calculated. The first step in calculating the minimum replication model simulation is calculating the degree of freedom (df) of the input data. The following is the calculation of the degree of freedom (df) of the input data.

$$df = \frac{\left[\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right]^2}{\frac{\left[\frac{s_1^2}{n_1}\right]^2}{[n_1 - 1} + \frac{\left[\frac{s_2^2}{n_2}\right]^2}{n_2 - 1]}}$$

$$df = \frac{\left[\frac{630{,}6605}{20} + \frac{166{,}01}{20}\right]^2}{\frac{\left[\frac{630{,}6605}{20}\right]^2}{20-1} + \frac{\left[\frac{166{,}01}{20}\right]^2}{20-1}} = 28{,}35$$

Next, the half-width (hw) is calculated which describes the distribution of the data as follows.

$$hw = t_{df,\alpha/2}\sqrt{\frac{{s_1}^2}{n_1} + \frac{{s_2}^2}{n_2}}$$

$$hw = t_{28,35,0,05/2}\sqrt{\frac{630,6605}{20} + \frac{166,01}{20}}$$

$$hw = (2,0484)(6,3114) = 12,928$$

After finding the half-width value, the minimum number of simulation replications can be calculated as follows.

$$n = [\frac{Z_{\alpha/2} \times {s_2}^2}{hw}]$$

$$n = [\frac{1,6455 \times 166,01^2}{12,928}] = 2,689 \approx 3$$

From the calculations above, it can be seen that the minimum replication in the model simulation that should be carried out is three times. Once the minimum number of simulation replications is known, the next step in model validation is to test the significance of the difference in the average simulation output with the observed data. The method used in this test is the Welch Confidence Interval method. The model is said to be valid when the confidence interval formed accommodates the value 0.

Table 1. Data for Determining the Number of Simulation Replications and Testing the Significance of the Average Simulation Output

Number of Date	Number of Customer	Number of Customer Simulation Model
1	117	120
2	127	129
3	143	117
4	148	125
5	191	142
6	167	124
7	132	107
8	98	130
9	146	139
10	171	141
11	129	112
12	112	132
13	116	150
14	133	126
15	104	121
16	105	116
17	158	131
18	102	107
19	126	128
20	132	150
Rata-rata ($\bar{x}$)	**132,85**	**128,7**
Variansi	**630,6605**	**166,0105263**
Standar Deviasi (s)	**25,11296**	**12,88450722**

The following are the steps and calculations of the Welch Confidence Interval method for validating the simulation model.

H0 : μ_1-μ_2=0

HA : μ_1-μ_2≠0

Calculation of the Welch confidence interval for the level of significance α:

$$P[(\bar{x}_1 - \bar{x}_2) - hw \leq \mu_1 - \mu_2 \leq (\bar{x}_1 - \bar{x}_2) + hw] = 1 - \alpha$$

$$hw = t_{df,\alpha/2} \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$$

$$df = \frac{\left[\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right]^2}{\frac{\left[\frac{s_1^2}{n_1}\right]^2}{n_1 - 1} + \frac{\left[\frac{s_2^2}{n_2}\right]^2}{n_2 - 1}}$$

Using the input data in table 2, the Welch confidence interval value using a significance level of 0.05 is as follows.

$$df = \frac{\left[\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right]^2}{\frac{\left[\frac{s_1^2}{n_1}\right]^2}{n_1 - 1} + \frac{\left[\frac{s_2^2}{n_2}\right]^2}{n_2 - 1}}$$

$$df = \frac{\left[\frac{630{,}6605}{20} + \frac{166{,}01}{20}\right]^2}{\frac{\left[\frac{630{,}6605}{20}\right]^2}{20 - 1} + \frac{\left[\frac{166{,}01}{20}\right]^2}{20 - 1}} = 28{,}35$$

$$hw = t_{df,\alpha/2} \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$$

$$hw = t_{28{,}35,\ 0{,}05/2} \sqrt{\frac{630{,}6605}{20} + \frac{166{,}01}{20}}$$

$$hw = (2{,}0484)(6{,}3114) = 12{,}928$$

Welch confidence interval 95% confidence level:

$$(\bar{x}_1 - \bar{x}_2) - hw \leq \mu_1 - \mu_2 \leq (\bar{x}_1 - \bar{x}_2) + hw$$

$$(132{,}85 - 128{,}7) - 12{,}928 \leq \mu_1 - \mu_2 \leq (132{,}85 - 128{,}7) + 12{,}928$$

$$-8{,}78 \leq \mu_1 - \mu_2 \leq 17{,}078$$

Because the value 0 is in the 95% Welch confidence interval, H0 cannot be rejected. The difference in the average number of customers from the simulation model output and observation data is not significant, so the simulation model can be said to be valid.

4.4 Experimental Scenario Simulation

This research tries to find the best scenario in the operations of the ABC Hospital Outpatient Pharmacy Installation. The improvement scenario that will be carried out is a combination of the availability of the number of officers serving each section. Apart from increasing the number of officers, this research also tries to carry out a simulation when the number of officers available in each section is reduced due to being assigned to another location.

Table 2. Improvement Response Variables from Each Experiment Scenario

Name of Scenario	Total Average Customer System Time	Improvement
Skenario Awal	0.23	-
Non Racik (+1)	0.206	10.4%
Non Racik (+2)	0.201	12.6%
Non Racik (-1)	1.346	-485.2%
Packaging (+1)	0.22	4.3%
Packaging (+2)	0.22	4.3%
Packaging (-1)	0.232	-0.9%
Packaging (-2)	0.579	-151.7%
Racik (+1)	0.241	-4.8%
Racik (+2)	0.24	-4.3%
Racik (-1)	0.236	-2.6%
Racik (-2)	0.403	-75.2%
Apoteker (+1)	0.228	0.9%
Apoteker (+2)	0.228	0.9%
Apoteker (-1)	0.254	-10.4%
Non Racik (+1) Packaging (+1)	0.195	15.2%
Non Racik (+1) Racik (+1)	0.201	12.6%
Packaging (+1) Racik (+1)	0.241	-4.8%
Non Racik (-1) Packaging (-1)	1.445	-528.3%
Non Racik (-1) Racik (-1)	1.381	-500.4%
Packaging (-1) Racik (-1)	0.267	-16.1%

Table 2 shows the mixed medicine (+1) scenario, the addition of an officer making compound drugs causes an increase in the value of the response variable so that the system performance becomes worse. This is mainly influenced by the very high variability of the time distribution of the compounded drug manufacturing process. However, in general, the addition of compounding medicine manufacturing staff did not result in an improvement in the value of the response variable. The combination that produces better response variable values is shown by the non-mixed medicine (+1) Packaging (+1) scenario, then the non-mixed medicine (+1) mixed medicine (+1) scenario, and non-mixed medicine (+2) in the next position.

The non-mixed medicine (+1) Packaging (+1) scenario uses an additional officer in the non-mixed drug manufacturing section and an additional officer in drug packaging, resulting in the largest response variable improvement of 15.2%. Meanwhile, the non-mixed medicine (+1) mixed medicine (+1) scenario uses an additional officer in the non-mixed medicine (+1) mixed medicine (+1) scenario resulting in an improvement of 12.6% in the response variable value. In non-mixed medicine (+2), two additional officers were assigned to the non-mixed medicine drug manufacturing section which resulted in an improvement of 12.6%, or equivalent to the non-mixed medicine (+1) mixed medicine (+1) scenario.

The scenario for reducing the number of officers that is capable of having the worst effect on system performance is the non-mixed medicine (-1) Packaging (-1) scenario, then the non-mixed medicine (-1) mixed medicine (-1) and non-mixed medicine (-1) scenarios in the next position. In the non-mixed medicine (-1) Packaging (-1) scenario, there is a non-mixed medicine drug manufacturing officer and a drug packaging officer who does not serve the system, so the system performance becomes 528.3% worse than the initial condition. Meanwhile, in the non-mixed medicine (-1) mixed medicine (-1) scenario, there is an officer who makes on-mixed medicine medicines and an officer who makes compounded medicines who does not serve the system, so the system performance becomes 500.4% worse than the initial condition.

5. CONCLUSIONS AND SUGGESTIONS.

5.1 Conclusions

Based on a series of data processing, scenario preparation, and analysis of research results, some conclusions can be drawn as follows:

a. From the results of data collection and processing, it was found that in existing conditions the average time required for officers to prepare medicine was 0.23 hours or 13.8 minutes.

b. After carrying out several experimental scenarios using a process analyzer, 3 (three) best scenarios were produced, namely:

1. Non-mixed (+1) Packaging (+1) scenario, by adding 2 (two) employees in the Packaging position to 1 (one) person from the previous 3 (three) to 4 (four) and 1 (one) in the non-mixed medicine preparation position) people from originally 2 (two) became 3 (three). Of the additional employees, the average total customer time in the resulting system is 0.195 hours (702 seconds or 11 minutes 7 seconds).
2. Non-mixed medicine (+1) mixed medicine (+1) scenario, by adding 2 (two) employees in the position of preparing mixed medicine medicines to 1 (one) person from the original 2 (two) to 3 (three) and in the position of making compounded medicines as many as 1 (one) person, from 3 (three) to 4 (four). From these additional employees, the average total customer time in the system was 0.201 hours (723.6 seconds or 12 minutes 0.6 seconds).
3. Non-concocted (+2) scenario, by adding 2 (two) employees in non-concocted drug preparation positions from 2 (two) to 4 (four). From these additional employees, the average total customer time in the system was 0.201 hours (723.6 seconds or 12 minutes 0.6 seconds).

c. Comparison between existing conditions and the 3 (three) best scenarios, namely:

1. The results of the comparison between existing conditions and the non-mixed medicine (+1) Packaging (+1) scenario, namely the average total customer time in the system is 0.23 and 0.195 so that in the non-mixed medicine (+1) Packaging (+1) scenario this can be achieved. improving processes in the system by 15.2%.
2. The results of the comparison between existing conditions and the non-mixed medicine (+1) mixed medicine (+1) scenario, namely the average total customer time in the system is 0.23 and 0.201 so that in the non-mixed medicine (+1) mixed medicine (+1) scenario this can be improving processes in the system by 12.6%.
3. The results of the comparison between existing conditions and the non-mixed medicine (+2) scenario, namely the average total customer time in the system is 0.23 and 0.201 so that in the non-mixed medicine (+2) scenario this can increase the process in the system by 12.6%.

5.2 Suggestions

Based on the results of the research that the author has done, there are several inputs in improving and developing this research in the future, namely:

a. To improve the quality of service at the outpatient pharmacy installation of ABC Hospital can apply the results of the non-mixed medicine (+1) Packaging (+1) scenario, which will be able to improve processes in the pharmaceutical installation system by 15.2%.

b. If you want to involve personnel in this outpatient pharmacy installation, you can use the results from the Packaging (-1) scenario, namely by only reducing 1 (one) person in the drug packaging position. Reducing 1 person in the position of packaging drugs will increase the average value of total customer time in the system which is not very significant, namely 0.232 hours (835.2 seconds or 13 minutes 9 seconds), or experience a decrease in processing in the system by 0.9%.

ACKNOWLEDGEMENT

The authors greatly acknowledge the support from Indonesia Naval Technology College STTAL Surabaya Indonesia for providing the necessary resources to carry out this research work. The authors are also grateful to the anonymous reviewers and journal editorial board for their many insightful comments, which have significantly improved this article.

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APPLICATION OF X BAND AND S BAND RADAR ON THE SHIP MV BULK CARRIER TO DETECT OBJECTS UNDER THE SURFACE OF THE SEA FOR SHIPPING SAFETY

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ABSTRACT
Radio Detection And Ranging or often called RADAR is an electromagnetic wave system used to detect, measure, and find out objects and bad weather within a certain range as long as RADAR can reach it. The purpose of the study was to determine the cause of RADAR in MV. Bulk Carrier cannot detect an object below the surface of the water and To find out the benefits of optimizing X Band and S Band RADAR on MV ships. dear Bulk Carrier This type of research is qualitative descriptive research. This research was carried out on March 16, 2023 at PT. L… P… L… at MV Bulk Carrier The results of the study obtained that X band and S band radars have different capabilities in detecting objects below sea level. X band radars have a shorter detection range but higher resolution, making them more suitable for detecting small objects. S band radars have a longer detection range but lower resolution, making them more suitable for detecting large objects. The use of X band and S band radars on the MV Bulk Carrier is quite effective in detecting objects below sea level, such as corals, obstacles, and submarines. However, there are some obstacles faced, such as interference from sea waves and bad weather. The application of X band and S band radars on the MV Bulk Carrier ship can improve shipping safety by detecting objects below sea level. However, efforts need to be made to optimize its use to make it more effective.

KEYWORDS: X band radar, S band radar, subsurface object detection, shipping safety.

1. INTRODUCTION.

In the world of transportation, especially in the world of sea transportation, often when sailing in a channel or in the open sea where movement is not limited, the ship where I practice really needs navigation equipment in the hope that it can help while sailing for shipping safety. As far as I know, as a cadet at the Surabaya Shipping Polytechnic, the ship has several navigation tools used by the watch captain or other deck *officers* to assist in carrying out bridge watch duties such as GPS, ECDIS, AIS, and also including RADAR and ARPA.

RADAR plays a big role when a ship is sailing, especially in narrow shipping lanes with the aim of determining whether or not there are dangers around the ship. *Radio Detection And Ranging* or often called RADAR is an electromagnetic wave system that is used to detect, measure and identify objects and bad weather within a certain range as long as RADAR can reach it.

RADAR can detect nearby objects by emitting (Transmitter) radio waves and when the emitted radio waves hit an object, the waves will automatically reflect on the RADAR *Receiver* . After receiving these waves, RADAR will show where the object is and what objects have been detected, not only that but can detect the distance of the object and find out whether the object is moving or not.

There are 2 types of RADAR on board ships, namely X Band RADAR which has a frequency range of around 8.0 – 12.0 GHz and a wavelength of 2.5 – 3.75 cm in the RADAR has different wave propagation ranges to suit its use in detecting distant and close targets around the ship so that the ship can avoid existing dangers.

In accordance with the STWC 1978 provisions in section AI/12 of the STCW Code, however, even though it has been tested and officially has regulations that require every ship to have a RADAR on board, there are still times when electronic items experience *errors* , which is from my experience.

The incident that I experienced when sailing in the waters of *the Makassar Strait* , in fact the waters were safe, but considering the meteorological location of these waters is close to the island of Kalimantan which still has lots of forests and swamps plus coal mining which is increasingly widespread and resulting in land clearing and trees and swamp plants being carried away. to the sea.

The case that occurred when I was passing through these waters in the evening and raining where the RADAR was already in the active position and in accordance with *the Master Night Order* , we who were on the bridge during the watch felt that there was a hard object that hit/collided the ship MV. Bulk Carrier After carrying out an inspection It turned out that there was a log accompanied by swamp plants (Nipah plants) around it that had been hit by the ship's bulbous, causing the front of the ship to be damaged and scratched.

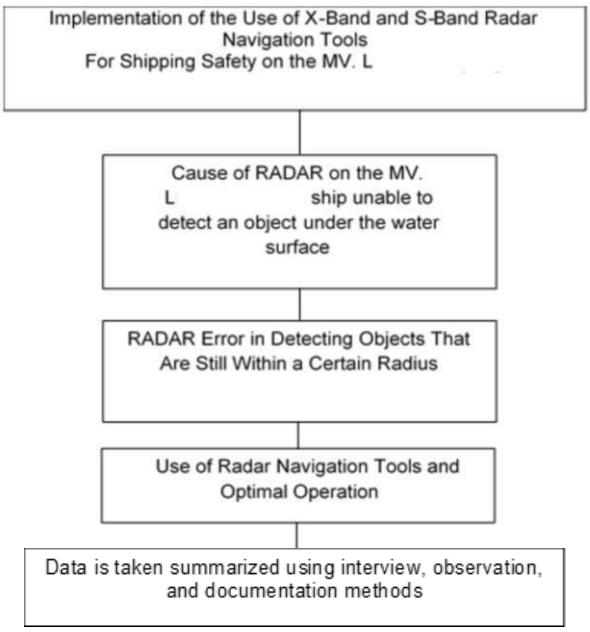
This incident forces us who are on guard duty to be alert to all objects around us and optimize all navigation equipment on the ship to support safety when the ship is sailing. From the description of the incident above, the author will discuss the title "Implementation of X Band and S Band Radar Onboard an MV . Bulk Carrier Dear To Detect Objects Below Sea Surface For Safety Voyage **"**.

2. MATERIALS/METHODOLOGY; EXPERIMENTAL PROCEDURE.

Research Framework

This writing has a framework that shows the flow and steps of writing such as the framework below:

Figure 1. Research Framework



Source: Personal

2.1. Types of research

This research was written using qualitative research methods. Qualitative research is descriptive and often uses analysis. In qualitative research, the emphasis is on process and meaning (subject perspective). The theoretical basis is used as a guide to ensure that the research focus is in accordance with the facts in the field, and also provides a general description of the research setting and discussion of research findings.

2.2. Research Location and Time

To obtain data related to the problems discussed in this paper, the author carried out research during marine practice (PRALA) precisely from March 4 2023 to August 7 2023 at the company PT. L… P… L… on one of the MV Bulk Carrier ships.

2.3. Data Sources and Data Collection Techniques

Data sources are anything that can provide information about related research. The data used in this research uses two types of data sources, namely primary data and secondary data.

According to Sugiyono (2018:456) Primary data is a data source that directly provides data to data collectors. Data is collected by the researcher himself directly from the first source or place where the research object is carried out. Researchers used the results of interviews obtained from informants regarding the research topic as primary data. According to Sugiyono (2018:456) secondary data is a data source that does not directly provide data to data collectors, for example through other people or through documents. In this research, the secondary data sources are in accordance with the Employment Law, books, journals, articles related to research topics regarding internal control systems for payroll systems and procedures in an effort to support labor cost efficiency.

study , the research informants were crew members on commercial ships used as a place to carry out maritime practices (PRALA). Data collection techniques used include interview techniques , observation techniques and documentation techniques.

An interview is a question and answer session with someone who needs to be asked for information or an opinion about something where the interviewer (*Interviewer*) asks questions to the interviewee (*interviewee*). This is done to evaluate the capabilities of the ship's crew in certain situations. Observation is a condition where direct observations are carried out by researchers in order to be better able to understand the context of the data in the entire social situation so that a holistic (comprehensive) view can be obtained (Sugiyono, 2020: 109). This technique is used in dealing with emergencies on board ships carried out by the ship's crew. Documentation is a method used to obtain data and information in the form of books, archives, documents, written numbers and images in the form of reports and information that can support research (Sugiyono, 2018:476). This technique is used to support or as evidence related to institutions and administration as well as in dealing with emergencies on ships and so on.

2.4. Data analysis technique

The presentation of this thesis writing can use descriptive analysis methods. Descriptive means describing in detail events in the field and putting them in written form starting from the emergence of a problem, until finding a solution to the problem.

Qualitative means collecting data that is narrative, descriptive and contains intensive field notes. The data that has been obtained is processed according to the theories and methods that have been determined from the start before carrying out data collection. The data that has been processed is then analyzed

according to the scientific discipline used. Based on the results of this analysis, discussions were then carried out until everything was finished, then questions related to the research could be confirmed and concluded through this research.

3. RESULTS AND DISCUSSION.

3.1 Overview and Location of Research

In this thesis the author will describe a general description of the research object according to the title, namely " Application of X Band and S Band Radar Onboard an MV . Bulk Carrier Dear To Detect Objects Below Sea Surface For Safety Voyage ". So, with a general description of this research, readers can understand and understand what happened when the author conducted research on the MV. Bulk Carrier which is owned by PT. L… P… L… .

The following is *the Ship Particular* MV. Dear Bulk Carrier :

Ship Particular

Ship Name	: Bulk Carrier DEAR
Vessel Type	: *Cargo*
Vessel Specific Type	: *Bulk Carrier*
IMO	: 9******
MMSI	: 5********
Call Sign	: Y****
DWT	82133
Year Built	: 20**
Managing Company	: N/A
Flag	: ID
Engine Type	: Kawasaki Heavy Industries l Motor l 6s60me-c8
GT	43361
KW	: N/A
Length	: 229 AD
Width	: 32 M

Figure 2. MV. Bulk Carrier Dear

Source: Personal Documents

3.2 Research result

A. Data Presentation

In presenting this data, it will be described using the results of observations and interview results which can be explained as follows.

a. Observation Results

1) On Tuesday, April 12 2023, at 16.45 WITA, when the ship sailed to Adang Bay to load, it was already in *Makassar Strait* . The ship experienced problems where the ship hit or collided with logs and palm trees and caused vibrations that were felt up to the bridge. This incident was very detrimental and worrying because it was feared that there would be a leak or fatal damage that would endanger the ship's cargo and crew, but at that time there was no leak or major damage to the front of the ship and the ship had almost arrived at its destination. Optimal and effective use of navigation tools must always be implemented to avoid fatal errors occurring in the future , due to the use of less effective navigation tools.
2) When the ship sailed towards *Adang Bay* , on April 12 2023, precisely at *Makassar Strait* at 16.45 the ship experienced a collision or hit a log and palm tree which caused vibrations that could be felt on the bridge, where the distance from the bow to the bridge at the stern was very far. up to 200 meters more. At that time the target was visible on *the Radar* but it only blinked or was not clear enough (appearing to disappear and disappearing) and the officer on duty only predicted that it was only a small object that was under the surface of the water but could still rise to the surface of the water (the object only floated and did not sink fully).
3) At that time the 2nd Officer who was still on the bridge and *the cadet* who was on guard duty went straight to the bow on the orders of *the Chief Officer* who was on the bridge to check whether there was a leak or not and what impact the incident had. Where at that time the ship was empty or had just finished unloading at PLTU Tanjung Wangi, and would be loading at Adang Bay. When inspected it turned out that the front of the ship had scratches and damage that was not too fatal which resulted in a leak, however, to minimize the occurrence of leaks, the 2nd captain informed the C/O to contact the bosun and bring a wrench to open *the Forecastle Ballast Tank Manhole* and enter to Check the condition of the inner plate if the impact occurred, whether it was damaged or not, fortunately there was no damage that caused the plate to be dented inward due to the impact. After carrying out careful and thorough observations and confirmation via radio with the bridge or C/O the ship was declared safe and only suffered minor damage and was still normal, where the vibrations felt from front to back occurred because the ship was empty and had no cargo, the dimensions of the hatch were Big and high are the main factors for continued vibrations. However, the lack of optimization of navigation tools, especially radar, can be detrimental to the ship's *crew* , cargo and company if a leak occurs on the ship.

Figure 3. MV. Bulk Carrier Dear

Source: Personal Documents

b. Interview result

From the results of interviews with respondent 1 (*Chief Officer*), respondent 2 (*Second Officer*), and respondent 3 (*Third Officer*), the author found that optimization of radar navigation tools still needs to be improved to minimize and avoid collisions, especially with relatively small objects and not only focuses on ships and *buoys* only.

1) The results of the interview with respondent 1, stated that the reason why ships can hit logs causing vibrations to the bridge is because the predicted C/O of wood or nipa palm plants is small and is only considered harmless marine debris, because our ship itself has large dimensions and is not will be affected but there will be prediction errors and less optimization of the use of navigation tools and circumnavigation.
2) The results of the interview with respondent 2, stated that the cause of the ship experiencing this incident was because the use and setting of the radar was not appropriate for the water conditions, the weather, and in the conditions of the evening or near night, where the radar should have been used more optimally and was able to detect the movement of objects. certain things which are actually difficult to detect, such as in this case where the object is floating and going up and down on the surface of the sea water, so that if it is detected by radar, the officer on duty can know that there is an object in front of the ship and can confirm it through direct observation whether the object is whether it is dangerous or not and what actions need to be taken, whether to avoid it or go through it safely.
3) The results of the interview with respondent 3 stated that the reason the ship experienced this incident was due to lack of preparation when carrying out guard duty and it was only considered a normal problem or radar *error* , so this incident occurred. However, less than optimal use of navigation tools also has an impact at that time, so the use of navigation tools must be optimized to avoid undesirable events.

B. Data analysis

The use of navigation tools in the world of shipping plays a very important role in having a positive impact on shipping safety and security, especially radar which is always used on any shipping route and anywhere.

However, there are several obstacles in using and optimizing radar on ships, therefore to help optimize it by providing procedures and SOPs for operating or maintaining radar on ships.

a. Many officers when carrying out guard duty still neglect to turn off and on the radar and do not follow the appropriate procedures, do not change the radar display to the zero position and still apply objects on the target and *range.* When they want to turn off the radar, they immediately turn it off without changing it to *range* 6 NM uses x-band and s-band radar, which means the radar navigation tool does not work optimally when it is turned on again and is long-term.
b. *False echo* radar interference occurs where more than one shadow of an object appears, in the radar layer where *the false echo* consists of:
    1) *Multiple echo* radar interference where the image of the target is split or biased into 2 with the same bearing, due to the strong *echo reflection power* and *the gain* being too large.
    2) *Indirect echo* radar interference where the image of a target in the opposite direction from the target is caused by reflections from the ship itself.
    3) *Side echo* radar interference, which causes false images that are influenced by strong side lobes.
c. When carrying out the watch handover, the author saw that the officer on watch often gave information about the surrounding situation and neglected to check the ship's position on ECDIS, AIS, especially on the x-band radar and s-band radar to carry out *performance tests* and did not *record it* in the *radar log book.* which is only done once, which can be 5-10 days before writing on the platform. This is very important because from this it can be seen and monitored that the operation of the radar is working optimally or requires repair, so that officers are aware of the deterioration in the condition of the radar they are operating.

Table 1. Data analysis

NO	Question	Resource Person's Answer
1.	What causes RADAR on MV ships? Bulk Carrier unfortunately, can't detect objects below the water surface?	Speaker 1 The reason the radar on the ship could not detect this object was due to an error in identifying it and the ship was empty Interviewee 2 So the radar at that time was not set to relative, so if the object was large and moving it would have a tail in the opposite direction to our ship Interviewee 3 This may be due to lack of preparation when carrying out observations and less than optimal use of radar
2.	How to optimize the use of X-Band and S-Band RADAR on MV ships. Bulk Carrier darling?	Speaker 1 Can see and ensure that when carrying out guard duty and operate correctly and as effectively as possible as well as more thorough observation Interviewee 2 Follow procedures and follow the radar manual correctly so that errors and accidents can be minimized Interviewee 3 Can be further improved in knowledge, use and operation of navigation tools and ensure more thoroughness

3.3 Discussion

Based on the results of observations and interviews with several *crew*, what the author obtained while carrying out practices on board the ship and produced supporting statements, namely:

1. Radar is an electronic navigation tool that is very influential and very helpful in the world of shipping, which is useful for determining and detecting the position of targets or ships from time to time on a regular basis. To determine the position of the target to be observed, you can use a stand or distance and setting is also very important to ensure that the target or object is moving or not. When operating the radar position at *head up* , so that the radar functions effectively and efficiently, it is not difficult to determine the position of the ship or objects in front of the ship, it is also very helpful when making observations to avoid whether or not there is a danger of collision. Then by looking at *the layers crt* or *Catode Ray Tube* which is shown on the radar layer which shows the strength of the reflection received, which will produce dots that show the surrounding conditions of bad weather, rain or existing objects and the denser the object, the clearer it will be shown on the x-radar screen band and s-band. Even

though the signal obtained is relatively small, it can be strengthened with radar, which is very helpful in the shipping process and ship operations safely and efficiently to get to the destination safely .

4. CONCLUSION.

Based on conclusions from facts and research on the application of x-band and s-band radar on board the MV. Bulk Carrier. To detect objects below sea level for shipping safety, researchers can draw the following conclusions:

1. The factors that cause x-band radar and s-band radar are not optimal and cannot detect objects below sea level, according to discussions and interviews with sources who knew at the time of the incident, it is known that the operation of radar navigation equipment must be careful and can operate and adjust x band radar and s band radar in every situation and be less careful about what dangers await when taking something that is considered normal for granted .
2. The lack of effective operation and use of the x band radar and s band radar navigation tools, which should be operated and observed while on guard duty and should not underestimate something that is observed, should always be ready and must understand in every situation what should be done and the use of the x-radar. and s-band which should be able to avoid unwanted events.

On this occasion, the researcher will provide several suggestions that may be useful and helpful to other people, other researchers, and also readers. The suggestions are as follows:

1. It is best when carrying out guard duty to at least check the operation of the x-band radar and s-band radar which should be checked and also the surrounding situation, optimizing the use of x-band radar and s-band radar must be carried out to find out what objects are ahead and around the ship to avoid objects or ships that have a risk of colliding with the ship.
2. Always carry out and carry out safety and prevention measures related to collisions with ships and other objects of a wild or unknown nature which should be avoided, and of course increasing the operation and optimization of x-band radar and s-band radar navigation equipment for ship crews and of course The application of rules must be optimized again, so that you don't just use *feeling* and *instinct* which always underestimates something and considers it normal.

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FIELD II

HUMAN RESOURCE

Indonesian Naval Technology College
Postgraduate International Conference, Vol. 8, No. 1, pp. 89-103
June, 27th 2024

THE INFLUENCE OF CHARACTER EDUCATION, LEARNING MOTIVATION ON THE COMPETENCY AND PERFORMANCE OF PUSDIKLEK GRADUATES IN CARRYING OUT THE MAIN DUTIES OF THE INDONESIAN NAVY

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ABSTRACT

In carrying out the main tasks of the Indonesian Navy, professional and reliable personnel of the Indonesian Navy's defense equipment are needed. This can be done by improving the quality of character education and learning motivation, especially at the Pusdiklek Kodikdukum Kodiklatal which is responsible for preparing marine soldiers of the electronics corps who are moral, professional and have mastered the technology in the fields of electronics and informatics. This study examines the influence of character education, learning motivation and competence on the performance of Pusdiklek graduates, using the Structural Equation Modeling (SEM) method. This study aims to test the significance of the influence of character education, learning motivation both directly and indirectly through competence on performance. The results of the study indicate that character education has a direct and significant effect on competence with an estimated path coefficient of 0.415; learning motivation has a direct and significant effect on competence with an estimated path coefficient of 0.522; competence has a direct and significant effect on performance of 0.359; character education has a direct and significant effect on performance with an estimated path coefficient of 0.288; learning motivation has a direct and significant effect on performance with an estimated path coefficient of 0.454; character education has a significant influence on the performance of soldiers graduating from Pusdiklek through competence (as a mediating variable) with a mediation coefficient of 0.149; and learning motivation has a significant influence on the performance of soldiers graduating from Pusdiklek through competence (as a mediating variable) with a mediation coefficient of 0.187. All hypotheses proposed are accepted, indicating that increasing character education, learning motivation and competence can have a significant influence on improving the performance of Pusdiklek graduates.

KEYWORDS : character education, learning motivation, competence, soldier performance, SEM.

1. INTRODUCTION.

The Indonesian Navy, as the main component of maritime defense according to Law Number 34 of 2004 Article 9, has the responsibility to maintain and defend the sovereignty of the Republic of Indonesia by remaining loyal to Pancasila and the 1945 Constitution. Their main tasks include enforcing the law and sovereignty in the national jurisdictional sea area, implementing diplomacy, developing and building maritime power, and empowering maritime defense areas. To optimize these tasks, competent and responsible Indonesian Navy soldiers are needed, especially Electronic Corps soldiers who play a crucial role in maintaining national security through vital military electronic systems such as communication, radar, and navigation. Improving the competence and performance of these soldiers is important to ensure operational reliability and efficiency. However, there are challenges in achieving the desired competence, which can be seen from indicators such as low quality of work, speed, and initiative. In addition, rapid technological developments require soldiers to always update their knowledge and skills, although the current vocational education curriculum does not fully meet these technical needs. To carry out the vision of a reliable and respected Indonesian Navy and its mission in sustainable strength development, human resource development is the main priority of the Chief of Naval Staff (Kasal). The daily guidelines of the Chief of Naval Staff that focus on developing superior, competent human resources capable of facing various threats emphasize the importance of improving the quality, competence, and performance of Indonesian Navy soldiers for the best service and glory of the nation. Continuous efforts in developing soldier

capabilities ensure that the Indonesian Navy remains a reliable and respected force in carrying out its duties.

This study integrates theories from various journals and international studies that link four main variables: character education, learning motivation, competence, and performance. The main source of theory is research by (Ismail, 2021) which evaluates the influence of competence and compensation on civil servant performance through job satisfaction at the Malang Army Polytechnic. This study highlights the critical role of human resources in achieving organizational goals and uses an innovative approach to assess performance in the ministry/institution environment, which was first implemented by the Indonesian Government in 2012. This study develops a model that links learning motivation with competence and performance of the ministry/institution sector, which was previously used to predict business sector performance. Before discussing the theory of character education, learning motivation, competence, and performance, this study outlines the concept of organizational behavior, emphasizing the importance of the role of human resources in organizations that pay attention to individual actions and responses in various environments. In organizations, individuals are recruited, educated, trained, receive information, receive protection, and experience development, which refers to the way individuals interact in the organization. The organization itself is a group of two or more people who come together to achieve a common goal, with members who regularly interact, work together, have common goals, and carry out assigned roles (Baack, Reilly, 2014). According to Scott, an organization is a system of coordinated activities involving a group of people working together to achieve common goals, regulated by a certain authority (Hardjana, 2016). (Robbins, 2011) defines organizational behavior as the study of the influence of individual, group, and structural behavior on organizations, with the goal of improving organizational performance. (Schermerhorn Jr, 2002) adding that organizational behavior is the study of individuals and groups within organizations, while (McKenna, 1995) states that individual performance measurement involves indicators of ability and skills at work, work attitudes, and motivation.

The objectives of this study are: (i) to test the significance of the influence of character education on vocational competence, (ii) to test the significance of the influence of learning motivation on vocational competence, (iii) to test the significance of the direct influence of vocational competence on performance, (iv) to test the significance of the influence of character education on performance, (v) to test the significance of the influence of learning motivation on performance, (vi) to test the significance of the indirect influence of character education through competence (as a mediating variable) on performance, and (vii) to test the significance of the indirect influence of learning motivation through competence (as a mediating variable) on performance.

Many studies have been conducted on character education, motivation, competence, and performance, but none have specifically discussed the influence of character education and learning motivation on the competence and performance of Pusdiklek graduates. This is the background for the author to develop this research. This study acknowledges the complexity and intricacy of the relationship between variables and their indicators, so it uses the Structural Equation Modeling (SEM) method. SEM is a multivariate statistical analysis method that can measure latent variables, analyze factors, paths, and regressions simultaneously, and measure direct and indirect effects. The managerial implications of this study are to expand the findings of previous studies and contribute to the knowledge and literature on the impact of character education and learning motivation on the performance of Pusdiklek graduates, using vocational competence as an intermediary variable through SEM. This study also contributes to the development of human resources, especially in improving the performance of Pusdiklek graduates, and provides recommendations to the Indonesian Navy Education Office in implementing

vocational education and improving the performance of non-commissioned officers and privates graduates of Pusdiklek in work units.

2. METHODOLOGY

2.1. Research Approach

This study uses a descriptive quantitative analysis approach, which is a method that aims to describe and analyze phenomena or characteristics of a population or sample systematically with numerical data. This approach focuses on collecting quantitative data and statistical explanations to explain the distribution, frequency, and relationships between variables. Starting with the identification of problems which are then developed, followed by data processing, analysis, and drawing conclusions according to the research objectives. The significance of the variables is measured continuously through the interaction of variables during the study. This process involves observation, measurement, and data processing to find solutions to existing problems. The instrument used is a questionnaire, which has been tested for validity and reliability to ensure accuracy. After the data is collected, data processing and analysis are carried out, followed by in-depth and interpretation of the results that make a significant contribution to the development of science and technology, especially in the field of personnel competence and performance of non-commissioned officers of the Electronic Corps graduates of Pusdiklek.

2.2. Data Sources, Subjects and Objects of Research

(Sugiyono, 2021), Primary data is the main source in research, obtained directly through interaction with research subjects. In this study, primary data was collected through interviews with the head of the electronics department and questionnaires given to NCOs and Privates who graduated from Pusdiklek who served on the Republic of Indonesia Warship (KRI), with additional secondary data from related books and journals.

The subjects of this study consisted of 277 non-commissioned officers and private personnel who graduated from Pusdiklek. According to (Ghozali Imam, 2014), the minimum sample size for a structural equation model is 200 observations, Meanwhile (Hair *et al.*, 2014) suggested that the minimum sample size for SEM analysis is 100 to 200, or at least 5 to 10 times the number of variables in the model formulated as follows:

$$n = 5 \times Xvariabel\ Model\ s.d.\ 10 \times Xvariabel\ Model \quad (3.1)$$

From the formulation above, the minimum sample size is 150 samples. In addition to using the calculation above, the author also applies the Slovin Method as a comparison through the following equation:

$$n = \frac{N}{1+Ne^2} \quad (3.2)$$

with description:

n = sample size to be observed

N = population number of Pusdiklek Graduates

e = precision value (e.g. 95% confidence level, then e = 0.05)

The calculation results using the Slovin Method show that the number of samples needed is 164 respondents, thus the number of respondents has met the minimum sample size requirements.

The object of this research focuses on character education including religious, honest, tolerant, disciplined, hard working, creative, independent, democratic, curiosity, national spirit, love of the homeland, appreciation of achievement, communicative, love of peace, fond of reading, care for the environment, care for society, and

responsible. Learning motivation includes attention, relatedness, self-confidence and satisfaction. Competence includes knowledge, skills and work attitude and performance includes quality of work, speed, initiative, ability and communication possessed by NCOs and Privates who graduated from Pusdiklek.

2.3. Research design

2.3.1. Data collection technique

The data in this study are divided into two types, namely primary data and secondary data. Data collection is carried out through two main methods, namely measurement activities, observation and interviews for primary data and literature observations including notes, books, and supporting documents for secondary data.

2.3.2. Data Collection Instruments

The data collection instrument used is a questionnaire. Before the questionnaire can be used to collect data, validity and reliability tests are carried out on the instrument. After the data is collected, data processing and analysis are carried out. The next step involves in-depth exploration and interpretation of the results and conclusions, which are significant in contributing to the advancement of science and technology, especially in the context of the field of education and the performance of Pusdiklek graduates.

2.3.3. Data Analysis Techniques

This study uses quantitative descriptive analysis to describe the research object and variable characteristics, as well as inferential analysis with the SEM (*Structural Equation Models*) method to test the hypothesis at a significance level of $\alpha = 0.05$, which requires certain assumptions related to sample size, measurement scale, and data distribution. In data analysis techniques can be explained as follows:

a. Operational definition

Operational definitions, developed through literature review and theory analysis, help measure hidden variables and are used as a reference for data collection for the variables Character Education (X1), Learning Motivation (X2), Competence (Z), and Performance (Y), which are broken down into specific indicators.

1) Based on Presidential Regulation Number 87 dated September 6, 2017 concerning the Improvement of Character Education (PPK), the variables related to Character Education (X1) can be measured using other latent variables, namely: religious (X1.1), honest (X1.2), tolerant (X1.3), disciplined (X1.4), hard working (X1.5), creative (X1.6), independent (X1.7), democratic (X1.8), curiosity (X1.9), national spirit (X1.10), love of the homeland (X1.11), appreciate achievement (X1.12), communicative (X1.13), love of peace (X1.14), like to read (X1.15), care for the environment (X1.16), care for society (X1.17) and responsible (X1.18).

2) Research entitled Learner motivation and E-learning design: a multinationally validated process (Keller & Suzuki, 2004), the ARCS model introduced by John M. Keller and Suzuki Katsuaki can be used as a measurement variable that helps in understanding and assessing the level of learning motivation (X2) including: attention (X2.1), relevance (X2.2), self-confidence (X2.3) and satisfaction (X2.4).

3) Based on the Technical Guidelines for Job Competency Standards, the competency variable (Z) can be measured using other latent variables, namely knowledge (Z1), skills (Z2), and attitude

(Z3).

4) Performance measurement indicators (Y) explained by (Nahrisah & Imelda, 2019) include: Quality of Work (Y1), Speed (Y2), Initiative (Y3), Ability (Y4) and Communication (Y5).

b. Research Model and Indicators

Based on the operational definition and conceptual understanding that have been described previously, a detailed research model can be prepared, providing an overview of how Character Education, Learning Motivation influence the Competence and Performance of Pusdiklek graduates.

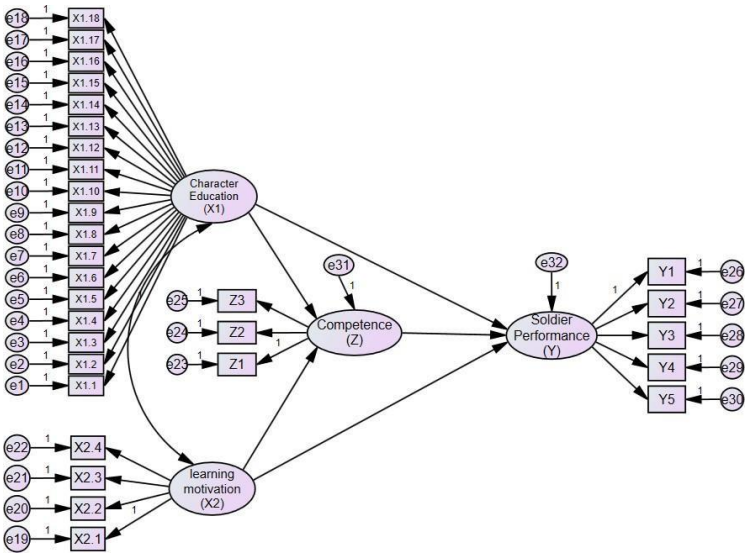

Fig. 1 Research Concepts and Variables
(Source: AMOS 24)

c. Sequence of Data Processing and Analysis Process

1) Data preparation stage with SPSS 25 software

The data obtained through the questionnaire were processed in SPSS file format (*.sav) and standardized into z-scores to maintain variance consistency by subtracting the data value from the mean and dividing it by the standard deviation.

$$z - score = \frac{X-\mu}{\sigma} \quad (3.3)$$

with description:

μ = average score

σ = standard deviation

This transformation or standardization of the results aims to obtain a data distribution that is close to normal, especially if the sample size used is large enough. Thus, the average value and standard deviation of the sample can approach the average value and standard deviation of the population of the research object.

2) SEM Analysis Stage with AMOS 24 software

After the SEM model was created with AMOS 24, the prepared data was entered for analysis using the Maximum Likelihood method in statistical software such as SPSS and AMOS to estimate model parameters. To ensure the accuracy of the model, a normality test was carried out using the C.R or Critical Ratio Skewness and Kurtosis values where according to (Finney, S. & DiStefano, 2006) the skewness value was accepted <±3 and Kurtosis <±7. Another opinion (Collier, 2020)

states that C.R Kurtosis <±10 can still accommodate normally distributed data. Multicollinearity testing is carried out by looking at the correlation between variables. A correlation value <0.90 indicates no multicollinearity (Yamin, 2024). Furthermore, the multivariate outlier test uses the Mahalanobis Distance statistic where in (Yamin, 2024) this value can be seen from the AMOS 23 output from the p1 and p2 values. If the value of p1 and p2 together is <0.001, then the respondent or row data is a multivariate outlier. With 164 respondents, the number of samples meets the minimum requirements multiplied by five with the number of indicators, which is 150. Furthermore, the evaluation of the CFA model is carried out through validity testing with loading factors, reliability with Cronbach's Alpha and Construct Reliability, and convergent and discriminant validity using metrics such as Average Variance Extracted and HTMT to ensure accuracy between variables.

2.4. Conceptual Framework

The conceptual model in this study is formulated based on a literature review and supported by previous research findings. The use of a conceptual framework is expected to provide a comprehensive picture of the research design to be implemented. Based on the theory of organizational behavior, which is a field of study that explores the influence of individual, group, and structural behavior on an organization, this knowledge improves organizational performance (Robbins, 2011) while according to (McKenna, 1995) measuring individual performance there are several indicators including abilities and skills in work/competence, individual work attitudes, and motivation. To understand the correlation between motivation variables, competence, and employee performance, exploration of their relationship is very important. The motivation theories used (Thomas L. Good & Jere E. Brophy, 1990), competence (Spencer & Spencer, 1993), performance (Stephen P., 1996). This conceptual framework is supported by previous studies that describe the relationship between variables, as seen in Figure 2.

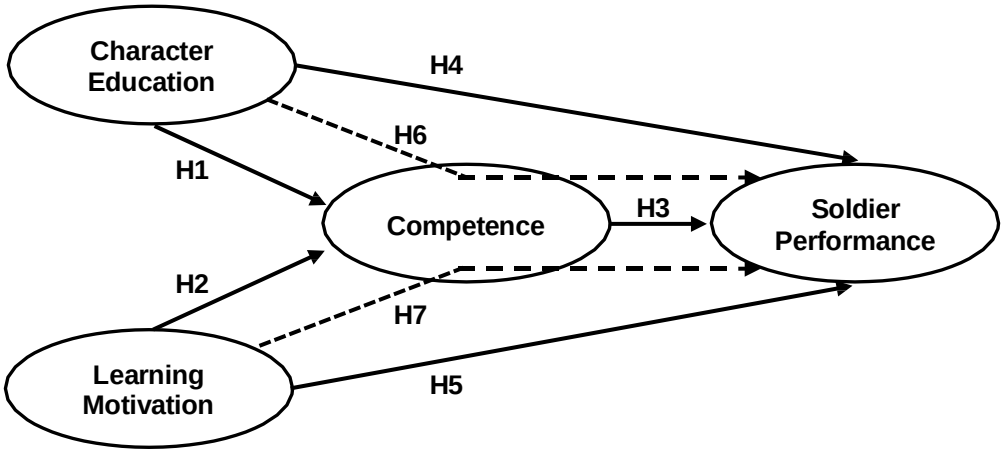

Fig. 2 Conceptual framework effect of Character Education, Motivation, and Competence on Performance of the employee

3. RESULT AND DISCUSSION

3.1. SEM Assumption Test

Before conducting the hypothesis test, this study first conducted a series of SEM analysis assumption tests. This was done to ensure that the data to be used in the SEM analysis met the required criteria. The SEM assumption tests conducted included multivariate outlier tests, normality tests, and multicollinearity tests.

3.1.1. Multivariate Outlier Test

The following are the results of AMOS 24 data processing.

Table. 1 Multivariate Outlier Test

Observation number	Mahalanobis d-squared	p1	p2
63	56,316	0,003	0,338
120	54,092	0,004	0,168
132	49,672	0,013	0,377
89	48,461	0,018	0,335
101	48,455	0,018	0,171
125	47,058	0,025	0,217
110	46,356	0,029	0,194
79	45,468	0,035	0,216
73	44,956	0,039	0,192
90	44,4	0,044	0,185
30	43,929	0,048	0,173
36	43,306	0,055	0,194
98	42,749	0,062	0,213
80	42,598	0,064	0,161
92	42,253	0,068	0,151
55	41,411	0,08	0,244
130	41,371	0,081	0,176
149	41,25	0,083	0,135

(Source: AMOS 24 Output)

Based on the results of simultaneous processing of the p1 and p2 values in the multivariate outlier test, none of them are less than 0.001, so this result shows that there are no respondents or data rows that are classified as multivariate outliers, none of the respondents' answers are classified as outlier data, the first SEM assumption is met.

3.1.2. Normality test

Second, data normality tests can be carried out univariately and multivariately where the normality test is seen from the size of skewness or kurtosis. The Critical Ratio (CR) value of skewness <± 3 and kurtosis <± 7 (Finney, S. & DiStefano, 2006) can be said that the data distribution is normal. However, according to (Collier, 2020) the Kurtosis value <±10 data can be said to be normally distributed. The following are the results of data processing.

Table. 2 Univariate and Multivariate Normality Tests

Variable	min	max	skew	c.r.	kurtosis	c.r.
X1.1	-3,871	1,953	-1,268	-6,627	2,907	7,598
X1.2	-3,790	1,938	-1,128	-5,896	2,542	6,644
X1.3	-3,790	1,938	-1,128	-5,896	2,542	6,644
X1.4	-3,744	1,955	-0,729	-3,809	1,482	3,875
X1.5	-3,681	2,082	-0,694	-3,629	1,260	3,295

Variable	min	max	skew	c.r.	kurtosis	c.r.
X1.6	-3,924	1,939	-1,006	-5,259	2,144	5,605
X1.7	-3,618	1,966	-0,525	-2,742	1,115	2,916
X1.8	-3,627	1,919	-0,951	-4,971	1,955	5,110
X1.9	-3,688	1,978	-0,948	-4,956	2,081	5,440
X1.10	-3,489	1,947	-0,789	-4,123	1,496	3,910
X1.11	-4,050	2,030	-0,688	-3,596	1,237	3,234
X1.12	-3,913	1,619	-0,709	-3,705	1,273	3,328
X1.13	-3,485	1,758	-1,002	-5,236	2,150	5,620
X1.14	-3,765	1,687	-0,814	-4,254	1,711	4,472
X1.15	-3,566	1,703	-0,807	-4,220	1,744	4,558
X1.16	-3,516	1,498	-0,655	-3,424	0,959	2,507
X1.17	-3,782	1,768	-0,821	-4,292	1,738	4,543
X1.18	-3,518	1,977	-0,643	-3,364	1,508	3,943
X2.1	-4,125	1,584	-0,920	-4,810	2,675	6,993
X2.2	-3,584	1,429	-0,762	-3,983	1,560	4,077
X2.3	-3,630	1,480	-0,562	-2,941	0,963	2,516
X2.4	-3,579	1,183	-0,697	-3,643	0,679	1,774
Z1	-3,648	1,369	-0,782	-4,090	1,279	3,344
Z2	-3,660	1,605	-0,706	-3,689	1,339	3,500
Z3	-3,633	1,322	-1,000	-5,230	2,013	5,263
Y1	-3,500	1,480	-1,072	-5,606	2,281	5,964
Y2	-3,336	1,381	-0,940	-4,914	1,891	4,942
Y3	-3,389	1,321	-0,791	-4,133	1,119	2,924
Y4	-3,360	1,310	-1,058	-5,529	2,078	5,432
Y5	-3,382	1,338	-0,713	-3,727	0,992	2,593
Multivariate					50,56	7,388

(Source: AMOS 24 Output)

Although the data in univariate skewness is not normally distributed, the data in multivariate kurtosis is distributed normally. SEM assumptions of data normality are met.

3.1.3. Multicollinearity Test

(Ghozali:73) states that with a significance level of 90% the existence of multicollinearity between independent variables can be seen using the following correlation matrix:

Table. 3 Multicollinearity Test

Correlation Between Variables			Estimate
X1	<-->	Z	0,710
X1	<-->	Y	0,794
X2	<-->	Y	0,884
X2	<-->	Z	0,760
Z	<-->	Y	0,897
X1	<-->	X2	0,583

(Source: AMOS 24 Output)

Based on the results of the multicollinearity test, it can be seen that the correlation between variables is <0.90, so it can be said that there is no multicollinearity between the variables, thus the SEM assumption is met.

3.2. Outer Model Evaluation

Aims to assess the validity and reliability of measurement constructs, ensuring that the indicators used accurately reflect the latent variables being studied.

3.2.1. Convergent Validity

This evaluation was carried out by examining the loading factor values ≥ 0.60 (Chin et al., 1998), Cronbach's Alpha and Construct Reliability ≥ 0.70 and Variance Extracted ≥ 0.50 (Hair *et al.*, 2014), along with the results of AMOS 24 processing.

Table. 4 Validity of Character Education Variables

Indicator				Loading Factor	Note
Religious	X1.1	<---	X1	0,767	Valid
Honest	X1.2	<---	X1	0,788	Valid
Tolerant	X1.3	<---	X1	0,785	Valid
Discipline	X1.4	<---	X1	0,766	Valid
Hardworking	X1.5	<---	X1	0,750	Valid
Creative	X1.6	<---	X1	0,777	Valid
Independent	X1.7	<---	X1	0,734	Valid
Democratic	X1.8	<---	X1	0,764	Valid
Curiosity	X1.9	<---	X1	0,774	Valid
National Spirit	X1.10	<---	X1	0,741	Valid
Love of the Country	X1.11	<---	X1	0,682	Valid
Appreciate Achievement	X1.12	<---	X1	0,694	Valid
Communicative	X1.13	<---	X1	0,747	Valid
Peace-loving	X1.14	<---	X1	0,722	Valid
Like to Read	X1.15	<---	X1	0,687	Valid
Care for the Environment	X1.16	<---	X1	0,694	Valid
Care for Society	X1.17	<---	X1	0,709	Valid
Responsible	X1.18	<---	X1	0,729	Valid

(Source: AMOS 24 Output)

Character Education (X1) is measured by 18 indicators where the loading factor value lies between 0.682 - 0.788. All indicators have a loading factor > 0.60, so all indicators are valid in measuring the Character Education variable (X1) (Chin et al., 1998).

Table. 5 Validity of Learning Motivation Variables

Indicator				Loading Factor	Note
Attention	X2.1	<---	X2	0,790	Valid
Relationship	X2.2	<---	X2	0,807	Valid
Self-Confidence	X2.3	<---	X2	0,780	Valid
Satisfaction	X2.4	<---	X2	0,714	Valid

(Source: AMOS 24 Output)

Learning Motivation (X2) is measured by 4 indicators with all loading factors > 0.60 (valid). The loading factor value is between 0.714 - 0.809 which shows that the four indicators are valid in reflecting the measurement of the Learning Motivation variable (X2).

Table. 6 Validity of Competency Variables

Indicator				Loading Factor	Note
Knowledge	Z1	<---	Z	0,787	Valid
Skills	Z2	<---	Z	0,763	Valid
Work Attitude	Z3	<---	Z	0,779	Valid

(Source: AMOS 24 Output)

Competence (Z) is measured by 3 indicators with all loading factors > 0.60 (valid). The loading factor value lies between 0.763 - 0.787 which shows that the three indicators are valid in reflecting the measurement of the Competence variable (Z).

Table. 7 Validity of Soldier Performance Variables

Indicator				Loading Factor	Note
Quality of Work	Y1	<---	Y	0,794	Valid
Speed	Y2	<---	Y	0,839	Valid
Initiative	Y3	<---	Y	0,785	Valid
Ability	Y4	<---	Y	0,835	Valid
Communication	Y5	<---	Y	0,810	Valid

(Source: AMOS 24 Output)

The loading factor value > 0.60 (valid) is between 0.785-0.839 which shows that the five indicators are valid in reflecting the measurement of the Soldier Performance variable (Y).

3.2.2. Construct Reliability Test and Variance Extract

In SEM analysis, Reliability Construct and Variance Extract tests are used to ensure internal consistency and reliability of the measured constructs. The test results can be seen in Table 8.

Table. 8 Construct Reliability Test and Variance Extract

Construct	Indicator	SFL	SFL Kuadrat	Error	Construct Reliability	Variance Extracted
Character Education (X1)	X1.1	0,767	0,588	0,412	0,956	0,548
	X1.2	0,788	0,621	0,379		
	X1.3	0,785	0,616	0,384		
	X1.4	0,766	0,587	0,413		
	X1.5	0,750	0,563	0,438		
	X1.6	0,777	0,604	0,396		
	X1.7	0,734	0,539	0,461		
	X1.8	0,764	0,584	0,416		
	X1.9	0,774	0,599	0,401		
	X1.10	0,741	0,549	0,451		
	X1.11	0,682	0,465	0,535		
	X1.12	0,694	0,482	0,518		
	X1.13	0,747	0,558	0,442		
	X1.14	0,722	0,521	0,479		
	X1.15	0,687	0,472	0,528		
	X1.16	0,694	0,482	0,518		
	X1.17	0,709	0,503	0,497		
	X1.18	0,729	0,531	0,469		
Learning Motivation (X2)	X2.1	0,790	0,624	0,376	0,856	0,856
	X2.2	0,807	0,651	0,349		
	X2.3	0,780	0,608	0,392		
	X2.4	0,714	0,510	0,490		
Competence (Z)	Z1	0,787	0,619	0,381	0,820	0,603
	Z2	0,763	0,582	0,418		
	Z3	0,779	0,607	0,393		
Soldier Performance (Y)	Y1	0,794	0,630	0,370	0,907	0,661
	Y2	0,839	0,704	0,296		
	Y3	0,785	0,616	0,384		
	Y4	0,835	0,697	0,303		
	Y5	0,810	0,656	0,344		

(Source: AMOS 24 Output)

3.3. SEM Research Model Testing

Hypothesis testing in SEM analysis consists of direct effect hypothesis testing and mediation effect testing. In direct hypothesis testing, it is seen from the estimate value which shows the magnitude of the direct effect and significance is seen from the CR (Critical ratio) and p-value. If CR> 1.96 or p-value <0.05 then there is a significant effect.

3.3.1. Direct Effect Hypothesis Test

The results of testing the hypotheses proposed in this study are briefly shown in table 9.

Table. 9 Direct influence test results

Hypothesis	Hypothesis Statement	Estimate	S.E.	C.R.	P value	Note
H1	X1 --> Z	0,415	0,089	4,682	0.000	Signifikan
H2	X2 --> Z	0,522	0,093	5,603	0.000	Signifikan
H3	Z --> Y	0,359	0,098	3,649	0.000	Signifikan
H4	X1 --> Y	0,288	0,068	4,253	0.000	Signifikan
H5	X2 --> Y	0,454	0,084	5,402	0.000	Signifikan

(Source: AMOS 24 Output)

3.3.2. Indirect Effect Hypothesis Test

Next is the mediation test, namely testing the role of competency variables that mediate the indirect influence between Character Education (X1) and Learning Motivation (X2) on Soldier Performance (Y).

Table. 10 Mediation Test of the Indirect Effect of Character Education (X1) on Soldier Performance (Y) through Competence (Z) Mediation

Hypothesis	measurement	X1 --> Z	Z --> Y	X1 → Z → Y	Z	P-value
H6. Indirect Effect of Character Education (X1) on Soldier Performance (Y) through Competence (Z) mediation.	Estimates	0,415	0,359	0,149	2,881	0.003
	S.E	0,089	0,098	0,052		

(Source: AMOS 24 Output)

Table. 11 Mediation Test of the Indirect Influence of Learning Motivation (X2) on Soldier Performance (Y) through Competence (Z) mediation

Hypothesis	measurement	X2 --> Z	Z --> Y	X2 → Z → Y	Z	P-value
H7. Indirect Effect of Learning Motivation (X2) on Soldier Performance (Y) through Competence (Z) mediation.	Estimates	0,522	0,359	0,187	3,067	0.002
	S.E	0,093	0,098	0,061		

(Source: AMOS 24 Output)

3.4. Managerial Implications and Research Recommendations

In this study, there are several findings that need to be followed up in providing a positive influence on increasing the strengthening of character education and learning motivation towards competence so that it can improve the performance of soldiers who graduate from Pusdiklek.

3.4.1. Implications and recommendations for Character Education variables

This study shows that the honesty indicator (X1.2) with a loading factor value of 0.788 is the most influential in the formation of the Character Education variable (X1), so that increasing honesty must be a top priority to improve the competence and performance of soldiers who graduate from Pusdiklek.

3.4.2. Implications and recommendations for the Learning Motivation variable

The relevance indicator (X2.2) with a loading factor value of 0.807 is the highest in the Learning Motivation variable (X2), so the relevance of learning materials to students' needs and interests needs to be increased through active participation, consistency in assignments, and utilization of additional learning resources.

3.4.3. Implications and recommendations for Competency variables

Knowledge (Z1) with a loading factor value of 0.787 is the highest indicator in the Competence variable (Z), so increasing knowledge must be the main focus to improve the competence and performance of soldiers who graduate from Pusdiklek.

3.4.4. Implications and recommendations for the Performance variables of Pusdiklek graduate soldiers

Speed (Y2) with a loading factor value of 0.839 is the highest indicator in the Soldier Performance variable (Y), so to improve the performance of soldiers who graduate from Pusdiklek, intensive technical training, repeated simulations, use of the latest technology, and efficient time management methods need to be carried out.

4. CONCLUSION.

Using the Structural Equation Modeling (SEM) method, this study provides strong empirical evidence regarding the direct and indirect influence of character education, learning motivation on the competence and performance of Pusdiklek graduates with the following conclusions:

a. Character Education has a direct influence on Competence with an estimated path coefficient value of 0.415, CR 4.682, and p-value of 0.000, formulated as: ***Soldier Competence = 0.415 * Character Education***.

b. Learning Motivation directly affects Soldier Competence, with an estimated path coefficient value of 0.522, CR 5.603, and p-value of 0.000, which is formulated as: ***Soldier Competence = 0.522 * Learning Motivation***.

c. Competence has a direct effect on soldier performance with an estimated path coefficient value of 0.359, CR 3.649, and p-value of 0.000, formulated as: ***Soldier Performance = 0.359 * Competence.***

d. Character Education has a direct influence on Soldier Performance with an estimated path coefficient value of 0.288, CR 4.253, and p-value of 0.000, formulated as: ***Soldier Performance = 0.288 * Character Education***.

e. Learning Motivation has a direct effect on Soldier Performance with an estimated path coefficient value of 0.454, CR 5.402, and p-value of 0.000, formulated as: ***Soldier Performance = 0.454 * Learning Motivation***.

f. Character Education has an indirect influence on Soldier Performance through Competence with a mediation coefficient of 0.149, standard error of 0.052, and Z 2.881, formulated as: ***Soldier Performance = 0.149 * Character Education***.

g. Learning Motivation has an indirect influence on Soldier Performance through Competence with a mediation coefficient of 0.187, standard error of 0.061, and Z of 3.067, formulated as: ***Soldier Performance = 0.187 * Learning Motivation***.

5. ACKNOWLEDGEMENT

The author would like to thank the Commander of the Indonesian Navy's electronics education center (Pusdiklek) and the commanders of warships of the Republic of Indonesia for the resources provided, namely the electronics corps who were respondents in this research.

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Indonesian Naval Technology College
Postgraduate International Conference, Vol. 8, No. 1, pp. 104-114
June, 27th 2024

STRATEGIES FOR MANAGING CHANGE IN HUMAN RESOURCE MANAGEMENT IN INDONESIAN HIGHER EDUCATION: A SYSTEMATIC LITERATURE REVIEW (SLR)

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ABSTRACT
Managing change in human resource management (HRM) is a crucial aspect for the sustainability and advancement of institutions, particularly in educational settings such as universities. This study aims to reveal effective strategies for managing change within such environments, focusing on a case study of developments in a higher education institution. In this dynamic era, understanding and applying appropriate strategies is key to ensuring successful adaptation and innovation amidst ongoing changes. HRM is a primary pillar in maintaining an organization's continuity and progress. Amidst the constant flux of change, strategic HRM becomes increasingly important, serving not only as a guide but also as a foundation that enables organizations to adapt, grow, and succeed in an ever-changing environment. This research offers valuable insights into HRM strategies by deeply understanding how organizations manage their human resources, both in specific contexts like universities and in broader scopes. By identifying successful patterns, potential obstacles, and opportunities for innovation (Wang, Z., Xu, H., & Song, M., 2021), this study provides essential knowledge. Case studies, such as the one detailed in this article, offer concrete insights. By examining specific development cases in universities, we learn about strategic steps such as organizational restructuring, employee development, effective communication, and active stakeholder engagement, each significantly impacting organizational well-being. Therefore, this research aims to explore how these strategies are understood, adopted, and adjusted within the context of universities. It is hoped that a profound understanding of HRM strategies will contribute positively to sustainable and innovative managerial practices in the future. The study employs a systematic and comprehensive literature review approach using the SCOPUS database, considered credible and internationally indexed, to identify research trends and developments in HRM strategies. This methodology ensures an objective, transparent, and replicable analysis, providing a rich and beneficial contribution to the field of strategic HRM in higher education.

KEYWORDS: Strategic, Human Resource Management, Education, University, Indonesia

1. INTRODUCTION.

Managing change in human resource management is a crucial aspect for the continuity and progress of institutions, especially in educational settings such as higher education institutions. This study aims to uncover effective strategies for managing change in this environment, with a focus on case studies of developments in higher education institutions. In this dynamic era, understanding and applying the right strategies are key to ensuring successful adaptation and innovation amidst ever-changing dynamics. Human Resource Management (HRM) is one of the main pillars in maintaining the continuity and progress of an organization (Nur & Khalid, 2024). Amidst ongoing dynamics of change, strategies for managing HR become increasingly important. These strategies not only serve as guidelines but also as foundations that enable organizations to adapt, grow, and succeed in a continuously changing environment.

In this context, research on HRM strategies offers valuable insights. Through a deep understanding of how organizations manage their HR, both in specific contexts like higher education institutions and in broader scopes, we can identify successful patterns, potential obstacles, and opportunities for innovation (Bidandari et al., 2024). Case studies, as outlined in this article, provide highly valuable insights. By examining concrete cases of developments in higher education institutions, we can study the strategies that have been

implemented in real contexts. From organizational restructuring to employee development, from effective communication to active stakeholder engagement, each strategic step has a significant impact on organizational well-being (Bidandari et al., 2024). Thus, this study aims to explore how these strategies are understood, adopted, and adjusted to the context of higher education institutions. It is hoped that a deep understanding of these HRM strategies can positively contribute to sustainable and innovative managerial practices in the future. In Human Resource Management (HRM), strategy is not merely a set of random steps taken arbitrarily. Behind every strategic decision lies a strong theoretical foundation that provides deep insights into how organizations can manage their HR effectively. This theoretical foundation not only provides an understanding of basic concepts and principles but also serves as a valuable guide in designing, implementing, and evaluating HRM strategies (Wang, Z., Xu, H., & Song, M., 2021).

Several key theories form the theoretical foundation in HRM strategy. First, Change Management theory highlights the importance of adaptation and innovation in facing environmental dynamics. Then, leadership and motivation concepts provide an understanding of how to motivate employees and guide them towards achieving organizational goals. Next, organizational development models offer frameworks for understanding organizational dynamics and how changes in HRM can be implemented effectively. Organizational communication also plays an important role in HRM, with communication theories providing insights into how messages can be delivered effectively, influencing organizational culture. Finally, organizational structure theories help us understand how organizational structures can be tailored to the context and goals of the organization to achieve efficiency and effectiveness in HRM. By understanding and applying these theoretical foundations, organizations can develop more directed and effective HRM strategies in facing challenges and opportunities in a continuously changing environment.

This theory offers insights into how organizations can design and implement effective change strategies. Change management becomes critical in the context of HRM because organizational changes often affect the structure, processes, and culture of the organization, impacting human resources. Leadership and motivation concepts play a significant role in HRM. Theories such as Douglas McGregor's Theory X and Theory Y, Abraham Maslow's Need Theory, and the Psychological Well-being Theory provide an understanding of how to motivate employees and lead them towards achieving organizational goals (Pradana & Arijanto, 2024). According to Amelia et al. (2024), nothing is constant in this world; the world is always moving forward. Those who continue to move forward will be at the forefront, while those who stop will be left behind. Change must occur, whether in leaps or quanta. The concept of a "quantum leap," a rapid jump leveraging changes in vision, mission, strategy, structure, and personnel, is common in the industrial world.

Quantum leaps in personnel start with changes in mindset, ways of thinking, and the adoption of progressive ideologies. Often, quantum leaps begin with the adoption of new beliefs. In the context of human history, there is no stagnation or permanence; history is always changing over time (Amelia et al., 2024). Models such as the Burke-Litwin Model and Lewin's Change Management Cycle provide frameworks for understanding organizational dynamics and how changes in HRM can be effectively implemented. Organizational Communication Theory: Effective communication is a key element in managing change and in general HRM strategies. Organizational communication theories, such as the Shannon-Weaver Model, Persuasion Theory, and Interpersonal Communication Theory, offer insights into

how messages can be effectively delivered and how good communication can influence organizational culture (Fitriyani & Erlina, 2024).

The arrangement of organizational structures plays an important role in HRM. Theories such as Contingency Theory and Structural Functional Theory provide an understanding of how organizational structures can be adapted to the context and goals of the organization to achieve efficiency and effectiveness in HR management. In the context of change management, theoretical foundations play a crucial role in guiding the steps taken by organizations. These theoretical concepts provide important frameworks for understanding the dynamics of change and how organizations can effectively manage it (Purnomo et al., 2024). One of the main theories in change management is Transition Theory. This theory highlights that change does not happen instantly but through a series of stages that involve the adaptation process of individuals and organizations from the previous state to the desired state. Stages such as denial, uncertainty, and eventual adaptation are integral parts of the change process (Fitriyani & Erlina, 2024).

Additionally, the Kubler-Ross Model of the Five Stages of Grief is often used in the context of change management. Although this model was initially developed to understand individual responses to death, the parallels drawn with the emotional stages experienced by individuals during organizational change are highly relevant. Stages such as denial, anger, and eventual acceptance help in understanding and managing the emotional responses that may arise during the change process. By understanding these theoretical foundations, organizations can take more directed and informed steps in managing change. These theoretical foundations provide deep insights into the dynamics of change and offer guidelines on how to face challenges and exploit opportunities in an ever-changing environment.

2. METHODOLOGY

2.1. Size of datasets

The Scopus database search used the term "human resource management change strategy" as a basis. We did not restrict the years in the database collection because we wanted to observe the development of research from the main theory to the latest research data. This allowed us to analyze research trends over time. We selected the highest citation category with the Web of Science index. The study selection process was conducted by creating a Prisma. Literature data were taken from subject fields based on searches in the Web of Science using Publish or Perish. To analyze the bibliometric relationships of an object, it is necessary to analyze the document subjects. Scopus provides subjects on the given algorithm and will be further analyzed using the VosViewer tool (van Eck & Waltman, 2014).

2.2. Data Unit Analyze

A systematic approach is employed to identify, select, and evaluate relevant literature. This structured process is considered replicable, objective, transparent, free from bias, and rigorous. The initial stage in this research involves a comprehensive literature search using the Scopus database. Scopus was chosen due to its broader data coverage compared to other databases and its adherence to stricter methodological criteria in its data scope.

The keyword "Human resource management change strategy in Indonesian universities" was used as the basis for the search in the Scopus database. There was no restriction on the year of data collection. The development of research on resilience was selected because we wanted to understand how the literature has evolved from the main theory to the latest research data on human resource management change

strategies. This allows us to comprehensively analyze research trends over time. We also focused on the highest citation category.

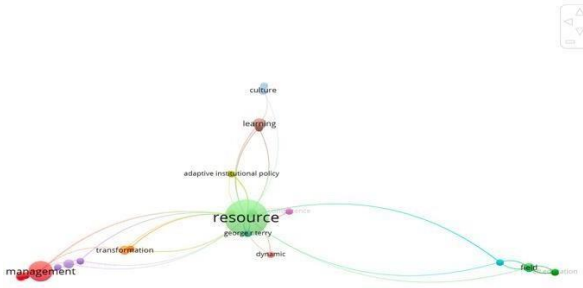

Figure 1: Vosviewer

Source: (Vosviewer, 2024)

Each article was analyzed in depth, followed by initial coding by identifying various definitions and conceptualizations of leadership as theoretical references, levels of analysis of objectives and research questions, methods used, and results, conclusions, and main findings of the research. Emphasis was placed on three dimensions - drivers, processes, and outcomes - with several sub-codes for each dimension. The above graph shows the development of journal publications up to 2021, with an increasing trend in research on human resource management change strategies.

There has been a continuous increase since 2005, peaking in 2024 with nearly 1000 articles, which were reduced to 81. Although the theme of leadership is crucial in facing recent global changes, the number of articles discussing it remains relatively low. A company with significant human resources and potential, but without managers possessing the necessary skills, will not be able to effectively utilize those employees or resources. Therefore, capability is a critical strategy for the sustainability and competitive advantage of a company. From this perspective, business capability is linked to human resources with management skills to become managers who can manage finances and market products to support the achievement of the company's goals and attain desired outcomes.

3. RESULT AND DISCUSSION.

In the context of change management, theoretical foundations play a crucial role in guiding the steps taken by organizations. These theoretical concepts provide an important framework for understanding the dynamics of change and how organizations can effectively manage it.

One of the key theories in change management is the Theory of Change Transition. This theory highlights that change does not occur instantly, but through a series of stages involving the adaptation process of individuals and organizations from the current condition to the desired one. Stages such as denial, uncertainty, and eventually adaptation are integral parts of the change process. Additionally, the Kubler-Ross Model of Five Stages of Grief is often used in the context of change management. Although this model was initially developed to understand individual responses to death, the parallels that can be drawn with the emotional stages experienced by individuals during organizational change are highly relevant. Stages

such as denial, anger, and ultimately acceptance help in understanding and managing the emotional responses that may arise during the change process.

By understanding these theoretical foundations, organizations can take more directed and informed steps in managing change. These theoretical foundations provide an in-depth insight into the dynamics of change and offer guidance on how to address challenges and exploit opportunities in an ever-changing environment. In relating to the Three Components of Change according to Thomas La Bella and Bartens (1991), we can explain how the previously mentioned theories (Theory of Change Transition and Kubler-Ross Model of Five Stages of Grief) align with the concept of the three components of change as depicted in the diagram below.

Figure 2: Management Traits Context

Source: (Self Identifed, 2024)

In the context of change management, theoretical foundations play a crucial role in guiding the steps taken by organizations. These theoretical concepts provide an important framework for understanding the dynamics of change and how organizations can effectively manage it. One of the main theories in change management is the Theory of Change Transition (Kenedi et al., 2024). This theory highlights that change does not only occur instantly but through a series of stages involving the adaptation process of individuals and organizations from the previous condition to the desired one. Stages such as denial, uncertainty, and ultimately adaptation are integral parts of the change process.

Thus, the Kubler-Ross Model of Five Stages of Grief is often used in the context of change management. Although this model was initially developed to understand individual responses to death, the parallels that can be drawn with the emotional stages experienced by individuals during organizational change are highly relevant. Stages such as denial, anger, and finally acceptance help in understanding and managing the emotional responses that may arise during the change process. Thomas La Bella and Bartens (1991) Three Components of Change provide a relevant framework referring to what changes within the organization. In

this regard, the theory of change transition helps identify specific elements of the changes that occur, both at the individual and organizational levels. For example, changes in organizational structure, business strategies, or the technology used.

Furthermore, referring to how these changes are implemented. The stages in the Theory of Change Transition and the Kubler-Ross Model provide guidance on the adaptation process experienced by individuals and organizations. This process involves emotional management, handling denial, and developing strategies to achieve adaptation and acceptance (Syamsuddin et al., 2024). Then the context includes external and internal factors driving change, such as changes in the market, new technologies, or changes in regulations. By understanding the context, organizations can better prepare and design effective strategies to address these changes. By understanding these theoretical foundations and relating them to the Three Components of Change according to Thomas La Bella and Bartens, organizations can take more directed and informed steps in managing change. These theoretical foundations provide an in-depth insight into the dynamics of change and offer guidance on how to address challenges and exploit opportunities in an ever-changing environment. These guidelines help organizations not only in identifying changing elements (content) but also in planning and managing the change process effectively (process) and understanding the background and reasons behind the changes (context) (Rismayadi, 2024).

In several findings and research reviews, the research is divided into several sections that have validity and relevance to this study.

Figure 3: Research Findings

Human Resource Management in Education	1. (Adeoye & Hakim, 2024): This research discusses the optimization of madrasah quality through a strategic approach to human resource management (HRM). They highlight the importance of the right HRM strategy to enhance performance and educational outcomes in madrasahs. 2. (Akbar et al., 2024): Examining the roles of human capital and sustainable HRM in supporting sustainable universities in Indonesia. This research emphasizes the mediating role of sustainable HRM practices in improving university performance. 3. (Alfarizi & Herdiansyah, 2024): Investigating the factors influencing ecopreneurial intentions among educational human resources in Indonesia, with a focus on inherent green tendencies.
Human Resource Planning and Strategy	1. (Asrin et al., 2024): Analyzing leadership strategies to enhance faculty performance and achieve excellence at universities. 2. (Astuti et al., 2024): Examining strategic planning and human capital planning in the business development project of Bina Insani University at Cikarang Campus.

	3. (Bidandari et al., 2024): Researching the school principal's strategies in establishing centers of excellence in Vocational High Schools in Indonesia.
Enhancing Quality and Performance of Human Resources	1. (Dacholfany et al., 2024): School principal leadership strategies in developing the quality of human resources in schools. 2. (Fitriyani & Erlina, 2024): Studying the application of strategic and global HRM in improving company performance in Indonesia. 3. (Haddade et al., 2024): Discussing quality assurance strategies in higher education in the digital era within the context of Islamic higher education institutions.
Strategic Management Strategies in Higher Education	1. (Istikhoroh et al., 2024): Strategi tata kelola universitas inovatif untuk meningkatkan daya saing di industri pendidikan tinggi. 2. (Kasimbara et al., 2024): Pemasaran strategis pendidikan tinggi di negara berkembang, dengan studi kasus pemasaran lokal di pendidikan tinggi swasta Indonesia. 3. (Kenedi et al., 2024): Mengkaji kapabilitas, pengetahuan, dan keterampilan SDM unggul melalui kompetensi karyawan di Pelabuhan Tanjung Balai Karimun, Kepulauan Riau.
Application of Technology and Innovation in HRM	1. (MEGAWATY et al., n.d.): Researching how the agility of human resources can improve the distribution of HRM performance in private universities in Indonesia. 2. (Muflihin & Warsito, 2024): Examining self-directed learning policies for quality strategic education management using IT skills in the Merdeka Campus program in Indonesia. 3. (Mursiti et al., 2024): Discussing competency mapping to develop human resources in the Indonesian sugarcane agro-industry in the era of Industry 4.0.
Strategic Approaches and Policies in HRM	1. (Nasution et al., 2024): Developing a strategic management model for state legal entity universities towards world-class universities with a strategic intelligence approach. 2. (Nur & Khalid, 2024): Investigating strategic HR management in the development of SMEs in the era of globalization. 3. (Nurbaya et al., n.d.): Enhancing HR competencies through edutourism services at Muhammadiyah Islamic College Singapore

Source: (Self Identifed, 2024)

The findings of this research identify strategic Human Resource Management (HRM) practices in the context of higher education institutions in Indonesia. This study employs a survey instrument to assess the extent to which strategic HRM implementation has been carried out. Statistical analysis is conducted to cluster similar variables and identify focus areas at a university (Ramly et al., 2024). The research results indicate that the surveyed higher education institutions have a high level of awareness of HRM. However, they face significant challenges regarding human capital development, especially among faculty members. The recruitment and selection processes are also deemed highly inadequate and require more effective attention. Performance appraisal and compensation systems are also considered insufficient to ensure the presence of highly motivated staff, especially for foreign workers (Purnomo et al., 2024).

The implications of these findings are highly relevant to administrators, faculty, and other higher education personnel interested in implementing and improving strategic HRM practices. Future research should involve more universities, both public and private, and consider moderation variables such as university culture, organizational climate, and the labor market, especially in the context of workforce nationalization, legal environment, and regulations. Based on this analysis, this research provides rich and beneficial findings in the field of strategic Human Resource Management.

The findings of this research can be associated with Bartens' three factors related to Human Resource Management (HRM), namely People, Process, and Policy. The Bartens model highlights the importance of human resource development and management in organizations. In the context of this research, the high awareness of HRM in higher education institutions in Indonesia affirms this aspect (Sundoro et al., 2024). However, the finding that there are significant challenges related to human capital development, especially among faculty members, underscores the need to enhance attention to this aspect in HRM in universities. The Bartens model encompasses operational processes related to human resource management, including recruitment, selection, training, and employee development processes. The research results indicate that the recruitment and selection processes are considered highly inadequate. Therefore, changes in these processes are needed to ensure effective implementation of strategic HRM in higher education institutions. Lastly, the policy in the Bartens model refers to the policies that form the basis for HRM practices in an organization. The finding that the performance appraisal and compensation system is not sufficient to ensure the presence of highly motivated staff, especially for foreign workers, suggests the need for improvements in policies related to performance appraisal and compensation in higher education institutions in Indonesia.

4. CONCLUSION.

From the results of this study, it can be concluded that there is a need for improvement in the implementation of strategic Human Resource Management (HRM) in higher education institutions in Indonesia. Although the awareness level regarding HRM is quite high, the challenges related to human capital development, recruitment and selection processes, as well as performance appraisal and compensation policies, require more serious attention. The implications of these findings are crucial for stakeholders in the field of higher education to implement sustained improvement measures to enhance the performance and effectiveness of higher education institutions in Indonesia, thus better coping with the dynamics of the modern higher education era.

Thus, this research underscores the necessity for improvements in the implementation of strategic Human Resource Management (HRM) in higher education institutions in Indonesia. Despite the relatively high

awareness level regarding HRM, the challenges related to human capital development, recruitment and selection processes, as well as performance appraisal and compensation policies, demand more serious attention. The implications of these findings are highly significant for stakeholders in the higher education sector to implement sustained and targeted improvement efforts to achieve the goals of higher education institutions in facing the dynamics of the modern higher education era.

Linking the findings of this research with Bartens' three factors provides a comprehensive overview of the challenges and implications of implementing strategic HRM in Indonesian universities. Previous research has highlighted strategic Human Resource Management (HRM) practices in higher education institutions in Indonesia. The research results indicate that higher education institutions in Indonesia have a high level of awareness of HRM. However, they also face significant challenges related to human capital development, especially among faculty members. The recruitment and selection processes are considered highly inadequate, and the performance appraisal and compensation system are also deemed insufficient to ensure the presence of highly motivated staff, especially for foreign workers.

Thus, these findings emphasize the need for improvement in the implementation of strategic Human Resource Management (HRM) in higher education institutions in Indonesia. High awareness of HRM is a positive first step, but challenges related to human capital development, recruitment and selection processes, as well as performance appraisal and compensation policies, still need to be the main focus in efforts to enhance the performance and effectiveness of higher education institutions. The implications of these findings have significant impacts on administrators, faculty, and higher education personnel in their efforts to implement and improve best practices in strategic Human Resource Management in Indonesia. Therefore, sustained and targeted improvement efforts are essential to achieve the goals of institutions in facing the dynamics of the modern higher education era.

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Indonesian Naval Technology College
Postgraduate International Conference, Vol. 8, No. 1, pp115-124
June, 27th 2024

ANALYSIS OF THE APPLICATION OF OCCUPATIONAL HEALTH AND SAFETY (K3) IN FABRICATION WORK WITH THE RISK ASSESSMENT METHOD AT PT INDUSTRI KERETA KERETA (INKA) BANYUWANGI

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ABSTRACT

Potential hazards always exist when we are doing daily activities and potential hazards always exist wherever we are, be it in every place of the work environment or outside the work environment. In the industrial business world, occupational safety and health (K3) is very necessary. There will always be a risk of failure (risk failures) in every work activity and when a work accident occurs, so that no matter how small the work accident will result in a loss effect for both the company and the worker. PT. Industri Kereta Api (INKA) Banyuwangi is a state-owned enterprise engaged in manufacturing services located in Ketapang Village, Kalipuro Banyuwangi. PT INKA Banyuwangi is still relatively newly inaugurated and has just started production, it is not surprising that the attitude of workers towards the application of K3 at PT INKA Banyuwangi has not gone well. The purpose of this research is to identify potential hazards and conduct risk assessment of the level of work accidents at PT INKA Banyuwangi.

From the results of the identification that occurred at PT. Industri Kereta Api (INKA) Banyuwangi, 10 potential hazards and risks were found in field workers. The risk level assessment for field workers contained 3 low risks and 5 medium risks. Assessment of risk control in field workers there are 4 mild risks and 4 moderate risks. While the results of the calculation of risidual risk or residual risk after control efforts are made there are still 5 hazard risks that require improvement in work accident control at PT. Railway Industry (INKA) Banyuwangi.

Keywords : Potential hazards, risk assessment, work accident

1. INTRODUCTION

Manufacturing companies in Indonesia are experiencing quite rapid development, this is evidenced by the existence of many jobs, both in the manufacturing and service industries. So that in order to continue to compete, it is important for companies to always make innovations and improvements, especially in terms of human resources. The success of human resource management in productivity and performance is used as one of the benchmarks for achieving company success. The success of a company or organization is determined by human resources because humans are living assets that need to be maintained and developed (Daulay, 2021). In this era of global competition, worker productivity is one of the important factors that can affect the success of a company. Productivity is the main indicator for the progress of a company. So that increasing productivity in all parts of the system is a way to increase the rate of economic growth of the company. Companies strive to increase the productivity of all their employees in order to compete with other companies because they can produce goods or services in a more efficient way. Potential hazards always exist when we are doing daily activities and potential hazards always exist wherever we are, be it in every place of the work environment or outside the work environment. In the industrial business world, occupational safety and health (K3) is now indispensable. There will always be a risk of failure (risk failures) in every work activity and when a work accident occurs, so that no matter how small the work accident will result in a loss effect for both the company and the worker (Alfatiyah, 2017). That is why prevention and control efforts are needed as an effort to prevent the risk of work accidents. Hazard identification is necessary to ensure the safety of the production process for workers, equipment and the environment from work accidents (Putranto, 2010).

PT. Industri Kereta Api (INKA) Banyuwangi is a state-owned enterprise engaged in manufacturing services located in Ketapang village, Kalipuro Banyuwangi. PT INKA Banyuwangi has 20 field workers, each of whom has a different task, of course, from each of their jobs they are never separated from a potential hazard of

work accidents both from the place where the work is done and the tools used. Work accident is an event that is never planned in advance.

Every accident that occurs can certainly hinder workers in doing work, on the contrary, good health conditions can create good work productivity for all workers. PT INKA Banyuwangi is still relatively newly inaugurated and has just started production, it is not surprising that the attitude of workers towards the application of K3 at PT INKA Banyuwangi has not gone well. This will lead to lower productivity levels. According to the results of direct field observations and interviews conducted with the head of the Production section at PT. INKA Banyuwangi, the following are data on work accidents in the fabrication work process obtained from PT. INKA Banyuwangi for 5 months, starting from January-May 2023 as follows:

Table 1.Type of Accident Details that occurred

Month	Month Accident Type	Quantity
January	Exposure to weld violet light	2
	Scratching the material	1
	Exposed to welding fume dust	2
February	Exposed to welding spatter	2
	Exposed to welding violet light	1
	Exposed to grinding blades	1
March	Scratching the material	2
	Exposure to welding fume dust	2
	Exposure to welding violet light	1
April	Exposure to welding violet light	3
	Exposure to welding fume dust	2
	Scratching the material	1
	Tripping over cables	1
May	Exposed to welding violet light	1
	Exposure to welding fume dust	2
	Scratching the material	2

Source: PT Railway Industry (INKA) Banyuwangi

Seeing from these conditions, it is necessary to analyze and identify risks in each accident. And one of the efforts to minimize the level of work accidents by implementing risk assessment of K3 at PT INKA Banyuwangi. Work accidents that occur include several things such as the machines used and the work environment. Risk management has a big role so that the risks and hazards that occur do not have a major impact on the company's operating processes (Supriyadi et al, 2015).

As a basis for previous research by Daulay and Nuruddin. (2021): "K3 Analysis at Dwi Jaya Motor Workshop Using HIRA Method Integrated with FTA Method". This research applies the HIRA and FTA methods to identify hazards in the workshop work environment and analyze risks and determine the

necessary controls. Other research was also found by Prasetya et al. (2020): "Risk Analysis on Tank Cleaning of Stockpile Tanks by Hiradc and Fta Methods with Recommendations Using the Bcr Method". This research focuses on the chemical industry and applies a combination of HIRADC and FTA methods to improve process safety in chemical plants. The results show that this approach is effective in identifying potential hazards, analyzing risks, and designing appropriate control measures to reduce the likelihood of accidents or serious incidents. The results show a significant reduction in the incidence of accidents after implementation of the recommended control measures. HIRADC aims to recognize potential hazards as well as recognize various kinds of operational capability issues in each fabrication work process.

2. METHODOLOGY

Data Collection Methods

Type of Data

The type of data used in this study consists of two types with data collection methods, namely:

1. Primary Data

Primary data is qualitative data obtained by conducting direct research or observation through interviews with field workers in the fabrication section at PT INKA Banyuwangi. With this interview, information is obtained which can later be concluded from the answers of the sources, which then the results will be arranged systematically so that a brief conclusion is obtained which contains data.

2. Secondary Data

Secondary data is data obtained from several parties or intermediaries who have conducted previous research such as obtained from journals, books, notes or scientific papers. Secondary data is data obtained directly from the object of research. Such as work accident data at PT. Indutrsi Kereta Api (INKA) Banyuwangi.

Data Collection :

1. Observation

Observation is a process that is preceded by observation and then recording which is systematic, logical, objective, and rational towards various kinds of phenomena in actual situations, or artificial situations. The purpose of observation is in the form of description, giving birth to theories and hypotheses (in qualitative research), or testing theories and hypotheses (in quantitative research). The function of observation in more detail consists of description, filling, and giving. From observations made directly at the work of the fabrication section at PT INKA Banyuwangi, it was found that several work accidents occurred while repairing the salurun such as being scratched by twigs during pipe replacement, exposure to dust, hands scratched by pipes and others.

2. Interview

An interview is an interaction conducted between the interviewer and the interviewee conducted directly. The interviewee will answer the questions given by the interviewer so that data, information, or about a matter will be obtained. In this case the author conducted an interview directly with the head of the workers' supervisory section at PT INKA Banyuwangi about work accidents that often occur and how many accidents occur in each month.

3. Literature Study

Literature study is a data collection activity by reading and studying from literature books or journals as a theoretical basis for a problem to be solved.

3. RESULT AND DISCUSSION

Work Accident and Risk Data

From the data on work accidents at PT. Railway Industry (INKA) Banyuwangi, the following data from January 2023 - May 2023 :

Table 2. Work Accident Data January 2023-May 2023

Month	Category				
	Light	Medium	Heavy	Total	Percentage
January	5	0	0	5	21%
February	3	1	0	4	15%
March	5	0	0	5	18%
April	6	1	0	7	25%
May	5	0	0	5	21%
Total				33	100%

Data Source: Pt. Railway Industry (INKA) Banyuwangi

From the results of interviews that have been conducted at PT. Industri Kereta Api (INKA) Banyuwangi, the results of work accidents that have been divided based on causes and consequences for five (5) months can be seen in table 3 below:

Table 3. Cause of Accident and total

Month	No	Cause of Accident	Result of Accident	Total
January	1	Welding violet light Eye Irritation	Welding violet light Eye Irritation	2
	2	Exposed to welding spatter Skin injury	Exposed to welding spatter Skin injury	2
	3	Exposed to grinding blades Hand Injury	Exposed to grinding blades Hand Injury	1
February	4	Scratch material Hand injury	Scratch material Hand injury	1
	5	Exposed to welding spatter Skin irritation	Exposed to welding spatter Skin irritation	1
	6	Welding violet light Eye irritation	Welding violet light Eye irritation	2
March	7	Exposed to grinding blades Hand injury	Exposed to grinding blades Hand injury	2
	8	Welding violet light Eye irritation	Welding violet light Eye irritation	3
April	9	Violet welding light Eye irritation	Violet welding light Eye irritation	3
	10	Exposed to welding splash Skin irritation	Exposed to welding splash Skin irritation	2
	11	Exposed to grinding blades Hand injury	Exposed to grinding blades Hand injury	1
	12	Exposed to welding spatter Skin irritation	Exposed to welding spatter Skin irritation	1
May	13	Exposed to grinding blades Hand injury	Exposed to grinding blades Hand injury	1
	14	Violet welding light Eye irritation	Violet welding light Eye irritation	2
	15	Scraped material Scratches	Scraped material Scratches	2

Data Source: Pt. Railway Industry (INKA) Banyuwangi

Discussion

Identification results

The results of hazard identification carried out during the study based on the work section, namely in the Welding, grinding to blander cutting section are presented in table 4

Table 4. Hazard Identification Results

Stage of Work	Potential Hazards	Risks
Welding work	Exposure to welding light Violet welding light can cause eye burns, heat and even eye irritation.	Exposure to welding light Violet welding light can cause eye burns, heat and even eye irritation.
	Exposure to welding sparks Hand injuries, even burns	Exposure to welding sparks Hand injuries, even burns
	on the skin due to welding sparks	on the skin due to welding sparks
Grinding work	Exposure to dust and gas in welding fumes makes the nose feel sore and hot	Exposure to dust and gas in welding fumes makes the nose feel sore and hot
	Cut by materials that are torn and injured hand skin	Cut by materials that are torn and injured hand skin
	Makes the nose feel sore and hot	Makes the nose feel sore and hot
Cutting work with blander	Exposed to dust and gas Hand and skin injuries	Exposed to dust and gas Hand and skin injuries
	Exposed to sharp materials Torn and injured hand skin	Exposed to sharp materials Torn and injured hand skin
	Exposed to sparks Sparks can cause serious injuries and burns.	Exposed to sparks Sparks can cause serious injuries and burns.

Sumber : PT. Industri Kereta Api (INKA) Banyuwangi

Penilaian Tingkat Risiko

From the results of observations that have been made at the PT Kereta Api Industri (INKA) Banyuwangi field work site, potential hazards and risks are obtained. The following is a ranking category based on the results of multiplying the probability times the severity:

a. Green color, has a score of 1-6, which means low risk and generally acceptable risk.
b. Yellow color, has a score of 7-14. This means the risk is moderate and can be tolerated.
c. Red color, has a score of 15-25. This means the risk rating is high and unacceptable.

Determination of risk level according to (Wicaksono, 2017) is with the equation

Risk = Likelihood x Severity

Calculation Example 1:

Risk = Likelihood x Severity

= 4 x 2

= 8

Description:

L = Likelihood.

S = Severity.

Table 5. Risk Assessment Results

no	Stage of work	Potential hazards	Risk	Risk Assessment		Risk assessment	Prioritization
				L	S		
1	Welding Work	Exposure to welding light Violet welding light can cause eye burns	Exposure to welding light Violet welding light can cause eye burns	5	1	8	low
		Exposure to welding spatter Hand injuries, even burns to the skin due to welding spatter	Exposure to welding spatter Hand injuries, even burns to the skin due to welding spatter	4	2	8	medium
		Exposure to dust and gas in welding fumes makes the nose feel sore and hot	Exposure to dust and gas in welding fumes makes the nose feel sore and hot	4	2	8	medium
2	Cutting work with blander	Exposure to sparks Sparks can cause severe injuries to the skin and even burns.	Exposure to sparks Sparks can cause severe injuries to the skin and even burns.	2	4	8	medium
		burns	burns	1	4	4	low
3	Grinding Work	Tripping over a falling cable and getting hurt or bruised	Tripping over a falling cable and getting hurt or bruised	2	4	8	medium
		bruises	bruises	4	2	8	medium
		Electric shock Pain and high fever	Electric shock Pain and high fever	3	2	6	low

Figure 1 Graph of Risk Assessment Results

Risk Control Level Assessment Results

The level of risk control is risk control by determining the control rating. The ranking category is based on the results of multiplying the control hierarchy with the control strategy, namely:

a. Light Green color has a score of 1-10, the existing risk control rating is the last choice

b. Orange color has 11-20, medium control rating means that the risk control options are good enough

c. Brown color has a score of 21-30, a good control rating which means that the existing risk control is the best choice.

How to find the value of risk control according to (Ramli, 2010) is:

Risk Control = Control Hierarchy x Control Strategy

Calculation Example 1:

Risk Control = Hierarchy of Control x Control Strategy

= 5 x 3

= 15

Tabel 6. Risk Control Level Assessment

Stage of work	Potential hazards	Control Hierarchy	Control Strategy	Risk assessment	Prioritization
Pekerjaan Pengelasan	Exposed to welding light	1	1	1	low
	Exposed to welding spatter	5	3	15	Medium
	Exposure to dust and gas in welding fumes	2	3	6	Low
Pekerjaan Pemotongan dengan blander	Exposure to sparks	4	4	16	Medium
	Tripping over cables	2	3	6	low
Pekerjaan Menggerinda	Electrocuted	5	3	15	medium
	Exposed to grinding blades	4	3	12	medium
	Exposed to sharp materials	2	3	6	low

Figure 2 Risk Control Level Assessment

after implementing the recommended controls. The grading levels are as follows :

a. Gray color has a score ≤ 1, meaning that the recommended control is appropriate.

b. Blue color has a score > 1, meaning that the control cannot reduce the risk completely and still needs to be considered.

The calculation of Residual Risk according to (Ramli, 2010) is:

Residual Risk = Risk Level - Control Value

Example of Calculation 1:

Residual Risk = Risk Level - Control Value

= 8 - 12

= -4

For the calculation results can be seen in table 7. below

Table 7. Residual Risk assessment results

Work	Potential Hazard	Risk Level	Risk Control	Residual Risk
Welding work	Exposed to welding light	5	1	4
	Exposed to weld spatter	8	15	-7
	Exposure to dust and gases in welding fumes	8	6	2
Cutting		8	16	-8
	Exposed to sparks	4	6	-2
gan with blander	Tripping over cables	8	15	-7
	Electrocuted	8	12	-4

Exposed to grinding blades	6	6	0

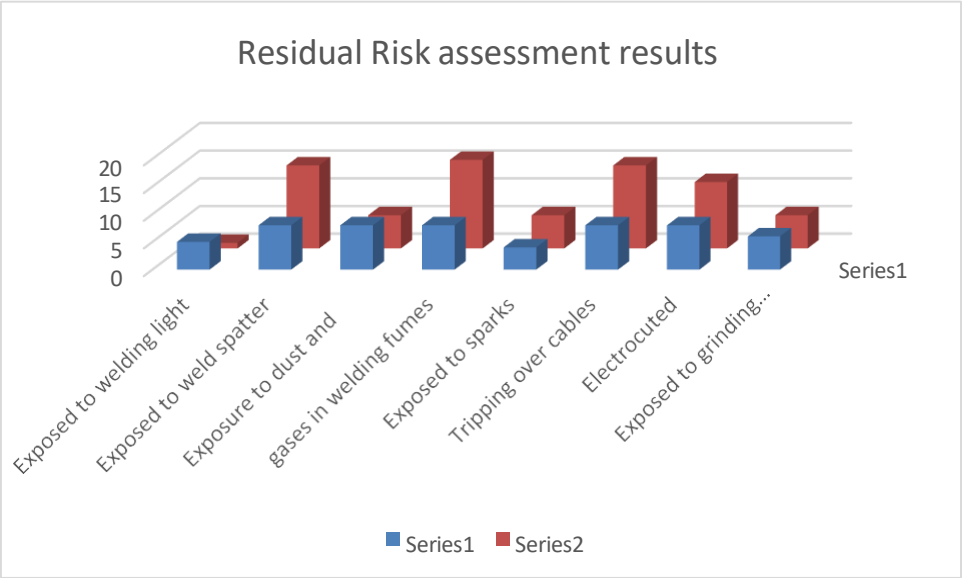

Figure 3 Residual Risk assessment results

Based on the results of the residual risk assessment, 3 hazard risks are grayed out, which means that the recommended controls are in accordance with the level of risk and the remaining 5 risks are blue, which means that the controls carried out still need to be considered again.

Control efforts that need to be done:

a. Exposed to welding sparks

Use fire-resistant and thick gloves during welding work, if welding splashes are not controlled, also use glasses and face shields to protect the eyes from irritation so that welding activities can run smoothly.

b. Exposure to dust and gas in fumes

Use a face shield when welding, if the dust is too much use protective glasses to protect the eyes from irritation.

c. Exposed to sharp materials

Use gloves made from special materials to avoid being cut by sharp materials.

d. Exposed to grinding eyes

Use safety gloves, apron and shoes when working. menggerinda supaya mencegah terjadinya goresan yang diakibatkan oleh mata gerinda.

4. CONCLUSION

Based on the results of research that has been carried out at PT. Industri Kereta Api (INKA) Banyuwangi, several conclusions can be drawn, namely:

1. From the results of the identification that occurred at PT. Industri Kereta Api (INKA) Banyuwangi, 10 potential hazards and risks were found in field workers.
2. Risk level assessment for field workers there are 3 low risks and 5 medium risks. Assessment of risk control in field workers there are 4 mild risks and 4 moderate risks.
3. The results of the calculation of risidual risk or residual risk after control efforts are made there are still 5 hazard risks that require improvement in work accident control at PT. Railway Industry (INKA) Banyuwangi.

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FIELD III

POLICY STRATEGY

Indonesian Naval Technology College
Postgraduate International Conference, Vol. 8, No. 1, pp. 125-135
June, 27th 2024

THE ANALYSIS OF STATE DEFENSE STRATEGY IN THE SEA OF THE MALAYSIA STATE IN ORDER TO FACE THE THREAT IN THE INDO-PACIFIC REGION

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ABSTRACT

Malaysia, as a strategic country in the Indo-Pacific region, faces various complex maritime security challenges. In maintaining its sovereignty, Malaysia must manage threats arising from overlapping territorial claims in the South China Sea, piracy and maritime crime in the Malacca Strait, as well as geopolitical tensions between major powers such as the United States and China. Malaysia's centralized federal structure gives the federal government the authority to determine national strategic policy, including international cooperation and maritime defense. This research aims to analyze Malaysia's maritime defense strategy in facing threats in the Indo-Pacific region using game theory, maritime strategy theory, and collective security theory. This research identifies several strategies that Malaysia can take, including carrying out bilateral military exercises, joint patrols, exchanges of officers and students, as well as sharing technology and defense industry cooperation with neighboring countries such as Indonesia. Through game theory analysis, it was found that the optimal strategy for Malaysia is to carry out joint operations around the Malacca Strait and the waters bordering Indonesia, which will increase maritime security and prevent illegal activities. The research results show that a combination of bilateral military exercises and joint patrols, supported by personnel exchange programs and technological collaboration, is the most effective strategy to increase Malaysia's maritime defense capabilities. Implementation of these strategies not only strengthens diplomatic relations and synergy in developing human resources and defense technology but also creates stronger stability and security in the Indo-Pacific region. The recommendation from this research is that Malaysia and Indonesia actively implement the strategies that have been identified and continue to evaluate and adjust to ensure the sustainability and increased effectiveness of maritime defense and security cooperation in the region.

Keywords: Game Theory, cooperative games, maritime defense strategy, Indo-Pacific

1. Introduction.

Malaysia, as a country in the form of a federation and strategically located in the Indo-Pacific region, has unique challenges in maintaining its security and sovereignty. Consisting of thirteen states and three federal territories (Kuala Lumpur, Labuan Island, and Putrajaya), Malaysia must manage defense and security affairs effectively between the federal and state governments. The geographical situation consisting of Peninsular Malaysia in the west and East Malaysia in the east also adds complexity to its maritime defense strategy.

In Malaysia's federal structure, defense and foreign affairs powers are under the federal government, giving it ultimate authority in determining national strategic policy. As a country with a constitutional monarchy system, Malaysia's head of state is the Yang di-Pertuan Agong who is elected from and by the nine Sultans of Malaya in rotation for a five-year term of office. Meanwhile, executive power is exercised by a cabinet led by a Prime Minister.

This division of power leads to a centralized approach in handling external threats, including in the maritime area. In the defense context, the Malaysian federal government has full control over the strategy and implementation of military policy, including international cooperation and maritime defense. Malaysia adopts a parliamentary system with the Westminster model, where executive power is more dominant than the legislature and judiciary. Although Malaysia has a democratic political system, extensive authoritarian controls also exist to prevent effective opposition. This can be seen from the dominance of the ruling party

coalition, Barisan Nasional (BN), in every election. This political structure allows the government to implement defense policies with relatively high political stability.

Malaysia's geographical situation, which consists of two main areas separated by the South China Sea, makes it a country that is vulnerable to various maritime threats. Peninsular Malaysia borders Thailand to the north and Singapore to the south, while East Malaysia borders Brunei and Indonesia. Apart from that, the tropical climate and two monsoon seasons that pass through this region also influence operational conditions at sea. Malaysia is in a very strategic region in the Indo-Pacific, a region that is now the center of global attention because of its security and geopolitical dynamics. The South China Sea, which is part of Malaysian waters, is one of the hot spots in the region, with various conflicting territorial claims between the countries involved.

Malaysia's economy, which is the third largest in Southeast Asia and twenty-ninth in the world by GDP, is highly dependent on regional stability and security. Strong economic sectors, especially in agriculture, electronics, and coconut oil, require protection from maritime threats such as piracy, smuggling, and territorial disputes. Malaysia has a long history of international relations, especially with countries in the Southeast Asia region. Bilateral relations with neighboring countries such as Indonesia and Singapore play an important role in maintaining regional stability. Apart from that, Malaysia is also involved in various international military cooperation to strengthen its maritime defense. Defense agreements and joint military exercises with major countries such as the United States and other ASEAN countries are part of Malaysia's defense strategy. This includes joint exercises and maritime patrols to ensure security in strategic waters, especially in the Malacca Strait which is one of the busiest shipping lanes in the world. The main problems facing Malaysia in its maritime defense strategy in the Indo-Pacific region include overlapping territorial claims in the South China Sea, the threat of piracy and maritime crime in the Malacca Strait, as well as geopolitical tensions between major powers such as the United States and China which affect regional security. Additionally, Malaysia faces limited defense resources that hinder the modernization and upgrading of military capabilities, as well as ensuring effective coordination and integration between the federal and state governments. International cooperation is also key, but maintaining a balance between strategic alliances and national interests remains a challenge.

2. LITERATURE REVIEW

2.1 Game Theory

This theory is a branch of game theory that studies how groups of players (coalitions) can work together to achieve better results compared to acting individually. The main focus of cooperative game theory is on coalition formation, profit sharing, and mechanisms for reaching mutual agreements. The main components in cooperative game theory include players (individuals or groups who can form coalitions), coalitions (subgroups of players who work together to achieve a common goal), coalition values (values or outcomes that can be achieved by coalitions), and shared solutions (methods for share profits among coalition members). Some of the key solution concepts in cooperative game theory are Shapley Value, Nucleolus, and Core, each of which provides a different way to distribute profits fairly based on players' contributions to the coalition.

2.2 Naval Strategy Theory.

Naval Strategy theory is a concept in military studies and international relations that focuses on the use and control of the oceans to achieve a nation's political and military objectives. The maritime strategy covers various aspects, including naval deployment, control of shipping lanes, protection and utilization of maritime resources, as well as preventing and overcoming threats from the sea. This theory also involves the planning and execution of naval operations in war and peace, including blockades, surface warfare, underwater warfare, and amphibious assaults. Important figures in the development of naval strategy theory include Alfred Thayer Mahan, who emphasized the importance of naval power for global domination, and Julian Corbett, who focused on the use of navies to support land strategy. Implementing an effective maritime strategy allows countries to secure their national interests, maintain regional stability, and project power around the world.

2.3 Collective Security Theory

Collective Security theory is a concept in international relations that states that global peace can be achieved through cooperation between countries to face aggression. The main principle is that an attack on one country is considered an attack on all countries participating in that collective system. Member states are committed to uniting in response to aggression to prevent such acts and maintain international stability. The main examples of the implementation of this theory are the League of Nations after World War I and the United Nations after World War II. Both organizations were created to promote collective security through mechanisms such as economic sanctions and collective military action. This theory is based on the belief that a country's security can only be guaranteed through collective security supported by an international commitment to uphold peace and counter common threats.

3. RESEARCH METHODS

This research is a descriptive study using qualitative methods, where data and information related to research problems obtained through literature studies and field interviews are analyzed quantitatively, and then interpreted according to the meaning contained in the data and information. Data collection techniques are carried out through library research and in-depth interviews with parties who are considered competent and have information and data related to research problems.

4. Result and Discussion

4.1 Determination of Player Game Theory

In game theory, determining players is an important stage in analyzing and modeling strategic interactions. In this game, we will involve two main players: Indonesia as the first player and Malaysia as the second player. The first player, Indonesia, will be taken as the first point of view in this analysis, which means the decisions and strategies taken by Indonesia will be analyzed first. The second player, Malaysia, will be analyzed based on how they responded to the actions and strategies of the first player. Indonesia, as the first player, will act as the initial decision maker in this scenario, determining the strategic steps that Malaysia will then respond to. These responses will be analyzed from the perspective of how they respond to Indonesia's actions, including possible diplomatic or military steps they take to protect their national interests.

By analyzing the interactions between these two countries within the framework of game theory, you will gain a better understanding of the strategic dynamics that occur, as well as predict the outcomes of various possible scenarios. This approach makes it possible to see how each country tries to achieve maximum profits

within the constraints of predetermined game rules. Through this modeling, we can see the potential for cooperation or conflict that may arise, as well as the optimal strategies that can be taken by both countries to achieve the desired results. The following are the players from this game theory.

a. Indonesia

Indonesia, located in the middle of the Indo-Pacific region, is the world's largest archipelagic country with more than 17,000 islands, including large islands such as Sumatra, Java, Kalimantan, Sulawesi, and Papua. This geographical location makes Indonesia a strategic point between two oceans, the Indian and the Pacific, as well as important trade routes such as the Malacca Strait, Sunda Strait, and Lombok Strait. With a coastline of more than 54,000 kilometers, Indonesia has a vast Exclusive Economic Zone (EEZ), allowing the exploration of rich marine resources, including fisheries, oil, and natural gas. This geographic potential also places Indonesia in a vulnerable position to maritime disputes and regional security threats, as seen in the conflict in the South China Sea.

From an economic perspective, Indonesia is the largest economy in Southeast Asia and a member of the G20 with a significant Gross Domestic Product (GDP), which is supported by sectors such as agriculture, manufacturing, and services. Indonesia's steady economic growth over the past few decades has been driven by urbanization, increased domestic consumption, and commodity exports. In terms of military technology, Indonesia is trying to modernize its armed forces through the procurement of advanced military equipment and increasing domestic defense technology capabilities. However, challenges such as limited budgets and the need to increase human resource capabilities still exist. Indonesia's human resources, with a population of more than 270 million people, provide great potential in the workforce and domestic market, although improvements in education and skills are needed to face the demands of the global economy and modern technology.

b. Malaysia

Malaysia, located in the heart of the Indo-Pacific region, consists of two main regions separated by the South China Sea: Peninsular Malaysia to the west and East Malaysia located on the island of Borneo. This geographical location makes Malaysia an important maritime trade center, with the Strait of Malacca being one of the busiest shipping lanes in the world. With a long coastline and extensive EEZ, Malaysia has significant access to marine resources, including fisheries and hydrocarbons. Being in this strategic area also makes Malaysia involved in various regional geopolitical dynamics, especially related to maritime disputes in the South China Sea.

Economically, Malaysia is one of the most advanced economies in Southeast Asia, with key sectors such as manufacturing, oil and gas, and services driving its economic growth. The country is known for its exports of electronics, palm oil, and petroleum products. Malaysia's military technology is developing with a focus on modernizing the armed forces and increasing international cooperation in the field of defense. Despite facing challenges such as a limited budget, Malaysia continues to strive to strengthen its military capabilities through the acquisition of advanced equipment and increased training. In terms of human resources, Malaysia has a diverse and well-educated population, with high levels of literacy and various government initiatives to improve the skills of its workforce to face the demands of an increasingly complex global economy.

4.2 Strategy Determination

Determining strategy is the next important step in game theory. The strategy in question is a series of actions that will be taken by both players. The first player will determine the first strategic move, and then the second player will respond with their strategic move. This process continues in turns until the first player plays his final strategic move. In this game, each player has four strategies which are assumed to be the same. The difference lies in the payoff or results obtained by each player from each strategy taken. The following is a breakdown of the strategies of each player.

a. Carrying out bilateral military exercises in the waters of countries in the Indonesia-Malaysia region.

Carrying out bilateral military exercises in the waters between Indonesia and Malaysia is part of the two countries' efforts to strengthen military cooperation and increase the operational readiness of their navies. These military exercises are often carried out both in Malaysian waters and in Indonesian waters, with the main aim of increasing interoperability, coordination and combat capabilities of the two navies in facing various maritime threats in the region. With a strategic geographical background in the Indo-Pacific region, this bilateral military exercise also aims to maintain regional stability and security. The continuation of such exercises shows Indonesia and Malaysia's commitment to strengthening their maritime defenses and facing common security challenges, such as piracy, smuggling and territorial disputes. This exercise also shows the close cooperation between the two countries in supporting security and peace in the wider region.

This bilateral military exercise can be linked to Collective Security Theory, which emphasizes that global peace and security can be achieved through international cooperation and a joint commitment to confront aggression. In this context, cooperation between Indonesia and Malaysia in military exercises is a real effort to build collective security in the Indo-Pacific region. The exercise strengthens bilateral relations and creates a safer environment by addressing joint maritime threats, as advocated by collective security theory.

Apart from that, this exercise is also in line with **Naval Strategy Theory** which emphasizes the importance of controlling the sea to achieve political and military goals. By conducting military exercises in strategic waters, Indonesia and Malaysia strengthen their capabilities in securing international shipping lanes and maintaining maritime sovereignty, by the principles of maritime strategy advocated by experts such as Alfred Thayer Mahan and Julian Corbett.

This military exercise also supports the provisions of the 1945 Constitution, especially Article 10 which states that the President holds supreme power over the Army, Navy, and Air Force. This exercise is part of the President and government's efforts to maintain the country's sovereignty and security by increasing naval capabilities. Furthermore, this exercise supports the implementation of Law Number 3 of 2002 concerning National Defense, which regulates national defense policies, strategies and systems including international cooperation in the defense sector. Through bilateral exercises, Indonesia and Malaysia demonstrate their commitment to international cooperation to strengthen regional defense and security. Apart from that, this exercise is also relevant to Law Number 34 of 2004 concerning the Indonesian National Army (TNI), which stipulates that the TNI plays a role as a state tool in the defense sector to defend state sovereignty and protect the territorial integrity of the Republic of Indonesia. Bilateral military exercises with Malaysia are part of the TNI's

efforts to increase professionalism and operational readiness in facing various threats, both from within and outside the country.

Through this bilateral military exercise, Indonesia and Malaysia not only strengthened their respective countries' defenses but also contributed to regional stability and security, in line with the principles of collective security, maritime strategy, and applicable national legal provisions.

b. Carrying out joint patrols in the waters of the Indonesia-Malaysia region.

Carrying out joint patrols in the waters of the Indonesia-Malaysia region is a strategic step to strengthen maritime cooperation and increase security in the Indo-Pacific region. These joint patrols are often carried out in important areas such as the Malacca Strait and the South China Sea, which are vital international trade routes. By carrying out joint patrols, the two countries seek to prevent and deal with maritime threats such as piracy and smuggling and strengthen their presence in this strategic area.

Patrolling the Malacca Strait, one of the world's busiest shipping lanes is vital to ensuring the security and smooth flow of global trade. The presence of joint patrols from Indonesia and Malaysia can significantly reduce maritime crime incidents and improve safety. In the South China Sea, joint patrols help maintain stability and prevent the escalation of territorial conflicts. These joint patrols enhance interoperability, intelligence sharing, and rapid response to threats, benefiting the international community.

This joint patrol is in line with Collective Security Theory, which emphasizes cooperation to face common threats. It also supports the Naval Strategy Theory by ensuring control of important maritime routes. This patrol supports the implementation of Article 10 of the 1945 Constitution, as well as Law No. 3 of 2002 concerning National Defense and Law No. 34 of 2004 concerning the TNI, all of which emphasize the importance of international cooperation and increasing military capabilities in maintaining national sovereignty and security.

c. Officer/student exchange to improve human resources in each country (Sesko Force Students, Courses, and other Military Education).

Program exchange of officers and students between Indonesia and Malaysia aims to improve the quality of military human resources (HR) of the two countries through various educational and training activities. In this program, officers and students from each armed force, including students from the Force Command and Staff College (Sesko), take military courses and education in partner countries. These exchanges cover a wide range of educational levels, from basic military education to advanced courses and specific specializations.

During exchange programs, officers and students gain the opportunity to learn about partner countries' military doctrine, strategies, and tactics, as well as broaden their horizons about various approaches to military operations. In addition, this program also strengthens professional ties and networks between the armed forces of the two countries, which in turn enhances operational cooperation and interoperability in the future. These activities include group exercises, seminars and academic discussions that enable the exchange of knowledge and practical experience.

Another benefit of these exchange programs is improved language skills and cultural understanding, which are critical in multinational and coalition operations. Participants gain valuable experience that not only enriches their knowledge but also builds mutual trust and deeper

understanding. Thus, this officer and student exchange program plays an important role in strengthening military capabilities and diplomatic relations between Indonesia and Malaysia.

c. Sharing technology, and working together in the defense industry to increase the military capabilities of both countries.

Program Sharing technology and cooperation in the defense industry between Indonesia and Malaysia aims to increase the military capabilities of both countries through joint development and technology transfer. This is in line with Collective Security Theory, which emphasizes that international security can be achieved through cooperation in facing common threats. By sharing military technology and cooperating in the defense industry, the two countries can strengthen their positions in facing external threats, thereby contributing to regional stability and security in the Indo-Pacific region.

In the context of Maritime Strategy Theory, this sharing of technology and cooperation allows both countries to improve control and operational capabilities at sea, which is very important for defending strategic trade routes such as the Malacca Strait and the South China Sea. Advanced technology such as radar systems, drones, and modern warships jointly developed will increase the efficiency and effectiveness of maritime operations between the two countries. This also strengthens their presence in a strategic area, helping to maintain sovereignty and protect national interests in waters that are often a point of dispute.

This collaboration supports the implementation of Article 10 of the 1945 Constitution, which states that the President holds supreme power over the Army, Navy, and Air Force. This program is also by Law Number 3 of 2002 concerning National Defense, which regulates defense policies and strategies including international cooperation in the defense sector. Apart from that, this collaboration is in line with Law Number 34 of 2004 concerning the Indonesian National Army (TNI), which emphasizes the importance of professionalism and operational readiness of the TNI. Through the development of military technology and defense industry cooperation, the TNI can increase its capabilities in facing various threats and maintaining national sovereignty.

4.3 Discussion

a) Matrix and Payoff Determination

In determining the matrix and payoff, there are 16 combinations of strategies and payoff values. The following is a combination of strategy and payoff value from game theory.

Table 1. Strategy and Payoff for each Player

No	INDONESIA	MALAYSIA	Payoffs
1	Carrying out bilateral military exercises in the waters of countries in the Indonesia-Malaysia region.	Carrying out bilateral military exercises in the waters of countries in the Indonesia-Malaysia region.	8.8
2	Carrying out bilateral military exercises in the waters of countries in the Indonesia-Malaysia region.	Carrying out joint patrols in the waters of the Indonesia-Malaysia region.	8.7
3	Carrying out bilateral military exercises in the waters of countries in the Indonesia-Malaysia region.	Officer/student exchange to improve human resources in each country	8.6
4	Carrying out bilateral military exercises in the waters of countries in the Indonesia-Malaysia region.	Sharing technology, and cooperation in the defense industry in increasing the military capabilities of the two countries.	8.6

No	INDONESIA	MALAYSIA	Payoffs
5	Carrying out joint patrols in the waters of the Indonesia-Malaysia region.	Carrying out bilateral military exercises in the waters of countries in the Indonesia-Malaysia region.	7.7
6	Carrying out joint patrols in the waters of the Indonesia-Malaysia region.	Carrying out joint patrols in the waters of the Indonesia-Malaysia region.	7.8
7	Carrying out joint patrols in the waters of the Indonesia-Malaysia region.	Officer/student exchange to improve human resources in each country	7.6
8	Carrying out joint patrols in the waters of the Indonesia-Malaysia region.	Sharing technology, working together in the defense industry to increase the military capabilities of both countries.	6,7
9	Officer/student exchange to improve human resources in each country	Carrying out bilateral military exercises in the waters of countries in the Indonesia-Malaysia region.	7.7
10	Officer/student exchange to improve human resources in each country	Carrying out joint patrols in the waters of the Indonesia-Malaysia region.	7.7
11	Officer/student exchange to improve human resources in each country	Officer/student exchange to improve human resources in each country	6.6
12	Officer/student exchange to improve human resources in each country	Sharing technology, working together in the defense industry to increase the military capabilities of both countries.	5,6
13	Sharing technology, working together in the defense industry to increase the military capabilities of both countries.	Carrying out bilateral military exercises in the waters of countries in the Indonesia-Malaysia region.	7.7
14	Sharing technology, working together in the defense industry to increase the military capabilities of both countries.	Carrying out joint patrols in the waters of the Indonesia-Malaysia region.	7.8
15	Sharing technology, working together in the defense industry to increase the military capabilities of both countries.	Officer/student exchange to improve human resources in each country	6.6
16	Sharing technology, working together in the defense industry to increase the military capabilities of both countries.	Sharing technology, working together in the defense industry to increase the military capabilities of both countries.	6,7

Source: Author's Process

After getting the strategy combination and payoff value, the next step is to make eliminations from the strategy matrix. Elimination will be carried out using the minimax model. Minimax elimination will be carried out in the next sub-chapter.

2) Cooperative Game Theory Strategy Elimination

Table 2. Matrix Game Theory

INDO\MALAY	Bilateral Lat	Joint Operations	HR Exchange	Technology Sharing
Bilateral Lat	8.8	8.7	8.6	8.6
Joint Operations	7.7	7.8	7.6	6,7
HR Exchange	7.7	7.7	6.6	5,6
Technology Sharing	7.7	7.8	6.6	6,7

Source: Author's Process

In the table above you can see the value of each strategy for each player. The payoff value for each first number is the value of the first player, namely Indonesia. For example, the value of bilateral training for Indonesia is 8, meaning the profit from bilateral training is 8, if player 2 plays the same strategy, then Malaysia also has the same advantage as Indonesia, namely 8 points. The next

steps are the same up to the last payoff. Next, we will look for the saddle point value using the maximin method, as in the table below.

Table 2. Game Theory Elimination Matrix

INDO\MALAY	Bilateral Lat	Joint Operations	HR Exchange	Technology Sharing
Bilateral Lat	**8**.8	**8**.7	**8**.6	**8**.6
Joint Operations	7.7	7.8	7.6	6,7
HR Exchange	7.7	7.7	6.6	5,6
Technology Sharing	7.7	7.8	6.6	6,7

Author's Processed Source

The table above shows that the compromise or saddle point value is 8.7, namely for Indonesia to carry out a bilateral training strategy with Malaysia to improve global security in the Indo-Pacific region, while Malaysia carries out joint operations to secure the Malacca Strait and its territorial waters to maintain security stability in the waters of the Indo Pacific region.

5 CONCLUSIONS.

5.1 Conclusion

Based on a series of data processing, scenario preparation and analysis of research results, some conclusions can be drawn as follows:

a. Determining the best strategy for Malaysia and Indonesia, which was carried out using a game theory approach, involved various strategies. These strategies include the implementation of bilateral military exercises in the waters of the Indonesia-Malaysia region, joint patrols in the waters of the Indonesia-Malaysia region, exchanges of officers or students to increase the human resources of each country, as well as sharing technology and cooperating in the defense industry to improve military capabilities of both countries. Through this analysis, it can be concluded that the most effective and profitable strategy for both countries is a combination of bilateral military exercises and joint patrols, reinforced by personnel exchange programs and technological collaboration. This approach not only increases maritime security and defense capabilities but also strengthens diplomatic relations and synergy in the development of human resources and defense technology. Implementation of these strategies will result in stronger stability and security in the Indo-Pacific region, providing strategic advantages for Malaysia and Indonesia.

b. The optimal strategy for Indonesia is to carry out bilateral joint exercises with Malaysia to increase security in the Indo-Pacific maritime region. This step will strengthen bilateral cooperation and increase maritime defense capabilities in the region. For Malaysia, the most effective strategy is to carry out joint operations around the Malacca Strait and the waters bordering Indonesia. This operation will strengthen maritime security, prevent illegal activities, and increase regional stability in these strategic waters. Implementation of this strategy will provide significant benefits for both countries in maintaining territorial sovereignty and creating a safer and more stable environment in the Indo-Pacific region.

5.2 Suggestion

Based on the results of the research that the author has done, there are several inputs in improving and developing this research in the future, namely:

a. for Indonesia and Malaysia to actively implement strategies that have been identified as most effective through a game theory approach. For Indonesia, it is important to prioritize the implementation of bilateral military exercises with Malaysia regularly. This step will strengthen maritime defense capabilities and increase cooperation in maintaining the security of the Indo-Pacific maritime region. In addition, Indonesia must continue to encourage officer and student exchange programs to increase the competency of military human resources.

b. For Malaysia, it is highly recommended to focus on joint operations around the Malacca Strait and the waters bordering Indonesia. This operation will play a crucial role in preventing illegal activities and increasing maritime security stability in the region. Malaysia must also strengthen cooperation with Indonesia in sharing technology and developing the defense industry to increase the military capabilities of both countries.

c. Both countries must develop better communication and coordination mechanisms to ensure the implementation of these strategies runs smoothly and effectively. In addition, Indonesia and Malaysia need to continue to evaluate and adjust the implemented strategies, to ensure sustainability and increase the effectiveness of maritime defense and security cooperation in the Indo-Pacific region.

ACKNOWLEDGEMENT

The authors greatly acknowledge the support from Indonesia Naval Technology College STTAL Surabaya Indonesia for providing the necessary resources to carry out this research work. The authors are also grateful to the anonymous reviewers and journal editorial board for their many insightful comments, which have significantly improved this article.

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Indonesian Naval Technology College
Postgraduate International Conference, Vol. 8, No. 1, pp. 136-154
June, 27th 2024

IMPACT OF BRI AND FOIP DEVELOPMENT ON NATIONAL SECURITY IN THREE TROUBLE SPOTS IN INDONESIA

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ABSTRACT

China's economic growth followed by its military progress has created imbalances in the Asia-Pacific region, especially Southeast Asia. At present, China's military is ranked third in the world, and even the China Sea is ranked second in the world. China is developing its *Belt and Road Initiative* (BRI) strategy to increase its geopolitical influence in the Southeast Asian region. The United States created America's Free and Open Indo-Pacific (FOIP) policy to counterbalance China's geopolitical influence. This study aims to determine the national security risks that occur in 3 touble spots in Indonesia as a result of the development of BRI and FOIP in the Southeast Asian region. This research uses the Analytical Hierarchy Process (AHP) Method approach. Based on the results of Risk Factor research consisting of threats, vulnerabilities and impacts showed that impact with a value of 0.396 was identified as the most important criterion followed by vulnerability with a value of 0.335 and threats with a value of 0.269. Sensitivity analysis showed minimal variation in ranking order across different scenarios, confirming the robustness of the proposed model. This analysis suggests that adjusting the weights and scores used in evaluating national security trouble spots can improve the decision-making process, as it shows the important role these factors play in risk ratings for each region.

Keywords: Belt and Road Initiative (BRI); Free and Open Indo-Pacific (FOIP); AHP

1. Introduction.

The Belt and Road Initiative (BRI) implemented by China and the Free and Open Indo-Pacific (FOIP) implemented by the United States (US) are two major geopolitical strategies aimed at expanding the influence of each country outside its territory (Shanahan, 2019). Both of these initiatives have a significant impact on the national security of countries in the Indo-Pacific region, including Indonesia. The U.S. and China have different visions for the region. The US vision, most recently articulated by the Trump Administration, was built on the axis of Asian rebalancing during the Obama Administration. This vision focuses on maintaining regional freedom, openness, security, and stability, as well as ensuring freedom of access to the common domain, in order to safeguard the interests of the US and its allies and prevent China from establishing an exclusive sphere of influence (Al, 2020).

Instead, China's vision is based on a China-centric model that involves expanding its power and influence in the region, fostering economic integration, and creating greater regional dependence on China.

Through the BRI, China seeks to expand infrastructure and economic investment to bring countries in the region under its leadership (Al, 2020). While not all U.S. and Chinese goals clash directly, the two major nations are seeking to advance different visions for the Indo-Pacific region to pursue their geopolitical goals.

One of the significantly affected regions is Southeast Asia, including Indonesia. Indonesia's strategic location, which sits at the crossroads of world maritime traffic between Australia and Asia and the Pacific and Indian Oceans, makes it key in the international production chain and a pivotal point in China's geopolitical ambitions. The Indo-Pacific region is expected by the U.S., Japan, India and Australia to increase collaboration with countries in the region to counter China's growing influence. Indonesia, as the largest country in Southeast Asia and the leader of ASEAN, seeks to balance the geopolitical influence of these two great powers (Pratiwi et al., 2021).

Indonesia faces major challenges in protecting its sovereignty from potential threats arising from its strategic position and abundant natural resources. The security implications of the BRI and FOIP policies are significant for Indonesia's national security, especially in three vulnerable points: the Natuna Sea, Papua, and Ambalat. These initiatives exacerbate existing geopolitical tensions and pose challenges to Indonesia's efforts to defend its sovereignty and secure its natural resources. The presence of foreign powers in these regions further complicates internal political issues and separatist aspirations, thus posing risks to Indonesia's territorial integrity (S. F. Putra, et al., 2022).

Research by Ali et al. (2021) shows that determining national jurisdictional boundaries often encounters obstacles, especially by island countries that have an interest in obtaining marine resources, both marine products such as fisheries and underwater products such as oil and gas. Cases such as Sipadan and Ligitan, Timor Gap, Ambalat Sea, and South China Sea trigger and increase tensions and conflicts over BRI and FOIP policies (Ali, et al., 2021).

Vulnerabilities arising from the development of BRI and FOIP in Indonesia include threats to maritime sovereignty and political instability in disputed areas. The Natuna Sea, which is rich in natural resources and geographically strategic, is often a point of tension between China and Indonesia. The assertion of territorial claims by China through the nine-dash line map triggered incidents between fishing boats and the Chinese coast guard and Indonesian authorities, potentially triggering small military conflicts in the region (Putra et al., 2022).

In Papua, the presence of foreign powers supporting the BRI fueled anti-foreign sentiment and strengthened separatist movements. Conflicts in the region may worsen due to great power competition that increases political and social instability. In Ambalat, the dispute with Malaysia over oil and gas exploration rights is also influenced by geopolitical dynamics involving BRI and FOIP, increasing the risk of diplomatic and military conflicts (Indriyani et al., 2022).

The impact of BRI and FOIP policies on Indonesia includes increasing geopolitical tensions and the risk of armed conflict in strategic areas. Tensions in the Natuna Sea could disrupt international shipping lanes and affect Indonesia's energy security, given the region's importance as a source of oil and gas. In Papua, conflict escalation can hinder economic development and political stability, while in Ambalat, a protracted dispute with Malaysia can disrupt bilateral and regional relations (Putra et al., 2022).

The influence of the Belt and Road Initiative (BRI) and the Free and Open Indo-Pacific (FOIP) covers a wide range of economic, political, security and social aspects. Economically, the BRI improves infrastructure and connectivity through investment, but also poses debt risks and economic dominance by China (Li, 2020).

FOIP, in contrast, encourages free trade and market-driven economic collaboration. In the political aspect, BRI strengthens China's political influence through infrastructure diplomacy, while FOIP strengthens US alliances in the region (Pradhan, 2021).

In terms of security, the BRI may raise concerns about China's military influence, while the FOIP focuses on maritime security and regional stability through military cooperation with US allies (Liff, 2019). BRI's social influence includes potential anti-foreign sentiment and concerns about sovereignty, while FOIP can encourage social and political reforms based on democratic values (Scott, 2020). The impact of these two initiatives on countries in the Indo-Pacific, including Indonesia, is complex, creating challenges and opportunities that require strategic navigation to maximize benefits and minimize risks.

Based on this phenomenon, in this study it can be seen that the increasing geopolitical competition between the US and China can fight for tension in the Indo-Pacific region and complicate diplomatic efforts and multilateral cooperation (Pradhan, 2021). This is an aspect that is considered less in-depth about the readiness of the long-term impact of BRI and FOIP on political and economic stability in recipient countries and limited in-depth research on how countries such as Indonesia can effectively navigate these dynamics (Ali, et al., 2021). Thus, several threats have emerged that disrupt national security due to dependence on foreign investment through BRI and increased risk of conflict and foreign intervention due to FOIP's militaristic approach (Putra et al., 2022).

To analyze Indonesia's national security risks related to BRI and FOIP, appropriate theoretical approaches include national security theory, geopolitical theory, and risk analysis theory. National security theory helps in understanding how states identify and respond to various threats to the sovereignty, territorial integrity, and safety of their citizens (Buzan et al., 1998). Geopolitical theory examines how geographical factors affect international politics and power relations between countries, which is relevant in understanding Indonesia's strategic position at the crossroads of world maritime traffic (Brzezinski, 1997). Risk analysis theory provides a framework for assessing and managing risk by identifying threats, vulnerabilities, and possible impacts (Kaplan & Garrick, 1981).

This research was conducted due to the significant strategic impact of the Belt and Road Initiative (BRI) and Free and Open Indo-Pacific (FOIP) on Indonesia's national security. These two initiatives have created complex dynamics in regional geopolitics, including increased tensions in strategic areas such as the Natuna Sea, Papua, and Ambalat. The presence of foreign powers in these regions increases risks to Indonesia's sovereignty and security and complicates efforts to maintain stability in the region.

The Analytical Hierarchy Process (AHP) method can be used in this study to analyze national security risks. AHP helps to determine the weight of each risk criterion based on the subjective assessment of experts. This approach allows the identification of the most critical risk scenarios and the development of effective mitigation strategies (Saaty, 1980).

This research is expected to provide a deeper understanding of national security risks arising from the implementation of BRI and FOIP in Indonesia, as well as help formulate effective mitigation strategies. By analyzing factors such as threats, vulnerabilities, and impacts, the study will help the Indonesian government and other stakeholders to identify hotspots and design concrete measures to mitigate those risks.

A key contribution of the research is to provide deeper insight into the geopolitical complexities in the Indo-Pacific region and their impact on Indonesia's national security. With a better understanding of the risks

and challenges faced, Indonesia can take more effective measures to protect its sovereignty and ensure regional stability.

2. Literature Review.

2.1. National Security

National Security will be a solid foundation in this research. According to Alan Collins in his research (Omoroje et al., 2021), National Security Theory is defined as "the need to maintain the survival of the nation state through the use of economic, military, and political force and the conduct of diplomacy." In elaborating this concept, focus will be given to these aspects, highlighting the role of the economy, military, and diplomacy in ensuring the stability and sustainability of the country.

The research will also involve an in-depth understanding of asymmetric warfare theory and communication theory, which are essential elements in the rapidly evolving context of national security. Asymmetric warfare theory highlights the strategies and tactics used by a significantly weaker side militarily to counter the stronger side, while communication theory considers the importance of effective communication in preventing and resolving conflicts.

2.2. Geopolitical

The definition of political geography is a science that studies the relationship between life and political activities with the natural conditions of a country or in other words studies *the states and it's natural environment* (Tampubolon, et al., 2022). In addition, political geography also studies the state as a political region that includes both internal geographical factors, and external, namely relations between countries (Syuryansyah &; Bethanila, 2022). The object and geography of politics is the analysis and relations between states and adaptation to environmental conditions within those countries. Thus political geography can be interpreted as "*Is the geography of states and provide a geographical interpretion of international relations*".

Geopolitics is the study of the relationship between geography, political power, and international dynamics. This theory attempts to understand how geographical factors such as location, topography, natural resources, and access to trade routes affect political decisions, security strategies, and power dynamics between countries on the global stage. Geopolitical theory involves analyzing the efforts of a country to expand its influence, protect its national interests, and interact with other countries in competition or cooperation to achieve certain political and economic goals (Erickson &; Strange, 2018; Limaye & Tellis, 2018).

2.3. Risk

Risk is the potential to gain or lose something of value. Values (such as physical health, social status, emotional well-being or financial wealth) can be gained or lost when taking risks resulting from an action or inaction, both foreseeable and unforeseeable. Risk analysis is to determine the magnitude of a risk which is reflected in the possibility and severity it causes. There are many techniques used to conduct risk analysis both qualitative, semi and quantitative. Qualitative risk analysis analyzes and assesses risks by comparing impact and opportunity parameters by comparing predefined matrices. Semiquantitative risk analysis has a method that is almost similar to quantitative methods (Raihan &; Fitriani, 2023). But the difference lies in the value / score that has been determined according to the risk. Quantitative risk analysis is carried out by determining

the value of each parameter obtained from the results of representative analysis such as statistical analysis, simulation, The parameters used in analyzing and assessing risk are threat, vulnerability, and impact.

A threat is something that can disrupt the activities of an organization (Kurnia et al., 2022). Emerging threats include military, economic, and sovereign aspects, which are potential and real in increasing tensions and conflict risks in the region.

Vulnerability analysis is used as: (1) a diagnostic tool to understand problems and factors that cause vulnerability, (2) a planning tool as a basis for prioritizing activities and the sequence of planned activities, (3) a risk measurement tool to assess specific risks, and (4) a tool to empower and mobilize vulnerable community groups. Vulnerability analysis is part of risk analysis that allows stakeholders to counter terrorism (Purwanto et al., 2021). The vulnerabilities are mainly related to infrastructure, economy, and politics, reflecting Indonesia's dependence on foreign investment and trade and the vulnerability of infrastructure to cyberattacks and sabotage.

Impact is the degree or magnitude of influence on other activities when unwanted activities occur. Impact (consequence) Assessment is carried out to assess the consequences/impact of the possibility of various identified threats to the facility under review. The assessment is based on criteria, including casualties, injuries, loss or damage to buildings/assets and Impact on the economic and/or socio-political welfare of the state/nation (Octavian et al., 2020b). Impact assessments in terms of the number of fatalities and potential number of injuries should take into account the worst-case scenario of full occupancy of the facility under review, economic, social, and environmental aspects, which are detrimental to economic growth, social stability, and environmental sustainability. The criteria for assessing the loss of damage to buildings/assets must consider the cost of building construction. The assessment of the loss of primary care must be in accordance with the recovery period for the rebuilding of buildings/assets and/or replacement of supporting equipment that determines the overall operation of the facility (Chang et al., 2021).

The analysis is a reflection of the complex risks affecting Indonesia's national security and demands a comprehensive and adaptive response from the government and other stakeholders. The nature of these threats, vulnerabilities, and impacts varies from potential, reflecting future possibilities, to real, existing or ongoing. This risk analysis has a proactive nature, with the aim to identify, evaluate, and mitigate risks associated with the implementation of BRI and FOIP, as well as to help formulate effective mitigation strategies in safeguarding Indonesia's national security.

Risk analysis can be written with a risk formula (Chang et al., 2021):

Risk = *Threat* (T) x *Vulnerability* (V) x *Impact* (I)

Chang et al (2021), explained that threats will exploit vulnerabilities that cause impact on the system, thus making it a risk to an organization. Therefore, if no threats, vulnerabilities and impacts are found, then there is no risk.

2.4. Methodology

2.4.1. Data Collection Techniques

This study used three data collection techniques, namely in-depth interviews, observation, and documentation studies to obtain primary and secondary data. Primary data is obtained directly from the place and subject of research, while qualitative data, according to Sugiyono (2020), consists of words and actions. The interview technique involves systematic questions that are asked openly to sources who understand the purpose

of the interview. Field observations were conducted to accurately document data and evidence, particularly in identifying potential risks in three vulnerable areas in Indonesia: North Natuna Sea, Ambalat, and Papua. The questionnaire, which is divided into four parts, is used to collect respondents' information, provide charging instructions, and assess risk through predetermined dimensional weights.

2.4.2 Content Validation Index

The Content Validity Index (CVI) stands as an important method for assessing the validity of instrument content, which is widely recognized for its applicability across various research domains. It measures the extent to which experts agree on the relevance or representativeness of an instrument item, offering insight into the validity of its content both at the item level (Item-level CVI or I-CVI) and across instruments (Instrument-level CVI). CVI calculations are supported by expert evaluations of each item, based on the relevance or representativeness of its content (Almanaksreh, Moles and Chen, 2018).

In assessing content validity, this study used item-level content validity index (I-CVI) and scale-level average content validity index (S-CVI/Ave). S-CVI/Ave is determined by dividing the number of I-CVI scores by the number of items. An S-CVI/Ave ≥ 0.8 is considered acceptable, while an S-CVI/Ave ≥ 0.90 indicates excellent overall content validity. I-CVI, on the other hand, is calculated as the number of experts assessing an item ≥3 divided by the total number of experts, with an I-CVI of ≥0.78 acceptable. The literature shows that for a new assessment instrument to be considered valid, it must achieve a total CVI of ≥0.90 or 90% and an I-CVI of ≥0.78 or 78% (Marisa, 2021).

2.4.3. Analytical Hierarchy Process (AHP)

AHP was developed by Saaty (2013) as a model for solving decision problems. AHP ensures that quantitative and qualitative variables can be evaluated together taking into account the priorities of decision makers. The stages in the AHP process can be summarized as follows:

a. Perform criteria definition

Identify risk analysis criteria that affect three *trouble spots* in Indonesia as a result of the development of BRI and FOIP. Each risk analysis criterion will be formed by a number of sub-criteria that are owned as an assessment of risks that can occur.

b. Formulate objectives, criteria, sub-criteria and alternatives in the form of a decision hierarchy

Compiling objectives, criteria, sub-criteria and alternatives in accordance with the research discussion, where in this study a number of risk analysis criteria were compiled that affect three trouble spots in Indonesia as a result of the development of BRI and FOIP which can also be influenced by sub-criteria so as to facilitate the assessment of the criteria studied.

c. Provide a current scale assessment on a criterion pairwise comparison matrix

Assess each criterion and sub-criteria of risk analysis through questionnaires with a scale of 1-9 in accordance with the conditions of the research object, namely three Indonesian trouble spots (North Natuna Sea, Ambalat Block and Papua).

d. Testing for consistency against comparisons between criteria

Perform CI and CR tests with the formula:

$$CI = (\lambda max - n) / (n - 1)$$

Where:

n = number of elements

$$CR = CI / RI$$

Where:

CR = *Consistency Ratio*

CI = *Consistency Index*

RI = *Random Consistency Index*

If the value is more than 10%, the judgment assessment must be corrected, but if the consistency ratio (CI/RI) is less or equal to 0.1, the calculation results can be declared correct.

Table 1. Random Index Value

Matrix Value (n)	1	2	3	4	5	6	7	8	9	10
Random Index (RI)	0,00	0,00	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49

Source: Saaty (2013)

e. Perform ranking

After CI and CR measurements can be obtained weight values for the assessment of criteria and risk analysis sub-criteria, then ranking can be carried out from the weight values obtained. Thus, it can be known the large or small risks that occur in three Indonesian trouble spots (North Natuna Sea, Ambalat Block and Papua) based on the criteria and sub-criteria studied.

2.4.4. Conceptual Framework

This research was conducted in three *trouble spots* in Indonesia, precisely in the North Natuna Sea, Ambalat and Papua. This study aims to determine national security risk factors in *three Indonesian trouble spots* as a result of the development of BRI and FOIP in the Southeast Asian region, focusing on this as case research and for the development of strategic initiatives. The determination of risk factors was determined through a study of previous research literature that has been conducted by Octavian, *et al* (2020).

This study uses a statistical descriptive qualitative approach that is used as a measure and describes national security risks that can occur using the *Analytical Hierarchy Process* (AHP) method.

The analysis begins with the application of the AHP method to assess risk factors and set priorities for addressing national security. As shown in the research of Octavian, *et al* (2020), along with sensitivity analysis to evaluate the reliability of results based on the weight of criteria (Axelsson, *et al*., 2021).

This study involved 10 experts based on established criteria in conducting assessments through questionnaires to collect data on criteria using a scale of 1-9 for the AHP method. The experts involved were mostly senior officials at Indonesia's three *trouble spots* .

The criteria for expert selection are set as follows (Fletcher &; Griffiths, 2020; Nguyen, *et al*., 2022; Khalilzadeh, *et al*., 2020):

a. Rank; Be at the level of decision-making, planning in national security operations.

b. Position; A position that shows the duties, responsibilities and authority held.

c. length of service; Minimum 10 years of service experience and experience in maritime intelligence operations.

d. Practitioners/Academics; Understand the problems of maritime areas in Indonesia's three *trouble spots* (North Natuna Sea, Ambalat and Papua).

e. Distribution of Work Units; Have served or carried out operations in the North Natuna Sea, Ambalat and Papua areas.

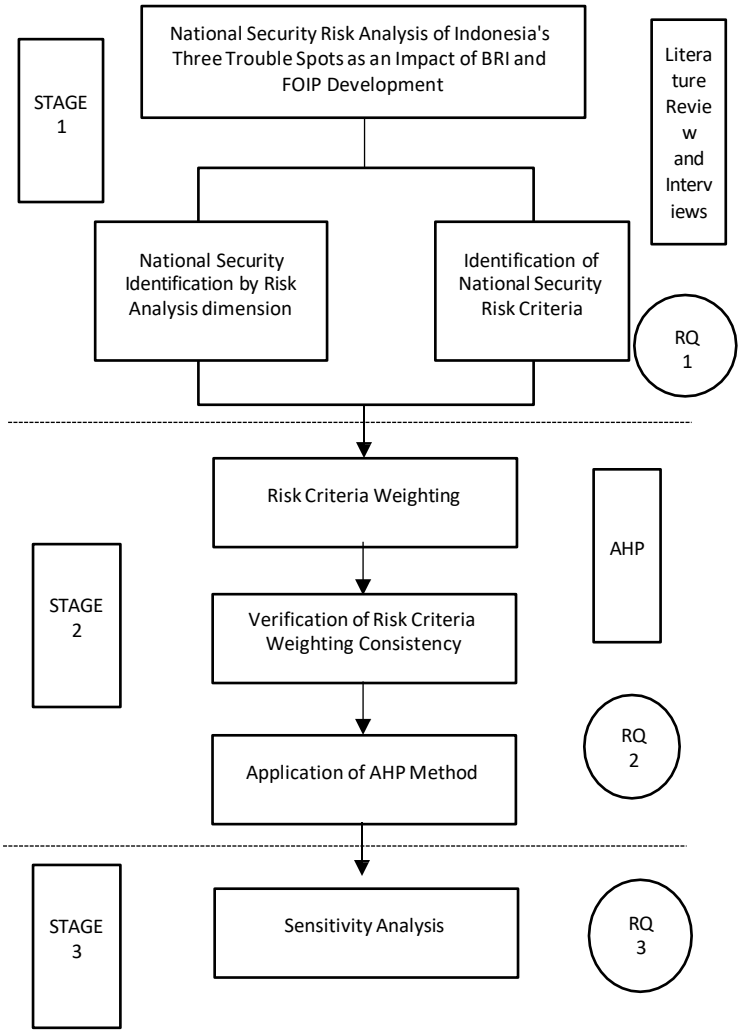

Figure 1. Conceptual National Security Risk Analysis Framework
Source: Son, *et al* (2023); Singh & Cage (2019); Octavian, et al (2020)

In this study there are several stages to achieve the expected goals through several research steps as follows:

Step 1 in this study identifies national security risks by conducting a literature study in understanding the dimensions and factors of national security risk relevant to the three trouble spots in Indonesia and considering them according to the impact of the development of BRI and FOIP. In identifying the dimensions and risk factors, this study obtained three main components of risk in accordance with Octavian, *et al* (2020) research, namely threat, vulnerability and *impact*.

Step 2 in this study involves the application of the AHP method by calculating the weight of risk criteria using AHP which helps in structuring the problem and decision making by comparing the criteria in passing.

After that the weight of the criteria is determined, the consistency of the assessment is checked to ensure the consistency of the data. Then, the AHP method is used to conduct national security risk ratings. The AHP method is used to determine the weight of the criteria.

Table 2. Assess the level of risk analysis of each criterion

Likert Score	***Risk Analysis Level***		
	Threat	***Vulnerability***	***Impact***
5	*Very High*	*Very High*	*Catstropic*
4	*High*	*High*	*Significant*
3	*Medium*	*Medium*	*Moderate*
2	*Low*	*Low*	*Minor*
1	*Very Low*	*Very Low*	*Insignificant*

(Octavian et al., 2020; Putra et al., 2023)

Table 3. Risk Assessment Level

AHP Scale	Definition	Description	Likert	Probability Value	Risk Level	Colour
1	Equally Important	Two elements contribute equally to the goal	1	0 – 0,2	Very Low	
3	A Little More Important	Experience and assessment favor one element slightly over another	2	0,21 – 0,4	Low	
5	More Important	Experience and assessment strongly favor one element over another	3	0,41 – 0,6	Medium	
7	Very Important	An element is highly favored over others and its dominance is demonstrated in practice	4	0,61 – 0,8	High	
9	Absolutely More Important	Evidence that supports one activity over another is the highest level of affirmation	5	0,81 – 1,0	Extreme	
2,4,6,8	Middle Value	When in doubt between two adjacent AHP values				

Source: Sudarsana (2021); Liu, et al (2012); Son, et al (2023)

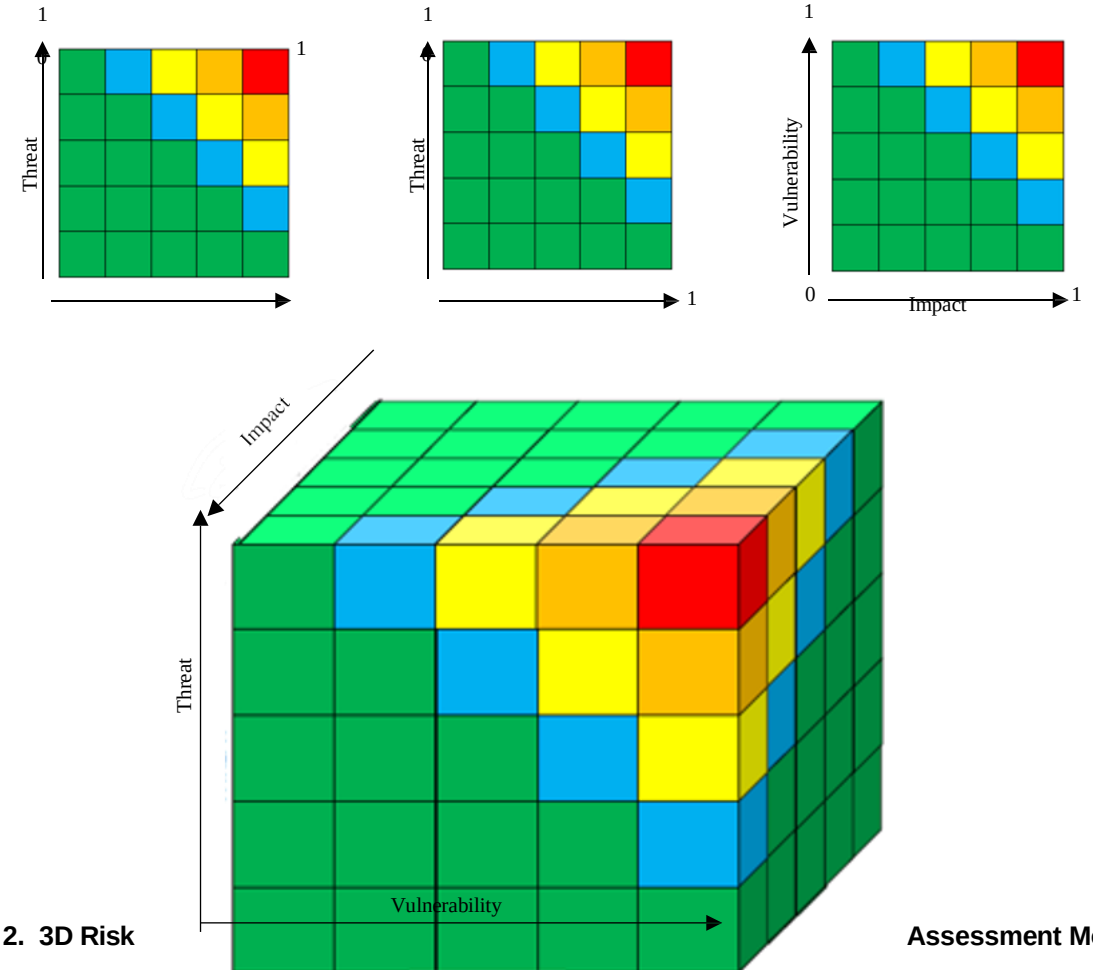

Figure 2. 3D Risk Assessment Model

Source: Processed through Sudarsana research (2021); Liu, et al (2012); Son, et al (2023)

Step 3 will conduct a national security risk sensitivity analysis. The result of implementing the AHP is a national security risk rating that indicates risk priority based on predetermined weighting and assessment criteria. Next, a sensitivity analysis is performed to evaluate how changes in the weighting of criteria or baseline assumptions affect the outcome of the risk rating. This analysis is important to ensure that the decisions taken are robust and can withstand a variety of scenarios. This systematic process results in a structured, data-driven risk rating that can be used by policymakers to improve Indonesia's national security.

3. Result and Discussion

3.1. Identification of impact factors and development strategies

This section outlines the systematic approach taken to determine risk factors: Threat, Vulnerability and Impact. Determination of risk dimensions and indicators based on research by Octavian, *et al* (2020).

Based on these three criteria, researchers involved 10 experts or experts in the maritime field who are experienced in the three *trouble spots of* Indonesia to take part in the research survey through the distribution of questionnaires.

The distribution of questionnaires was carried out through Google Form to 10 experts. This questionnaire outlines the research and its objectives and covers three dimensions and 17 risk indicators utilizing a Likert scale of 1 – 5 for assessment. The estimated time to complete the questionnaire is 10 – 15 minutes.

After taking the questionnaire, researchers will validate the I-CVI and S-CVI data as proof that all dimensions and indicators are very important to build an assessment tool. The S-CVI score is acceptable if it has a value of ≥ 0.8 and I-CVI has a value of ≥ 0.78 (Lakmini, *et* al.2023).

Table 5. Data Validity

No	Dimension	Items	Average	I-CVI	UA	Result
1	***Threat*** **(Threat)**	*Existence*	4.00	1,00	1	Accepted
		Terror Ability	3.50	1,00	1	Accepted
		Historic	4.20	1,00	1	Accepted
		Intensity	3.50	1,00	1	Accepted
		Type of Planning Activities	3.60	1,00	1	Accepted
		Target Strategies	3.20	1,00	1	Accepted
		Environmental Safety	3.60	1,00	1	Accepted
2	***Vulnerability*** **(Vulnerability)**	*Location*	3.60	1,00	1	Accepted
		Accessibility	3.60	1,00	1	Accepted
		Security Adequancy	3.80	1,00	1	Accepted
		Availability	3.40	1,00	1	Accepted
		Vulnerability	3.40	1,00	1	Accepted
3	***Impact*** **(Impact)**	*Insignificant*	3.30	1,00	1	Accepted
		Minor	3.30	1,00	1	Accepted
		Moderate	3.40	1,00	1	Accepted
		Major	3.70	1,00	1	Accepted
		Catastropic	3.80	1,00	1	Accepted
Total				16,9	16	
S-CVI/AVE				0,994		Accepted
S-CVI/UA					0,941	Accepted

Utilizing the results of the validity of this data, the AHP approach uses this data as the basic input for element creation in a paired comparison matrix. Strategies for alternative approaches, as obtained from based on research objectives that emphasize risk factors that can be used to improve national security in Indonesia's three *trouble spots* the impact of BRI and FOIP in the Southeast Asian region in the North Natuna, Ambalat and Papua Sea sectors. This requires strengthening the ability of the Indonesian Navy and related entities to conduct national security enforcement operations to address maritime crime and focusing on improving

maritime infrastructure and connectivity in coastal and border areas to facilitate logistics routes (Kukuh, *et al*., 2019).

3.2. AHP Analysis

The following steps involve organizing a hierarchy that includes objectives, criteria and sub-criteria/strategies. This structure was developed based on risk assessment factors obtained through the results of data validity from three dimensions and 17 indicators identified through a literature review in the research of Octavian, et al (2020).

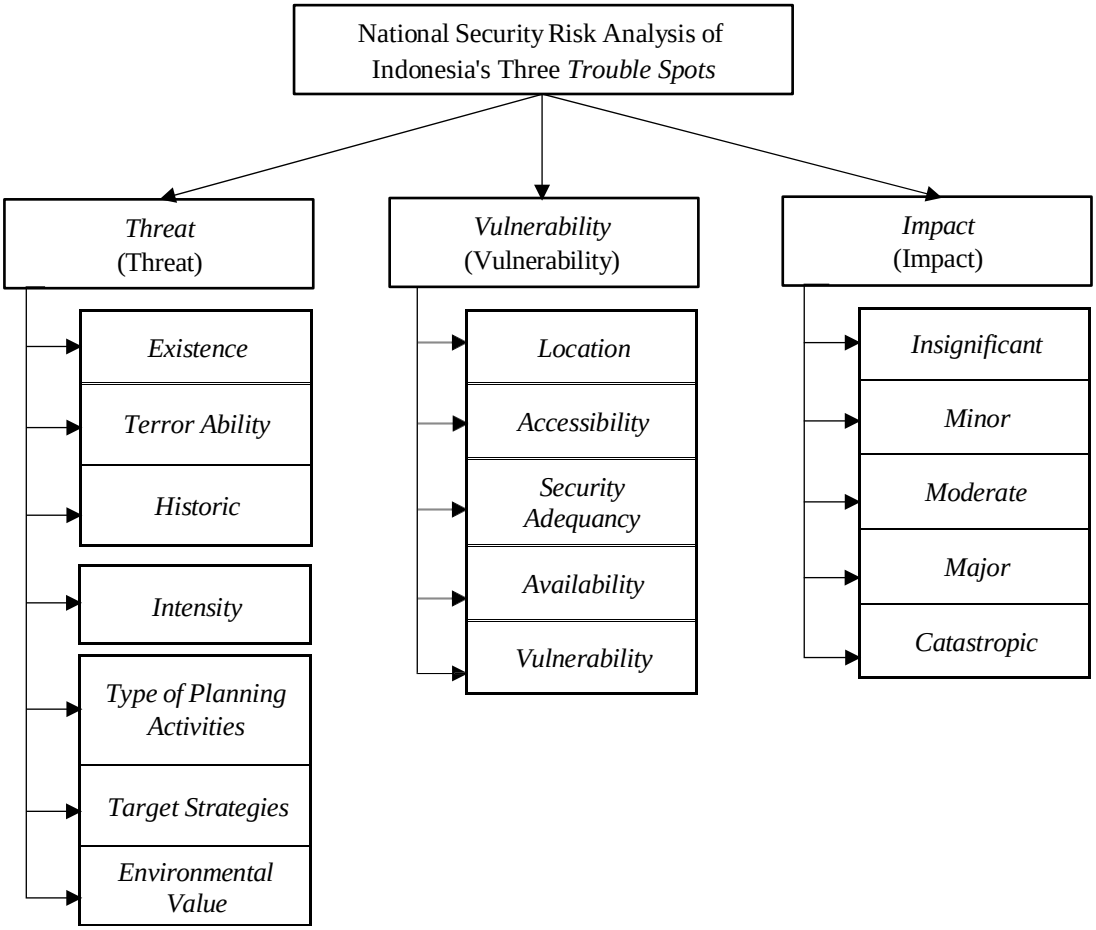

Figure 3. Risk Criteria and Sub Criteria

Identification of risk factors or criteria is essential for conducting risk research analysis in achieving national security. To this end, building a hierarchical structure is an important function in identifying and establishing correlation relationships between these risk factors. Specifically, the threat factor includes seven subfactors, the vulnerability factor includes five subfactors and the impact factor includes five subfactors.

Table 6. Hierarchical Weighting Results

Criterion	Weight Value	Rating	Sub Criteria	Weight Value	Rating
Threat	0.269	2	Existence	0.144	12
			Terror Ability	0.128	15

Criterion	Weight Value	Rating	Sub Criteria	Weight Value	Rating
			Historic	0.167	9
			Intensity	0.108	17
			Type of Planning Activities	0.201	5
			Target Strategies	0.134	14
			Environmental Safety	0.117	16
Vulnerability	0.335	3	Location	0.273	1
			Accessibility	0.243	2
			Security Adequancy	0.165	11
			Availability	0.183	8
			Vulnerability	0.136	13
Impact	0.396	1	Insignificant	0.212	4
			Minor	0.230	3
			Moderate	0.200	6
			Major	0.191	7
			Catastropic	0.167	10

After determining the significance of risk factors for a valid questionnaire, it can be found that the consistency index (CI) value of 0.0 and consistency ratio (CR) 0.0 are achieved in 3 main criteria and 17 assessment sub-criteria. The results showed that the questionnaire met the standard consistency criteria and was valid for use in this study. The relative importance of these key factors or criteria, important for the analysis of risk assessment to national security, according to table 6. The results of the AHP analysis show that the importance of the impact criterion with a value of 0.396 is identified as the most important criterion in analyzing national security risks in three Indonesian *trouble spots*. Then the criteria ranking is followed by vulnerability with a value of 0.335 and threat with a value of 0.269. This result can be used as one of the quantitative values in formulating national security strategies on Indonesia's three trouble spots as a result of the development of BRI (Belt and Road Initiatives) and FOIP (Free Open Indo-Pacific) with a regional focus on the North Natuna Sea, Ambalat and Papua.

Among the 17 sub-criteria of assessment, it can be seen that five sub-criteria are considered the most important with a greater value, namely location value 0.273, accessibility value 0.243 raises the dominance of the highest value which indicates the importance of geographical location and accessibility factors in addressing security challenges in the specified trouble spots, where infrastructure expansion and activities related to BRI and FOIP are focused.

Then, minor values of 0.230 and insignificant values of 0.212 highlight the important role of elements – small but impactful elements that can accumulate into significant threats to national security.

Furthermore, the type of planning activities valued at 0.201 is considered important because it affects the effectiveness of strategies designed to deal with complex challenges that arise.

The correlation between these sub-criteria highlights that in overcoming the challenges faced by cofleets related to BRI and FOIP, it is important to pay attention to location, accessibility, minor and insignificant impacts along with threats to the type of planning activities carried out. This reflects the complexity of the

national security challenges faced, where various aspects must be considered and analyzed in order to implement effective national security defense.

3.3. Sensitivity Analysis

Variable sensitivity analysis is needed to find and determine the variables that have the greatest degree of influence on modeling. From the model made, it is known that there are main criteria for risk analysis in national security, three *Indonesian trouble spots* as a result of the development of BRI (*Belt and Road Initiatives*) and FOIP (*Free Open Indo-Pacific*) with a regional focus on the North Natuna Sea, Ambalat and Papua. Of these three criteria, the highest to lowest risk can be known through the AHP analysis of these criteria as follows:

a. Impact Risk Analysis with a value weight of 0.396

b. Vulnerability Risk Analysis with a value weight of 0.335

c. Threat Risk Analysis with a value weight of 0.269

To determine the variables that have an influential contribution to the national security of Indonesia's three *trouble spots*, a classification of the 3 risk analysis criteria was made. The following is a sensitivity analysis of the results of national security modeling simulations of three *Indonesian trouble spots*.

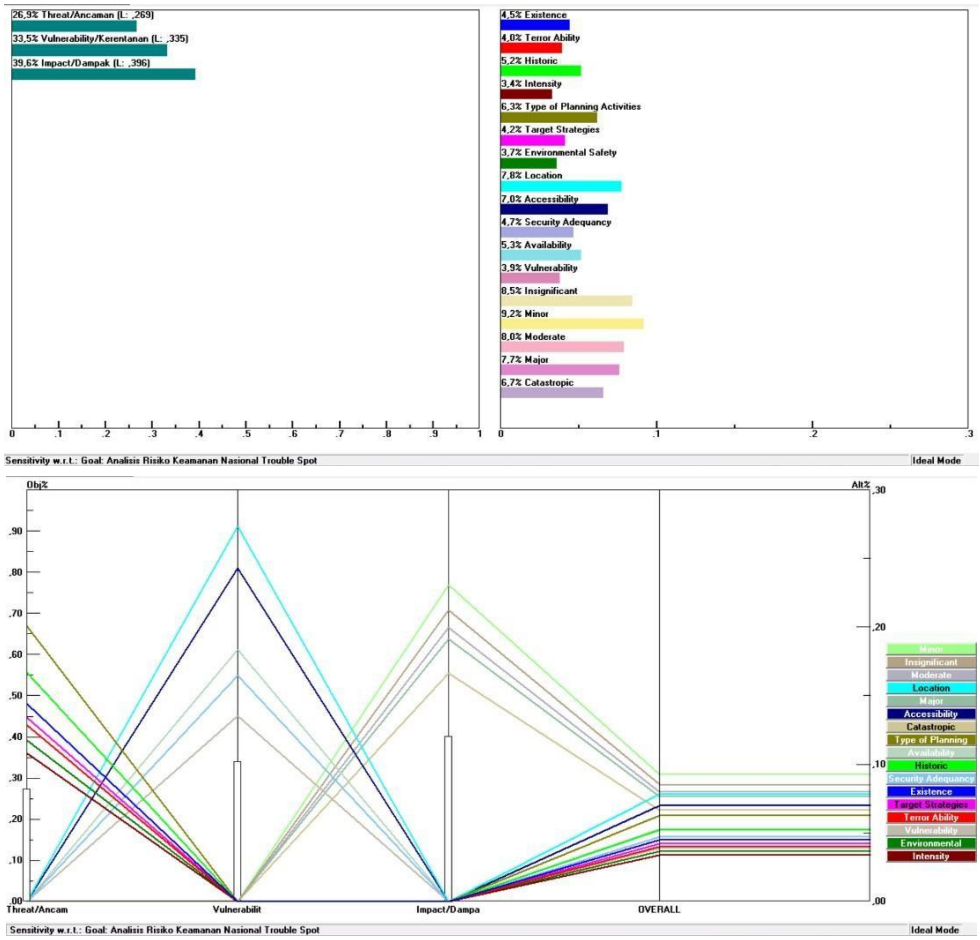

Figure 0.1 Sensitivity Analysis Results

Source: Primary Data Processed (2024)

The results of the expert *choice software* sensitivity analysis in the AHP analysis were used to describe the prioritization for all criteria and sub-criteria in the national security risk analysis *trouble spot*. Based on the graph and percentage, the overall sensitivity analysis shows the highest criteria on the impact risk criteria . Furthermore, the final result in the form of risk sub-criteria which will be able to become a top priority in knowing the highest risk factors that cause national security risks is known to be found in the impact sub-criteria , namely *minor*.

AHP sensitivity analysis through *expert choice software* can also be used to determine the possibility or forecast of changes in the conditions of each criterion and sub-criteria if there is a change in value, where this change can change the prioritization of national security risk analysis in *trouble spots*. From the sensitivity chart image above, it shows that if there is a change in weight in the criteria, it will not affect the determination of national security risk sub-criteria. So that the risk that is the most important basis for maintaining national security *trouble spot* is the risk of *impact* (impact) with sub-criteria (*minor*).

4. Conclusion

This study discusses the analysis of National Security Risk in Three Indonesian Trouble Spots as an Impact of BRI and FOIP Development in the Southeast Asia region utilizing the *Analytical Hierarchy Process* (AHP) approach, this method has proven to be an effective and efficient way to identify key factors and assess and analyze national security risks supported by research; Alizadeh et al (2021); Putra et al (2023) and Octavian et al (2020).

This study facilitates balancing and comparison of risks from various elements of national security in three *trouble spots*, while building a database enriched with factual data and supporting the identification and comparative analysis of 17 sub-factors or sub-criteria of risks raised through Octavian et al's (2020) research. This adoption of the risk research model by Octavian et al (2020) may provide important advantages of this analytical approach. When applied to Indonesia's maritime domain, the study reveals advances in national security defense analysis models compared to other methodologies. In terms of risk factors, this study identified three main factors or criteria namely; *Threat* (0.396), Vulnerability (0.335) and Impact (0.269) with *location* and *accessibility* as the most significant sub-factors or sub-criteria in risk assessment.

Inconsistencies in this study are caused by differences in data sources between backgrounds based on general information and research results that use quantitative data from experts. This indicates that mitigation and response efforts have been carried out by the Navy are effective in reducing the level of national security risk in the three areas studied.

Sensitivity analysis shows that the North Natuna Sea and Papua have a higher sensitivity to changing conditions, especially in terms of vulnerability and threat initially. On the other hand, Ambalat shows higher stability in terms of vulnerability and impact, but is sensitive to threats. This analysis is important for mitigation and response to national security threats, vulnerabilities, and impacts in each trouble spot area.

Limitations &; Future Research

The study acknowledges a number of research limitations that pave the way for future research. First, the study depends on the availability and quality of quantitative data available at the time the study is conducted, which can affect the accuracy of the risk analysis. Second, the focus of research on three main

trouble spots, namely the North Natuna Sea, Ambalat, and Papua, can ignore potential risks in other regions that are also affected by BRI and FOIP. Third, the risk analysis in this study includes threats, vulnerabilities, and impacts, but there are still other factors such as economic, political, socio-cultural and environmental that may affect national security that are not included in this analysis. Fourth, although the AHP method was used in this study, it also has its own limitations, such as sensitivity to the weights set in the AHP. Lastly, direct involvement from multiple stakeholders may not be optimal in this study, which could affect a more comprehensive understanding of national security risks. Awareness of these limitations is important to improve the quality of future research in this field and provide a stronger foundation for understanding and addressing national security risks associated with BRI and FOIP in Indonesia.

Through these limitations, researchers provide a number of research suggestions to researchers in the future to be able to expand the scope of data collected, this can include the use of diverse virgin sources and involve more respondents or experts in research. Future researchers may also explore and compare the various analytical methods available such as SWOT, Relationship Analysis and others to ensure that the findings obtained are the most relevant and reliable for research. Then, future researchers can improve risk analysis models by expanding on additional factors that may affect national security, such as political, economic and social dynamics at local, regional and global levels. Furthermore, future researchers can also explore in depth the impact and implementation of geopolitical strategies such as the *Belt and Road Initiative* (BRI) and *Free and Open Indo-Pacific* (FOIP) on countries in the Southeast Asian region, including Indonesia. This can help in identifying and responding to future changes related to national security and geopolitics.

5. Acknowledgement

This research was supported by a research grant for Indonesia Naval Technology College (STTAL) and Sepuluh November InstituteTechnology (ITS)

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Indonesian Naval Technology College
Postgraduate International Conference, Vol. 8, No. 1, pp. 155-166
June, 27th 2024

LOADING AND UNLOADING ON THE RORO FERRY DURING EXTREME WEATHER AT MERAK-BAKAUHENI PORT

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ABSTRACT

Indonesia, an archipelagic country with 31 million km² of water and an exclusive economic zone of 27 million km², plays an essential role in the global economy. Public transportation, including land, air, and sea, dramatically affects the region's economic performance. With their roll-on-roll-off design, Roro Ferry's passenger ships are becoming an efficient and effective mode of transportation. However, they still face shortcomings in terms of safety and convenience. The research used is qualitative with a descriptive approach. The study's location is the Merak-Bakauheni Ferry Terminal, the main link between Java and Sumatra. Data was collected through interviews, observations, and case studies and analyzed using Miles and Huberman's interactive data analysis techniques. The study results show that implementing appropriate safety procedures can minimize the risk of accidents and cargo damage. Using ramp doors makes the loading and unloading easier but requires special adjustments during extreme weather. In addition, strict checks on mooring ropes, ramp doors, ventilation, and the cleanliness of the loading room, as well as the readiness of the crew, are crucial. In adverse weather conditions, additional procedures are required to handle heavy loads, such as fuso and Ironton trucks. This study provides recommendations for infrastructure improvement, revision of standard operating procedures (SOP), safety training, and collaboration with BMKG to improve safety and operational efficiency.

KEYWORDS: Sea Transportation, Roro Ferry Ship, Loading and Unloading Safety, Merak-Bakauheni Terminal

1. INTRODUCTION.

As an archipelagic country in accordance with the 1982 United Nations Convention on the Law of the Sea, Indonesia has a vast maritime territory with waters covering an area of 3.1 million km2 and an Exclusive Economic Zone of 2.7 million km2. This study aims to identify and analyze issues in the loading and unloading process on the Roro Ferry during extreme weather at the Merak-Bakauheni port. The research focuses on finding practical solutions to improve the efficiency and safety of the loading and unloading process, especially in adverse weather conditions.

The background of this research is based on the frequent occurrence of cargo damage and accidents on ships caused by extreme weather and suboptimal handling of loading and unloading on the car deck. Some key issues identified include the suboptimal installation of lashing fixtures, a limited number of crew members, lack of cleanliness on the car deck, and lack of time available for loading and unloading. Maintenance of lashing equipment is rarely performed, which can be fatal due to the lack of quick handling of problems if they occur in the short term.

However, ferry operations face obstacles, especially those caused by extreme weather. Extreme weather conditions, such as those recorded at level 6 on the Beaufort Scale, can pose a risk of serious accidents, with strong winds of up to 27 knots and waves as high as 4 meters. In one instance, bad weather reportedly caused two trucks to overturn while loading at Motor Vessel Nusa Darma due to negligence in implementing cargo safety procedures.

The main goal of this study is to achieve maximum efficiency in transporting vehicles from the delivery site to the receiving location safely in any situation. Therefore, optimizing loading and unloading handling is very important, especially during dangerous weather conditions for crew and passengers.

This research seeks to provide practical guidance for better handling of loading and unloading on Roro ferries, reducing the risk of accidents and cargo damage. The approach includes direct observation, interviews with crew members, and data analysis collected during sea practice on the Motor Vessel Jagantara.As an archipelagic country in accordance with the 1982 United Nations Convention on the Law of the Sea, Indonesia has a vast maritime territory with waters covering an area of 3.1 million km2 and an Exclusive Economic Zone of 2.7 million km2. This study aims to identify and analyze issues in the loading and unloading process on the Roro Ferry during extreme weather at the Merak-Bakauheni port. The research focuses on finding practical solutions to improve the efficiency and safety of the loading and unloading process, especially in adverse weather conditions.

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2. MATERIALS AND METHODS

2.1. Procedure

by (Moekijat, 2001), a procedure is "a set of interconnected tasks that represent a specific sequence of time and steps to perform the work that needs to be completed." Procedures are an essential part of any company". Procedures are well-defined actions that must be performed in the same manner or technique as specified in a written procedure to achieve the same outcome. A procedure can also consist of a series of activities or steps that must be taken to produce something desired (Fani and Wibowo, 2021).

2.2. Understanding Loading and Unloading

Based on the book (Indonesian Central Bureau of Statistics, 1996), unloading is the unloading of goods from ships, both goods departing from the port of origin in Indonesia and from abroad. Loading is the act of loading, which means moving goods from the dock/warehouse to the cargo deck for safe transportation to the intended destination.

According to Chapter 1 Act 14 of Government Regulation No. 20 of 2010, loading and unloading activities are service activities that carry out loading and unloading activities inside and outside the ship, including loading and unloading activities and receiving or shipping.

In loading and unloading, RORO ships use methods that are different from those of other commercial ships, such as PT. Jemla Ferry Indonesia has standard operating procedures that must be complied with in the Safety Management Work Instruction Manual book. According to the description, the explanation of handling vehicle cargo is as follows::

a. After the ship is appropriately berthed, the engineer on duty turns off the engines when they are no longer used, such as:
   1) Main Engine
   2) Bow Thruster
   3) Steering Engine
   4) Compressor, etc.

   The engineer on duty rechecked the hydraulic system support engine:
   1) Bow Visor
   2) Ramp door
   3) Lower Cover

   The engineer on duty re-checked the cargo room ventilation system. The deck crew on watch duty opens and serves the bow visor, ramp door, and lower cover, which the Officer supervises on duty or the Officer in charge.
b. Before loading begins, the Officer on duty is responsible for checking whether all the means related to loading are ready. The officer on duty coordinates readiness with the Engineer on Watch. Things that an Officer must consider on duty are:
   1) The mooring ropes must be fast as well.
   2) Ramp door, stand on Moveable Bridge.
   3) The wire rope on the ramp door is loose.
   4) The Moveable Bridge position forms the smallest possible angle with the ramp door.

5) Ventilation should be in good working order.
6) The loading room must be clean and free of obstacles.
7) The deck and engine crew are ready in their respective places.
8) The Means of Communication worked as well.

c. Ensuring the ship is ready to receive the ship's cargo by the requirements.
d. If not, complete the things that have not been achieved.
e. When the ship is ready, report to the ground officer, communicate, and confirm the vehicle number, type, and tonnage to be loaded to facilitate planning.
f. After confirmation between the ship and the ground officer, officers from the land immediately send the vehicle cargo according to an officer on duty request. It will be subsequently received and arranged according to its size and type. Things that must be considered in the preparation of vehicles include:
   1) The side distance between vehicles is approximately 60 cm, and the front and rear distance is approximately 30 cm.
   2) Place heavier vehicles in the stern.
   3) Place the animal close to the ventilation.
   4) Place hazardous loads in a separate place that is easily accessible and supervised.
   5) small vehicles should not be placed separately and in the middle of a truck or similar vehicle for the safety of small vehicles.
   6) Avoid ample "broken stowage."
   7) Warn vehicle owners about the dangers of crime on board.
   8) Warn vehicle owners to use the handbrake, not start the engine, and not smoke during the voyage.
   9) Installing wheel shanks and vehicle lashing standards properly, according to the "Cargo Securing Manual."
g. After completing the loading, the ramp door and bow visor are closed by the crew on the deck, then prepare for sailing by the "Operation Preparation Procedure."
h. On the voyage, carry out the "Watchkeeping Procedure on the bridge."
i. Before arriving at the port, prepare such as the "Berthing Preparation Procedure."
j. After the ship is well berthing, the bow visor and ramp door are reopened, and preparations for loading and unloading are carried out as the first step. Whether the vehicle shank or lashing has been opened and secured must be considered.
k. After the ship is ready for loading and unloading, report to the ground officer and confirm the type and number of vehicles so that the ground officer can prepare all facilities according to the "Procedure for receiving and unloading vehicles."
l. After the ship and ground have been confirmed, the vehicle can be dismantled.

2.3. Extreme Weather

According to (Hamid and Dayana, 2022) in a book entitled Meteorology, extreme weather refers to weather conditions that are different from normal. Extreme weather events only occur in seconds, hours, or days. Extreme weather can also last up to 3 days.

Extreme weather greatly affects the sea transportation sector, especially inter-island ships, which are an important sector in transportation in Indonesia. The Beaufort Scale, invented by Francis Beaufort in 1805, was used to measure wind speed and its impact on ships and ocean waves.

According to the UK Meteorological Office, the Beaufort scale is an empirical measure to describe wind intensity based on observed sea conditions. The Beaufort scale starts from 0 for the calmest gusts of wind to 12 for gusts of wind that can cause destruction. The following Beaufort scale can be described in Table 1 below:

Table 1. Beaufort Wind Scale

Beaufort Number	MPH		Terminology	Description
	Range	Average		
0	0	0	Calm	Calm. Smoke rises vertically.
1	1-3	2	Light air	Wind motion visible in smoke.
2	4-7	6	Light breeze	Wind felt on exposed skin. Leaves rustle.
3	8-12	11	Gentle breeze	Leaves and smaller twigs in constant motion.
4	13-18	15	Moderatebreeze	Dust and loose paper is raised. Small branchesbegin to move.
5	19-24	22	Fresh breeze	Smaller trees sway.
6	25-31	27	Strong breeze	Large branches in motion. Whistling heard in overhead wires. Umbrella use becomes difficult.
7	32-38	35	Near gale	Whole trees in motion. Some difficulty whenwalking into the wind.
8	39-46	42	Gale	Twigs broken from trees. Cars veer on road.
9	47-54	50	**Severegale**	**Light structure damage.**
10	55-63	60	**Storm**	**Trees uprooted. Considerable structuraldamage.**
11	64-73	70	**Violentstorm**	**Widespread structural damage.**
12	74-95	90	**Hurricane**	**Considerable and widespread damage tostructures.**

2.4. Security Implementation

According to (Murdjito, 2022), ship safety can be defined as the state of the ship that meets the requirements of material, construction, building, machinery and electricity, stability, layout and equipment, auxiliary equipment and radio, ship electronics, as evidenced by a certificate after inspection and testing.

Safety on board is, therefore, a set of measures and procedures implemented to ensure the safety and well-being of everyone on board. It encompasses many aspects, including ship construction, safety equipment, crew training, and compliance with maritime safety regulations.

According to (Iwan Weda, 2022), ship security is defined as a state of fulfilment of safety and security requirements concerning water transportation and protection against all identified risks. The application of ship security has a broad and complex meaning. Ship security focuses not only on protecting the ship itself but also on protecting passengers, cargo, and associated port facilities. Ship security includes various aspects, such as surveillance, security, and escort, as well as various strategies to anticipate and deal with various threats that can occur at sea, such as crime, sabotage, and other disturbances.

2.5. Roro Ferry

According to (Rubiyanto and Wahyuni, 2022), ships are all types of conveyances on the water with all types of propulsion and function as a means of transportation in water. In the Big Indonesian Dictionary (KBBI), a ferry is a ship that functions as a means of crossing between islands permanently, commonly called a ferry. Meanwhile, RORO ships in the Big Indonesian Dictionary are ferries designed to carry vehicles (cars, buses, trucks, trailers, etc).

Figure 1. Example of Roro Ship's Cargo

From some of the above definitions, it can be concluded that the RORO ferry is a ship that can carry vehicles into the ship with its propulsion engine and exit the ship itself, so it is called a roll on - roll off ship, abbreviated as roro. Therefore, this ship has a ramp door connected to a moveable bridger (MB) or a floating dock connecting to a concrete pier.

2.6. Research Methods

This research uses a qualitative approach. Qualitative research is one of the systematic activities to explore theory, not to test theories or hypotheses. According to David Williams (1995) in Ratnaningtyas et al. (2022), qualitative research is a researcher's attempt to collect data based on natural circumstances. Of course, since it is done naturally, the results of this research are also scientific and can be researched and accounted for. Here are the detailed methodologies used:

a. Data Collection Techniques

1) Interview Method

Interviews were conducted to gather direct information from sources. This verbal process involves a series of questions and answers between the interviewer and interviewee, who interact face-to-face to exchange information. In this study, interviews were held with the third officer or Mualim III, who is responsible for safety equipment, to explain how to support cargo's smooth handling and unloading using safety equipment on the KMP. Jagantara ferry.

2) Observation Method

According to (Ridwan, 2003), observation involves direct monitoring of the research subject to gain insights into their activities. This method was used to gather data on the windlass operations, ramp door, and moveable bridges during the sea practice. The researcher participated directly in these operations to ensure that incidents were accurately recorded.

3) Documentation Technique

Documentation involves collecting data through written records such as documents, archives, and books. This method supplements written research by examining all documents related to the research problem, including cargo records and ship data.

b. Data Analysis Techniques

Data analysis involves systematically searching and organizing data from interviews, field notes, and documents. According to (Sugiyono, 2019), this process consists of categorizing, breaking down into units, synthesizing, organizing data into patterns, selecting what is important, and drawing conclusions that are understandable to oneself and others. According to (Miles & Huberman, 1992), data analysis involves three concurrent activities:

1) Data Reduction: This process includes selecting, simplifying, abstracting, and transforming raw data from field notes. Data reduction is continuous and can involve summarizing, coding, and grouping data into broader patterns.
2) Data Display: This involves organizing and compressing information into diagrams, charts, or matrices to facilitate understanding and drawing conclusions.
3) Conclusion Drawing and Verification: This involves interpreting the data and verifying the conclusions drawn to ensure they are valid

3. RESULT AND DISCUSSION.

The following is data analysis according to the Miles and Huberman model which includes data reduction, data display, and conclusions/verification.

a. Data ReductionThe loading and unloading process of roro ferries during extreme weather

1) Obstacles faced:

a) High waves that interfere with the stability of the ship when docked.

b) Strong winds that can cause shifts in the position of the ship.

c) Rainfall that reduces visibility for the driver and crew.

2) Procedures performed:

a) Use of loading and unloading aids to ensure the cargo position remains stable.

b) Improved coordination between the ship's crew, port authority and captain.

c) Use of radar and GPS systems to assist navigation in low visibility conditions.

3) Impact of extreme weather:

a) Longer loading and unloading times.

b) Increased risk of damage to cargo and equipment.

c) Decrease in port operational efficiency.

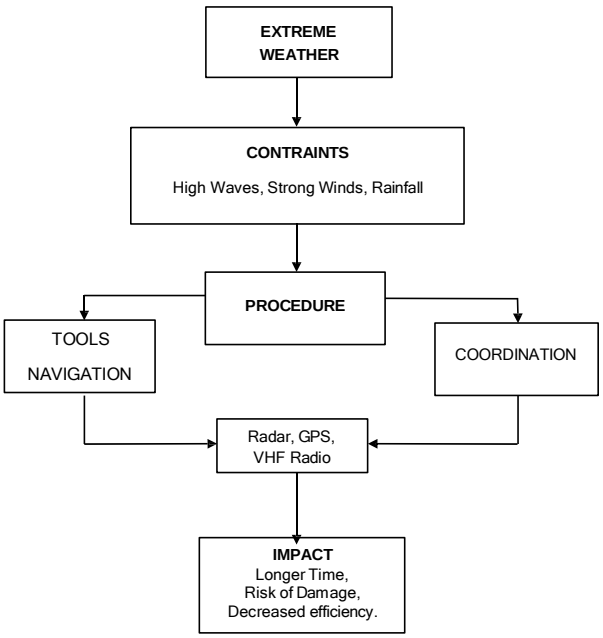
b. Data Presentation

Constraints and solutions matrix along with the loading and unloading process diagram of the data that has been reduced by the researcher.

Table. 2 Matrix of constraints and solutions

Constraints	Solution	Impact
High waves	Use of navigation aids	Longer loading and unloading time
Strong winds	Improved coordination between ship crew, authorities and captain	Risk of shifting ship position, unstable ship when loading and unloading.
Rainfall	Use of radar and GPS	Low visibility, rampdoor becomes slippery.

Fig. 2 Diagram of Unloading Process



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The loading and unloading of roro (Roll-On/Roll-Off) vessels at this port plays a vital role in mobilising goods and passengers. However, this process often faces major challenges, especially during extreme weather. Severe weather can cause high waves, strong winds and heavy rainfall, disrupting the smooth and safe loading and unloading process.

a. Problem Identification.

Some of the main problems faced in loading and unloading roro ships during extreme weather at Merak-Bakauheni Port include:

1) Cargo and Vehicle Safety:
   Extreme weather conditions increase the risk of cargo and vehicle damage during the loading and unloading process. Vehicles such as large trucks and buses are prone to shifting or falling if improperly handled. Existing tie-downs and securing systems often need to be improved to deal with the dynamic forces caused by high waves and strong winds.
2) Worker Safety and Health:
   Workers involved in the loading and unloading process face a higher risk of occupational accidents during inclement weather. Wet and slippery conditions can lead to slips and falls, and exposure to strong winds can compromise stability while working on the docks and vessels.
3) Operational Efficiency:
   Extreme weather often causes delays in loading and unloading schedules, leading to delays in vessel departures. This impacts operational efficiency and customer satisfaction. Longer and more careful adjustments to loading and unloading procedures are required, which can reduce productivity and increase operating costs.

b. Problem Cause Analysis.

1) Lack of Infrastructure and Adequate Equipment:
   The roro ferries need adequate equipment to deal with extreme weather, such as stronger vehicle tie-down systems.
2) Suboptimal Procedures and SOP:
   Existing Standard Operating Procedures (SOP) may need to be more detailed or well-implemented to deal with extreme weather situations. This includes worker training and safety equipment readiness.
3) Lack of Safety Training and Awareness:
   Port workers and crew members may need more specialized training to handle loading and unloading in adverse weather conditions. Awareness of the importance of safety and emergency procedures may also be suboptimal.

The data collected during the study covered various aspects such as vessel condition, weather, and cargo type. Data analysis was conducted using the Miles and Huberman interactive data analysis model, which involved data reduction, data presentation, and conclusion drawing or verification. The analysis results show that properly implementing safety and security procedures can minimize the risk of accidents and cargo damage during extreme weather. The following table summarizes the research data:

Table 3. Summary of Research Result Data

No	Aspects Studied	Key findings
1	Loading and Unloading Procedure	The use of Ramp Door facilitates the process of entering and exiting vehicles, requiring adjustments during extreme weather.
2	Safety and Security Implementation	Strict inspection of mooring ropes, ramp doors, wire ropes, ventilation, cleanliness of the loading room, and crew readiness.
3	Weather Conditions	Extreme weather affects the stability of the ship and cargo, requiring additional procedures for safety.
4	Load Type	Special handling is required for heavy loads such as fuso trucks, trontons, and other heavy vehicles.

4. CONCLUSION.

Based on the results of the research that has been conducted, some of the main conclusions that can be drawn are as follows:

a. Loading and Unloading Procedures:
   Rowing ramp doors on Roro vessels facilitate entering and exiting vehicles, but special adjustments are required during extreme weather to ensure safety and operational efficiency.
b. Safety and Security Implementation:
   Strict implementation of safety procedures, including inspection of mooring ropes, ramp doors, wire ropes, ventilation, loading bay cleanliness, and crew readiness, is essential to minimize the risk of accidents during extreme weather.
c. Weather Conditions:
   Extreme weather significantly affects the stability of the vessel and cargo. Therefore, additional procedures are required to ensure the safety of cargo and passengers during adverse weather conditions.
d. Type of Cargo:
   Special handling is required for heavy cargo such as fuso trucks, tronton and other heavy vehicles. Proper procedures must be implemented to prevent damage and accidents during the loading and unloading.

This research shows that implementing proper safety and security procedures can reduce the risk of accidents and cargo damage during extreme weather at Merak-Bakauheni port.

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Indonesian Naval Technology College
Postgraduate International Conference, Vol. 8, No. 1, pp. 167-178
June, 27th 2024

POLICY STRATEGIES FOR REDUCING CARBON EMISSIONS IN THE TRANSPORTATION SECTOR

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ABSTRACT
This study uses system dynamics modeling to explore policy strategies for reducing carbon emissions in the transportation sector by adopting electric vehicles (EVs). It addresses global warming and climate change, aligning with the 13th Sustainable Development Goal on climate action. The research focuses on transitioning from fossil-fuel-powered vehicles to EVs, with governments worldwide implementing incentives and tax benefits to promote this shift. The study develops a dynamic system model to assess both the economic and environmental impacts of EV adoption, considering international and national policy factors. By evaluating government incentives, infrastructure development, and public acceptance, the research aims to provide policy recommendations that optimize environmental and economic benefits, facilitating a smoother transition to EVs and contributing to sustainable development goals.

KEYWORDS : Vehicles, Renewable, Carbon Emission Reduction, System Dynamics Modeling, Sustainable.

1. INTRODUCTION.

Global warming and the climate crisis are recognized as urgent global issues, addressed under the 13th Sustainable Development Goal (SDG) which emphasizes climate action (United Nation, 2015). These issues are interconnected with other SDGs, suggesting that effectively addressing climate change is crucial for broader sustainable development achievements. The primary cause of climate change is identified as the excessive emission of carbon, predominantly from the use of fossil fuels in transportation (Suryani, Hendrawan, Eka Adipraja, *et al.*, 2022).

In Indonesia, the transportation sector significantly contributes to carbon emissions, necessitating strategic interventions to reduce its environmental impact. Various policies and measures are being implemented to address these challenges. The Indonesian government is promoting the use of public transportation, improving fuel efficiency, and encouraging the adoption of cleaner fuels. Strategies include regulatory measures, economic incentives, and investments in infrastructure to support sustainable transportation systems.

A thorough review of existing literature reveals a growing body of research focused on reducing emissions in the transportation sector. Studies emphasize the need for comprehensive strategies that address both environmental and economic challenges. These strategies include regulatory incentives, tax benefits, and the development of sustainable public transportation infrastructure (Hsiao et al., 2018; J. Liu et al., 2022).

The proposed study will use system dynamics modeling to analyze the comprehensive impacts of transportation policies on the environment and the economy in Indonesia. It will evaluate how various strategies contribute to reducing carbon emissions and improving air quality, while also considering broader economic implications such as job creation and shifts in the energy and transportation sectors (Wen & Wang, 2023)

The study will create scenarios to assess the effectiveness of different transportation policies, including government incentives, and the implementation of electric vehicles (Liu and Xiao, 2018; Pu, Jiang and Zhang, 2023). This research aims to provide policy recommendations that reduce carbon emissions, facilitating a smoother transition to sustainable transportation systems and contributing to Indonesia's sustainable development goals.

2. MATERIALS/METHODOLOGY.

This research employs the system dynamics method, a powerful tool for examining the behavior of intricate systems over time. By leveraging system dynamics, we can create models, conduct simulations, and analyze the interplay and feedback mechanisms within the system being investigated. This approach enables us to capture the evolving interconnections and temporal variations within the system, offering deep insights into its structure and functionality. The subsequent sections will outline the specific procedures and methodologies used in applying system dynamics to our study, including the construction, validation, and simulation of the model.

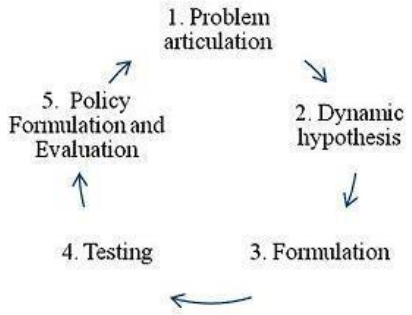

Fig. 1 System Dynamic Methodology

2.1. Problem Articulation.

This initial stage involves clearly defining and articulating the problem to be addressed. It includes identifying the key issues, setting the boundaries of the system, and determining the main variables and stakeholders involved. The goal is to establish a clear understanding of the problem context and objectives.

2.2. Dynamic Hypothesis.

In this stage, a dynamic hypothesis is formulated to explain the causes of the problem behavior. This hypothesis is based on the understanding of the system's structure and feedback loops. It involves identifying the relationships between variables and hypothesizing how these relationships drive the behavior of the system over time. This stage is where the causal loop diagram (CLD) start to develop, CLD is a mapping form aimed at understanding cause-and-effect relationships between variables (Sterman, 2000).

Table 1. Causal Loop Diagram Symbols

Variable	Symbol	Description
Positive Links	A $\xrightarrow{+}$ B	There is a positive/causal relationship from variable A to variable B.
Negative Links	C $\xrightarrow{-}$ D	There is a negative/causal relationship from variable C to variable D.

Delay Links		There is a time delay in the interaction between variable E and variable F.
Positive Loop		The effect of a positive/increasing influence among variables where its loop is named reinforcing. This loop occurs when the relationships among variables are the same (both + positive or both - negative).
Negative Loop		The effect of a negative/decreasing influence among variables where its loop is named balancing. This loop occurs when the relationships among variables are balancing (There is an odd number of variables with a - negative relationship).

After we find all the variables, define the characteristics of each variable in the model. Next, all the variables are modelled into a causal-loop diagram (CLD). The CLD model that has been developed can determine the cause and effect relationship between each variable in the system (Arishinta & Suryani, 2020).

2.3. Formulation.

During formulation, the dynamic hypothesis is translated into a formal model. This involves constructing stock-and-flow diagrams, defining equations, and specifying parameters. The model should capture the essential features of the system and allow for simulation and analysis. In this step is where the stock and flow diagram (SFD) being develop. In an SFD, stocks represent accumulations that can increase or decrease, while flows represent the processes that cause these changes in stocks (Suryani *et al.*, 2023). This structured classification enhances clarity and facilitates the creation of the stock and flow diagram. Following this, each variable is intricately linked based on their intrinsic relationships, ensuring that the final diagram provides a thorough and detailed depiction of the system's behavior over time (Chi et al., 2022).

Table 2. Stock and Flows Diagram Symbols

Variable	Symbol	Description
Stock (Level)		A variable that accumulates value over time based on rate changes.
Flow (rate)		A variable that influences the change in value of a stock.
Auxiliary		A variable that is influenced by other variables and contains calculation formulas.

Subsequently, dynamic systems utilize simulation processes to construct models that reflect real-world conditions. These models are rigorously tested to gain insights into the system's behavior (Shannon, 1998). Following testing, evaluations are performed to formulate operational strategies for the system. Simulations are invaluable for decision-making and designing solutions for intricate system issues, ultimately resulting in a framework that is free from assumptions (Chaharbaghi, 1990).

2.4. Testing.

The model is tested to ensure its validity and reliability. This involves comparing the model's behavior with real-world data, checking for consistency and plausibility, and performing sensitivity analysis. Testing helps

to refine the model and improve its accuracy in representing the actual system. In this research testing are held in 2 ways, first is verification which to ensure the model do not have bug and error within (Mudjahidin *et al.,* 2019). Secondly there is validation which to to ensure that the model's behavior outputs accurately represent current conditions. If the model does not function correctly or the results do not represent the current conditions, then the model is considered invalid (Barlas, 1996). In validation we use: mean comparison (E1) which is comparing the average of real-historical data and simulation results from the model, error varriance (E2) which is the same but comparing the standart deviation.

$$E1 = (\frac{S-A}{A}) \quad (1)$$

Where,

S= Average of simulation results

A= Average of real-historical data

The result will be considered valid if E1 < 5%.

$$E2 = (\frac{Ss-Sa}{Sa}) \quad (2)$$

Where,

Ss = Standart Deviation of simulation results

As = Standart Deviation of real-historical data

The result will be considered valid if E2 < 30%.

2.5. Policy Formulation and Evalution.

In this final stage, the validated model is used to design and evaluate potential policies or interventions. The goal is to identify strategies that can effectively address the problem and achieve desired outcomes. Different scenarios and policy options are simulated to assess their impacts and to support decision-making. The scenarios are separated into policy strategy on electric vehicle implementation which has 2 different approach the strategy to increase with incentives that stop in 2025 and the extended until 2045. There is also scenario on technology policy so to see if there will be effect if transportation must use some sort of filter to reduce the carbon production.

2.6. Data Collection.

The data used in this study were meticulously gathered from a variety of sources to ensure comprehensive coverage and reliability. This section outlines the data collection methodologies employed, including the types of data collected, the sources from which the data were obtained, and the procedures followed to ensure data accuracy and integrity. By systematically collecting and analyzing relevant data, we aim to create a robust model that accurately represents the system under study and supports effective policy formulation and evaluation. The data used were obtained from reports by the Central Statistics Agency, databoks, worldometers, transportologi, and data.worldbank.

3. RESULT AND DISCUSSION.

In this chapter, we present the findings of our study and provide a comprehensive discussion on their implications. The results are derived from the analysis and simulations conducted using the system dynamics model outlined in the methodology section. Each key result is discussed in detail, highlighting how it contributes to our understanding of the system under study. We examine the behavior of various system variables, the impact of different policy scenarios, and the overall performance of the model in

representing real-world conditions. Additionally, we interpret the significance of these findings in the context of existing literature and the practical implications for stakeholders. This discussion aims to provide a nuanced understanding of the complex dynamics at play and offer insights into potential strategies for effective system management.

3.1. Problem Articulation.

By establishing these variables, we lay the groundwork for the subsequent development of our system dynamics model, ensuring a comprehensive understanding of the intricate relationships and feedback loops that drive the system's behavior. This foundational step is crucial for accurately modeling the system and deriving meaningful insights into its operation and potential interventions. It is found that all the variables are categorized as below:

Table 3. Endogenous Variables from the system

Endogenous Variables
Amount of Passenger Cars, Freight Car Carbon Emissions, Carbon Quota Price, Broken Passenger Cars, Amount of Motorcycles, Average Car CO2 Produce, Used Passenger Cars Purchases, Average Motorcycle CO2 Produce, Transportation Sector Carbon Emissions, Passenger Cars Purchases, Used Motorcycles Purchases, Broken Motorcycles, Car Carbon Emissions, Motorcycles Purchases, Carbon Quota Revenues, Amount of Freight Cars, Motorcycle Carbon Emissions, Freight Cars Purchases, Broken Freight Cars, Carbon Emissions, Used Freight Cars Purchases.

Table 4. Exogenous Variables from the system

Exogenous Variables
Other Sector Carbon Emissions, Carbon Quota

3.2. Dynamic Hypothesis.

Having categorized the key variables influencing our system into endogenous and exogenous types, we now proceed to develop the Causal Loop Diagram (CLD). This step is critical as the CLD visually represents the complex interrelationships and feedback loops among the variables. The CLD will help elucidate how these variables interact over time, highlighting the reinforcing and balancing loops that drive system behavior. By constructing the CLD, we aim to capture the essence of the system's structure, providing a clear and detailed map of the causal relationships that will inform subsequent modeling and analysis stages.

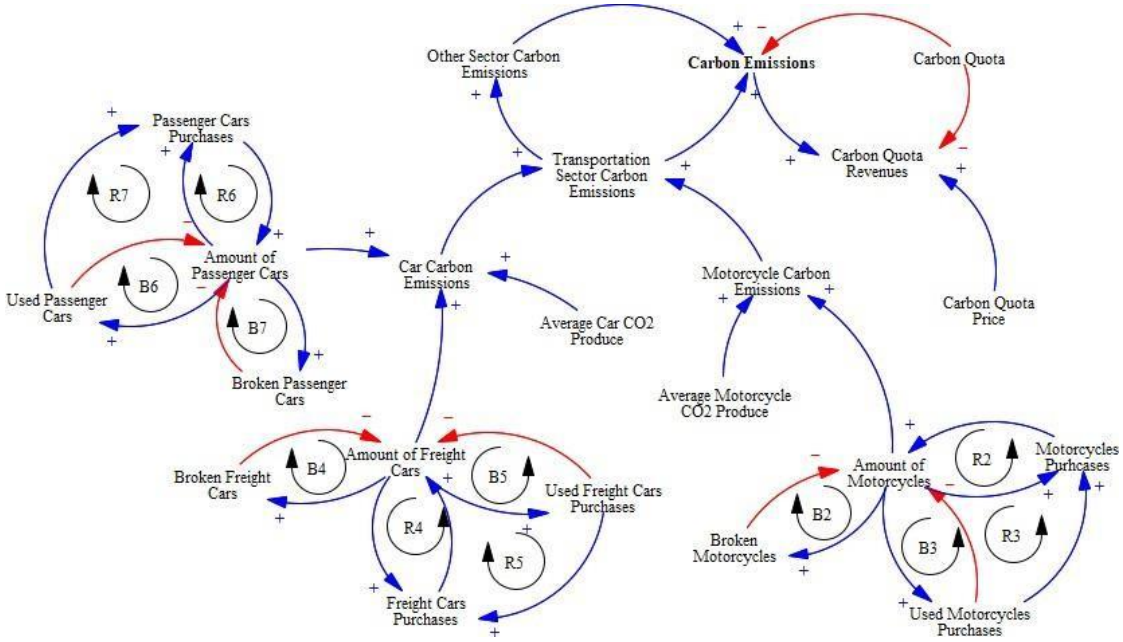

Fig. 2 Causal Loop Diagram

3.3. Formulation.

The model is divided into four sub-models, each with its respective name: Sub-model Cars Amount, Sub-model Motorcyles Amount, and Sub-model Carbon Emissions. A Stock and Flow Diagram (SFD) will be developed to create and give the results for analysis in Carbon Emissions from transportation sector. The SFD is to observe the relationships and interactions between variables, providing new information about the system's state. This knowledge will offer insights into the system and influence final decision-making. The developed SFD can be used for scenario testing simulations. Before conducting scenario testing, the model will undergo validation and verification.

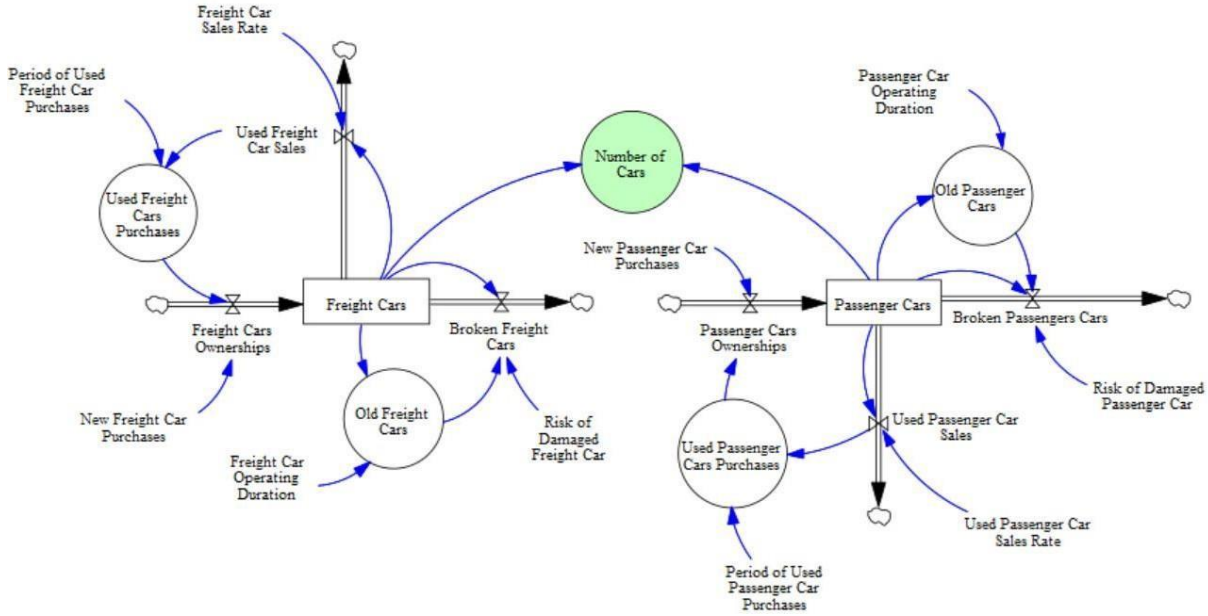

Fig. 3 SFD Sub-model Numbers of Cars

This diagram illustrates the dynamic system involving the number of passenger and freight cars in the transportation sector. It shows the flow from the purchase of new and used vehicles, their operation, to their eventual breakdown. The model highlights the interactions between new vehicle purchases, used vehicle transactions, and the attrition rate due to vehicle breakdowns, depicting how these factors collectively influence the total number of vehicles in operation over time.

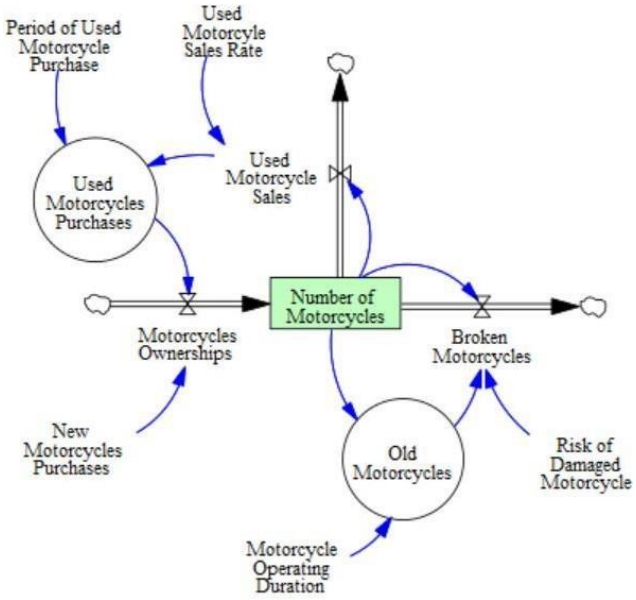

Fig. 4 SFD Sub-model Numbers of Motorcycles

This diagram depicts the dynamic interactions within the motorcycle sector, focusing on the number of motorcycles. It outlines the processes of purchasing new and used motorcycles, their sales, and their breakdown. The system dynamics model captures the lifecycle of motorcycles, including the purchase rates, operational duration, and the rate of breakdowns, providing a comprehensive view of how these elements affect the total motorcycle numbers.

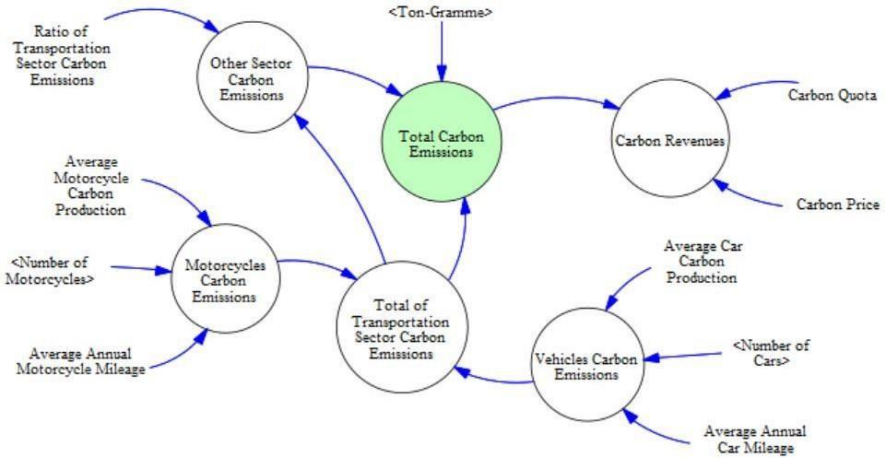

Fig. 5 SFD Sub-model Carbon Emissions

This diagram represents the dynamic system of total carbon emissions, focusing on contributions from the transportation sector and other sectors. It details the carbon emissions from vehicles and motorcycles, integrating them with overall carbon emissions. The model highlights the interactions between the number

of vehicles, their average carbon production, and total transportation sector emissions, providing a detailed view of how these factors contribute to overall carbon emissions.

3.4. Testing.

The model has undergone thorough structural and unit verification to ensure its robustness and accuracy. Structurally, each component and feedback loop within the system has been meticulously reviewed to confirm that all logical relationships and causal links are correctly represented. This verification process involved structural and unit verifications.

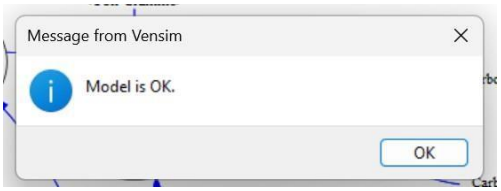

Fig. 6 Model Verification

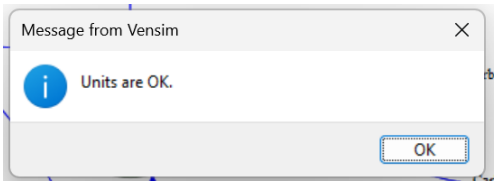

Fig. 7 Unit Verification

Model validation is conducted by comparing the average error rate and error variance stated as in 2.4 before. A model is considered valid if the error rate is ≤ 5% and the error variance is ≤ 30%. The results for the validation as shown below:

Table 5. Validation Results

Variables	Type of Validation	Results
Passenger Cars	Mean Comparison (E1)	3 %
	Error Variance (E2)	6 %
Freight Cars	Mean Comparison (E1)	3 %
	Error Variance (E2)	21 %
Number of Cars	Mean Comparison (E1)	4 %
	Error Variance (E2)	1 %
Number of Motorcycles	Mean Comparison (E1)	2 %
	Error Variance (E2)	7 %
Carbon Emissions	Mean Comparison (E1)	4 %
	Error Variance (E2)	29 %

3.5. Policy Formulation and Evalution.

In the dynamic system simulation model for the policy strategy for reducing carbon emissions in the transportation sector, scenarios were also implemented to understand the potential outcomes for the system. There are three types of scenarios that will applied in the model:

1. Existing Scenario: A scenario where the system or model operates under normal conditions without any additional factors altering the system to see what will happen in future (2045) under normal or no change circumstances.
2. Carbon Reduce Policy Scenario: A scenario where the system or model operates using technology and policy on the vehicles (both motorcycles and cars) so the carbon production from each vehicles is lesser than normal in hopes to reduce carbon emissions.
3. Electric Vehicle Poilcy Scenario: A scenario where the system or model try to implement electric vehicle promotion so the usage of electric vehicle increase and conventional vehicles decrease so the carbon emissions lessen. The program of incentives is started in 2021 therefore the effect of scenario would be seen around 2021-2022.

The sesults from each simulation can be seen as in figures below:

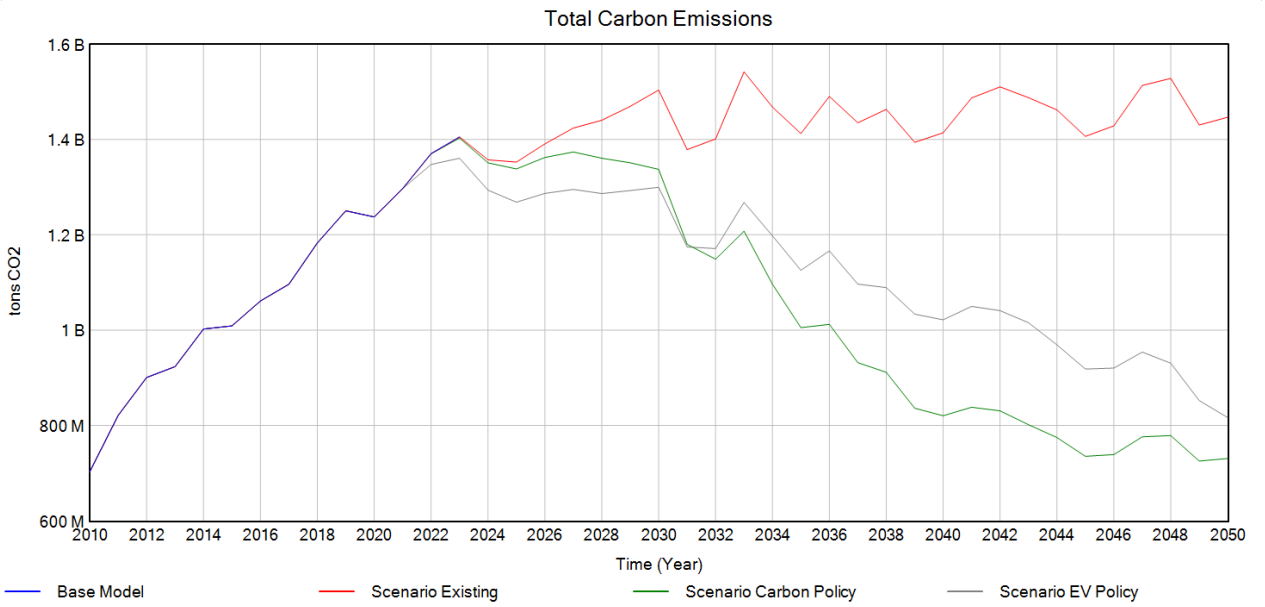

Fig. 8 Results Graph of Total Carbon Emissions

The provided graphs illustrate the trends in total carbon emissions and carbon revenues under four scenarios from 2010 to 2050: the Base Model, Scenario Existing, Scenario Carbon Policy, and Scenario EV Policy. The total carbon emissions graph shows the Base Model with a steady increase until 2025, then leveling off and gradually decreasing. The Scenario Existing continues to rise until 2030, then fluctuates slightly but remains high. The Scenario Carbon Policy indicates a significant decrease in emissions from 2025 onwards, reflecting effective policy impacts, while the Scenario EV Policy also shows a steady decline starting around 2025, though less aggressive than the Carbon Policy. The carbon revenues graph reveals that the Base Model experiences high revenues initially, followed by a sharp decline and remaining negative. The Scenario Existing shows a similar trend but stabilizes in negative territory. In contrast, the Scenario Carbon Policy and EV Policy show revenue improvements post-2025, with the Carbon Policy scenario achieving the most significant positive revenue gains by 2050. These graphs collectively highlight the environmental and economic impacts of different carbon management strategies.

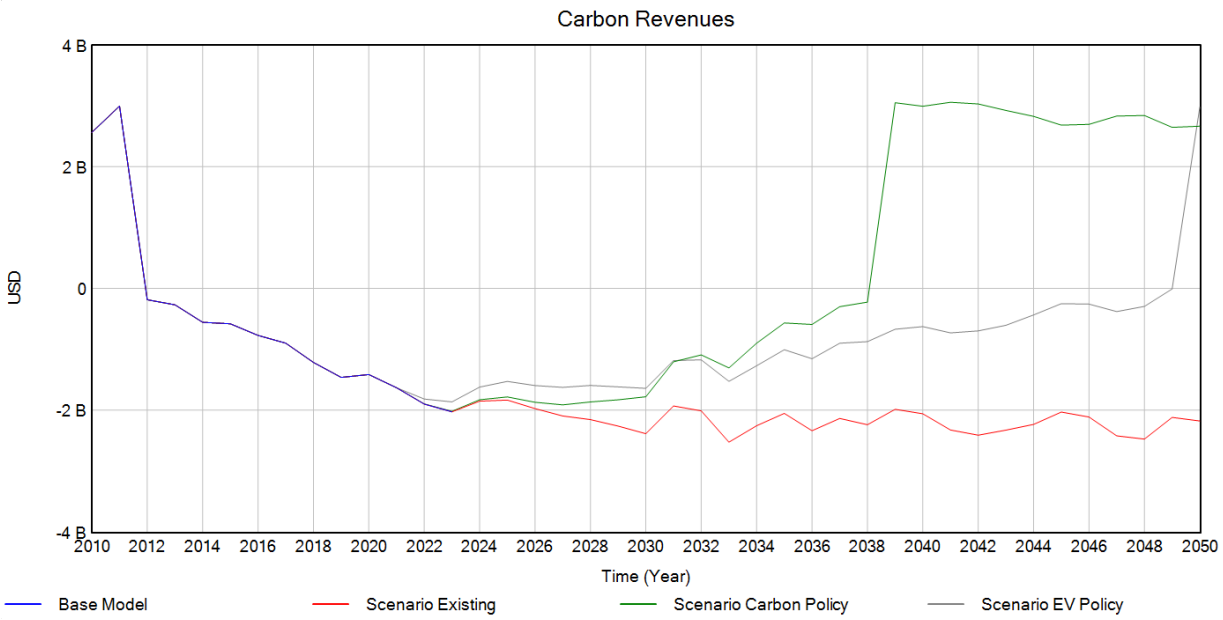

Fig. 9 Results Graph of Carbon Revenues

The provided graphs illustrate the trends in total carbon emissions and carbon revenues under four scenarios from 2010 to 2050: the Base Model, Scenario Existing, Scenario Carbon Policy, and Scenario EV Policy. The total carbon emissions graph shows the Base Model with a steady increase until 2025, then leveling off and gradually decreasing. The Scenario Existing continues to rise until 2030, then fluctuates slightly but remains high. The Scenario Carbon Policy indicates a significant decrease in emissions from 2025 onwards, reflecting effective policy impacts, while the Scenario EV Policy also shows a steady decline starting around 2025, though less aggressive than the Carbon Policy. The carbon revenues graph reveals that the Base Model experiences high revenues initially, followed by a sharp decline and remaining negative. The Scenario Existing shows a similar trend but stabilizes in negative territory. In contrast, the Scenario Carbon Policy and EV Policy show revenue improvements post-2025, with the Carbon Policy scenario achieving the most significant positive revenue gains by 2050. These graphs collectively highlight the environmental and economic impacts of different carbon management strategies.

4. CONCLUSION.

Based on the comprehensive analysis using system dynamics modelling, the study concludes that different transportation policies have significant impacts on both environmental and economic outcomes. The research highlights the following key points:

1. **Total Carbon Emissions**: The Base Model indicates a steady rise in carbon emissions until around 2025, followed by a gradual decline. The Scenario Existing continues to see rising emissions until 2030, with only minor reductions thereafter. The Scenario Carbon Policy and Scenario EV Policy both demonstrate substantial reductions in emissions starting around 2025, with the Carbon Policy scenario showing the most pronounced decrease. This underscores the effectiveness of robust carbon reduction policies in mitigating emissions.
2. **Carbon Revenues**: The analysis of carbon revenues reveals that the Base Model and Scenario Existing result in continued negative revenues, reflecting ongoing economic costs associated with high carbon emissions. Conversely, the Scenario Carbon Policy and Scenario EV Policy show notable improvements in revenues post-2025, with the Carbon Policy scenario achieving the highest

positive revenue gains by 2050. These findings suggest that strategic policy interventions not only contribute to environmental sustainability but also enhance economic benefits.

3. **Policy Effectiveness**: The study confirms that implementing strong carbon reduction policies and promoting electric vehicle adoption are critical strategies for reducing carbon emissions and improving economic outcomes. The success of these policies hinges on comprehensive approaches that include regulatory incentives, tax benefits, and the development of sustainable transportation infrastructure.
4. **Broader Implications**: The results align with the broader Sustainable Development Goals (SDGs), particularly the goal of climate action (SDG 13). By effectively addressing carbon emissions in the transportation sector, Indonesia can make significant strides towards achieving its sustainable development objectives, fostering a cleaner environment, and promoting economic growth.

In conclusion, the study provides robust evidence supporting the adoption of targeted transportation policies to reduce carbon emissions. These strategies not only help combat climate change but also offer substantial economic advantages, thereby contributing to Indonesia's sustainable development goals. The insights gained from this research can inform policymakers in designing and implementing effective interventions for a sustainable and economically resilient transportation sector. Further research could explore additional scenarios, such as the integration of renewable energy sources, regional and sectoral breakdowns, behavioural and social factors, technological innovations, economic impacts, climate adaptation, and international comparisons. These areas of further investigation would deepen our understanding and enhance the effectiveness of sustainable transportation policies.

5. ACKNOWLEDGEMENT.

The authors would like to express their gratitude to the Institut Teknologi Sepuluh Nopember and National Taiwan University of Science and Technology for their support and resources in conducting this research. We also thank the Central Statistics Agency and PLN for providing the necessary data. Special thanks to Prof. Erma Suryani who guides and help on this research, and to our families for their continuous encouragement and support.

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Indonesian Naval Technology College
Postgraduate International Conference, Vol. 8, No. 1, pp. 179-185
June, 27th 2024

INTEROPERABILITY CONCEPT OF INDONESIAN NAVY-INDONESIAN COAST GUARD IN NATUNA SEA REGION TO IMPLEMENT TOTAL DEFENSE STRATEGY AT SEA

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ABSTRACT

Defense is part of Indonesian national purposes mentioned in The Constitution of 1945 "to establish the government of Indonesia to protect all of Indonesian people and Indonesian region". The Constitution of 1945 also mentioned that every (Indonesian) citizen has right and obligation to join the effort of country defense and security then titled as total defense strategy. There are two great powers in maritime sector. First is Indonesian Navy as the representative of military force and Indonesian Coast Guard as the representative of civilian force. This research aims to formulate interoperability concept between Indonesian Navy and Indonesian Coast Guard based on division of tasks supported by optimization of surveillance equipment in scope of Natuna Sea region using qualitative method. Result of the research is concept of total defense strategy system built from interoperability between Indonesian Navy and Indonesian Coast Guard supported by academician and national defense industry.

KEYWORDS : total defense strategy, Indonesian Navy, Indonesian Coast Guard, interoperability.

1. INTRODUCTION.

There are several definitions about defense mentioned by the experts from Indonesian Navy Officer and Maritime Legal Expert. Rear Admiral (ret.) Soewarso as Indonesian Navy Officer mentioned that defense is war aims to fend off the opponent's attack. The underlined point is equality between defense and war (Soewarso, 1981). Professor M. Kusumaatmadja as Maritime Legal Expert mentioned that defense is the effort to protect national sea region or archipelagic marine space from external threats (Kusumaatmadja, 1978). Vice Admiral (ret.) A. Kurnia as Indonesian Coast Guard Officer mentioned that national defense at sea is organization to hold sovereignty, to secure territory intact, and to protect national honor (Kurnia, 2017). Those definitions explain defense from difference point of views, from military, civilian, and semi-military, but basically there are correlation to Indonesian national purposes mentioned in The Constitution of 1945 "to establish the government of Indonesia to protect all of Indonesian people and Indonesian region".

The Constitution of 1945 also mentioned that every (Indonesian) citizen has right and obligation to join the effort of country defense and security then titled as total defense strategy. Lieutenant General (ret.) J. Prabowo explained that the whole national components, both military and civilian, have role to be the joint strength (Prabowo, 2009). There are two great powers in maritime sector. First is Indonesian Navy as the

representative of military force and Indonesian Coast Guard as the representative of civilian force. Establishment and role of Indonesian Navy is based on the Law No. 34 of 2004, meanwhile Indonesian Coast Guard is based on the Law No. 32 of 2014. Those mean that both Indonesian Navy and Indonesian Coast Guard have equal strong legal basis. Unfortunately, there is a problem about overlapping between authorities of Indonesian Navy and Indonesian Coast Guard (Andrizal *et al.*, 2021) mainly because of overlapping their operation region. Besides that, there isn't any legal basis to regulate interoperability between those (Yolanda *et al.*, 2022). So this research aims to formulate interoperability concept between Indonesian Navy and Indonesian Coast Guard based on division of tasks supported by optimization of surveillance equipment in scope of Natuna Sea region because it is one of international sea line (ALKI I) with highly threat exhalation (Rohana, 2022).

2. METHODOLOGY

This research uses combination of two methodologies, first is qualitative method and second is normative law method. The obtained data and information then analyzed by Miles and Huberman method that contain four steps; Data Collection, Data Condensation, Data Display, and Conclusion (Miles & Huberman, 2014).

2.1 Qualitative Method

Qualitative method is analytical method that place the researcher as the instrument (human instrument) (Sugiyono, 2018) based on concept that human senses are the most reliable instrument to synthesize some relations in complex universe (Soewarso, 1981). Then qualitative method aims to construct phenomena and to develop theory built by field research (Sugiyono, 2018) as literature research to the primary resources and secondary resources.

2.2 Normative Law Method

Normative law method is a legal research method focused on an emptiness that cause uncertainty of law (Christiawan, 2023). The uncertainty of law in this research refers to lack of legal basis to regulate interoperability between Indonesian Navy and Indonesian Coast Guard to implement total defense strategy at sea. It gives recommendation about existence of norm or regulation (Christiawan, 2023), which in this research is interoperability concept of Indonesian Navy-Indonesian Coast Guard to implement total defense strategy at sea.

3. RESULT AND DISCUSSION.

a. Results

Natuna is one of Indonesian sea region that mostly called 'Indonesian Maritime Gate' (Rohana, 2022). Beside that this region is also included in maritime high priority zone (Taufiqoerrochman, 2018) because of high vulnerability on illegal fishing and maritime border violation done by foreign flag ship. Sooner or later the condition will make Natuna region into Grey Zone Area, an ambiguous condition between peace and war but has potency to grow into real war (Robertson, 2022).

By comparing satellite image that show position of illegal fishing ships to Automatic Identification System/AIS data from patrol ships, there is clear gap that the position of illegal fishing and border

violating ships are on the north of Natuna region but the position of patrol ships are only concentrated on the south (Dewantara, 2019).

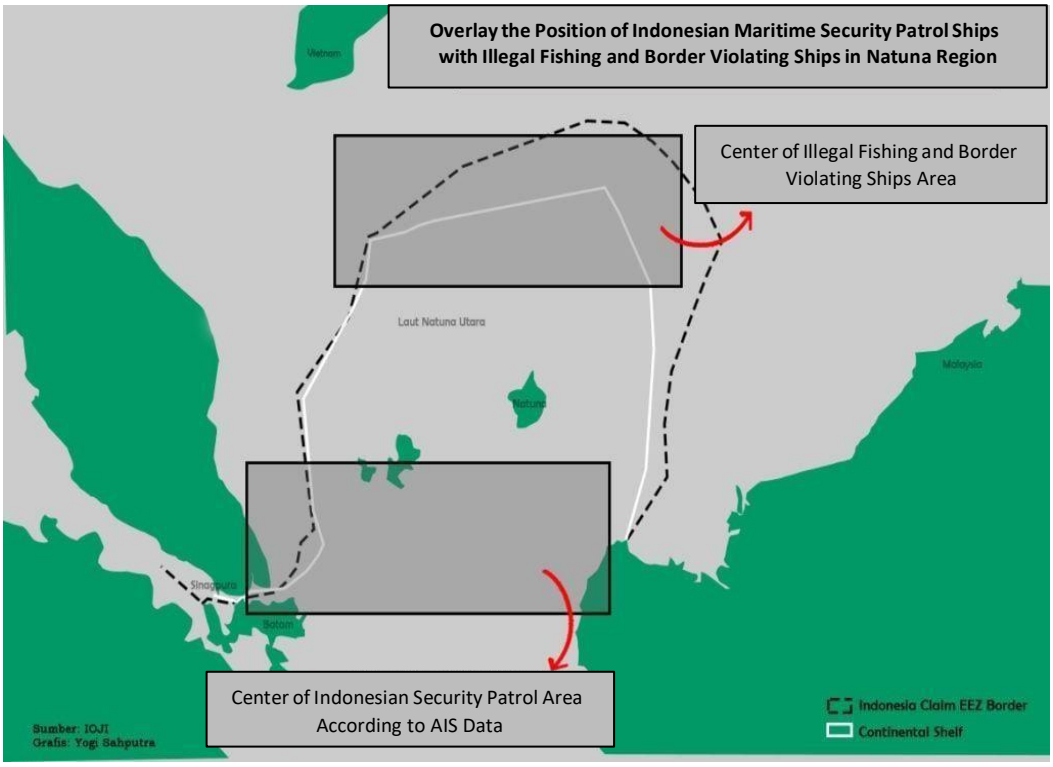

Fig. 1 Map Shows the Position of Illegal Fishing and Border Violating with Security Patrol Ships

Placement of the patrol ships having still been concentrated around Batam region because there is 4th Indonesian Main Navy Quarter (Lantamal IV) equipped by class A maintenance and repair facility that available to all of war vessel (KRI) type even its weapon and command sensor, meanwhile there is only class B facility in Natuna that only available in moderate level of maintenance and repair (Suharyo & Purnomo, n.d.). Also, Indonesian Coast Guard Patrol Ships having been still placed around Batam that cause the emptiness of Natuna region (Sudiro & Jupriyanto, 2022).

Fig. 2 Position of Indonesian Coast Guard Patrol Vessel, around West Zone (include Natuna)

b. Discussion

That gap should be solved by formulating concept of interoperability of Indonesian Navy-Indonesian Coast Guard. Interoperability is collaboration among elements in a defined system (Dewantara, 2019). The defined system in this research refers to total defense system in Natuna region. From legality point of view, the interoperability of Indonesian Navy-Indonesian Coast Guard should be established. The Law No. 34 of 2004 mentioned that Indonesian Navy is tasks executor in sea defense field detailed as war military operations and non-war military operations. Meanwhile, the Law No. 32 of 2014 mentioned that one of Indonesian Coast Guard functions is to organize surveillance system. Both are supported by Indonesian Sea Defense Strategy that place Natuna as communication region (Widjajanto *et al.*, 2023) so that there must be built the surveillance equipment to establish security and safety at sea. In arranging the interoperability concept, strengthening its communication and coordination system are crucial (Rohana, 2022).

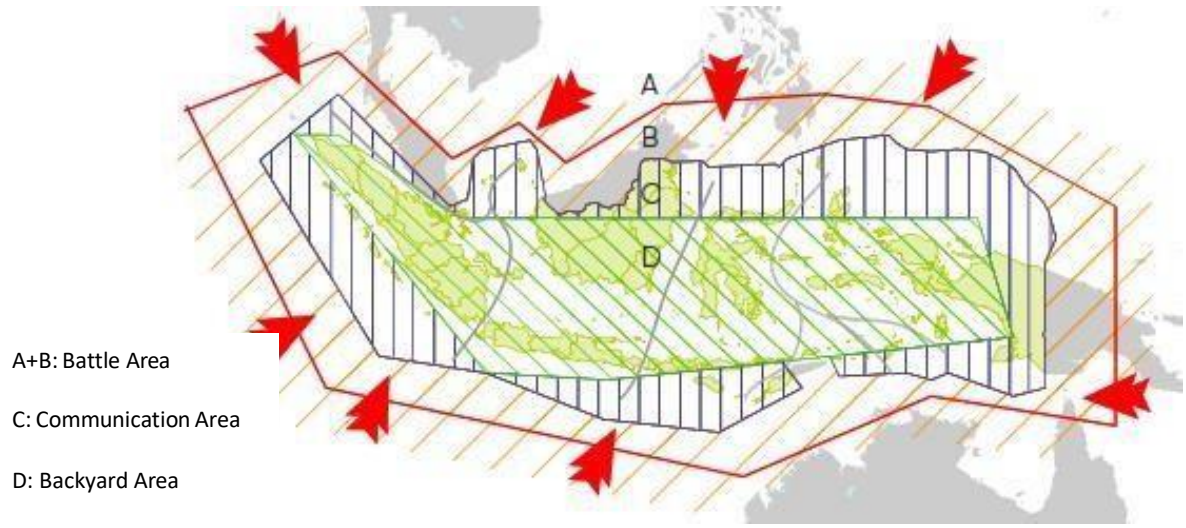

Fig. 3 Illustration of Indonesian Sea Defense Strategy

According to Memorandum of Understanding (MoU) between Indonesian Navy and Indonesian Coast Guard in 2015 (maybe should be renew), there are three main points related directly to interoperability of Indonesian Navy-Indonesian Coast Guard; first is organizing security and safety operation at sea, second is using equipment, and third is sharing necessary data and information (Andrizal *et al.*, 2021). Those points, according to the Law No. 34 of 2004 and the Law No. 32 of 2014 show interoperability duty sharing between them. As the surveillance system organizer, Indonesian Coast Guard operates surveillance equipment to get all real time information about security and safety at sea. But at the increase of exhalation time, the information collected by those equipment can be shared to Indonesian Navy task force to implement war military operations and non-war military operations. Then at the normal time, the task force can be focused in operation training or maintenance and repair.

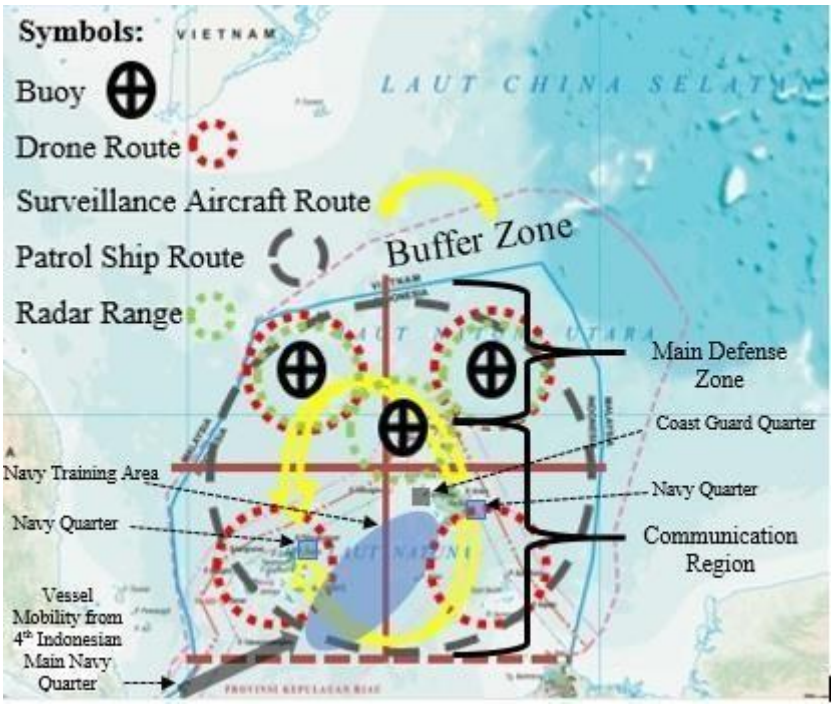

Fig. 4 Map Shows Interoperability of Indonesian Navy-Indonesian Coast Guard

The figure 4 above shows interoperability concept of Indonesian Navy-Indonesian Coast Guard which divide Natuna region into three parts according to Indonesian Sea Defense Strategy; Buffer Zone, Main Defense Zone, and Communication Region. Inside Main Defense Zone, there are two surveillance equipment; Passive Radar and Drone operated from Floating Buoy. Passive Radar as passive equipment and Drone as active/mobile equipment monitor and control the sea region periodically. Each equipment is connected to the Coast Guard Quarter (Sudiro *et al.*, 2023) inside Communication Region. When the equipment detects an anomaly (e.g. presence of illegal ships), it will send its detection image to the Coast Guard Quarter as basis of decision making. The Coast Guard Quarter also connected with two Navy Quarters (one in Ranai and the other in Tarempa) in order to prepare for countering if there is increase of exhalation. Beside the surveillance equipment, there are patrol armada both from Indonesian Coast Guard and Indonesian Navy. Indonesian Coast Guard will operate Patrol Vessel around whole Natuna region and Surveillance Aircraft across two main islands (Natuna and Anambas), then Indonesian Navy will operate its war vessel (KRI) from the 4th Indonesian Main Navy Quarter in Tanjung Pinang into Navy Training Area (according to the Presidential Decree No. 41 of 2022) for training and preparing.

Determination of the surveillance equipment is made also based on capacity and capability of national defense industry as implementation of the Law No. 16 of 2012. Using the national products to decrease foreign dependencies will make deterrent effect. Besides that, Indonesia needs to develop the technologies independently to prevent the having fallen behind (Kumalasari, 2016). There are several national industries with capacity and capability to produce the equipment shown by Fig. 4. The industries contain of national company, private company, and research institution which connected each other in form of multi-helix relation with the government and funding institution. Those relations also implement the Total Defense Strategy as form of participation in every effort to support national defense and security according to The Constitution of 1945 and as joint role of all the national components into the joint strength (Prabowo, 2009).

The following table shows list of national industries with capacity and capability to produce (or develop) the equipment used by the interoperability concept of Indonesian Navy-Indonesian Coast Guard.

Table 1. List of National Industries with Capacity and Capability to Produce Surveillance Equipment

No	Industries	Equipment
1	Republic of Indonesia Defense University	Floating Buoy (produced by PT WISE)
2	Ministry of Defense (Research and Development Division)	Passive Radar (collaborated with PT LAPI ITB)
3	PT Bhinneka Dwi Persada	Drone
4	ORPA BRIN	Surveillance Aircraft
5	PT Palindo Marine	Patrol Vessel
6	PT PAL	War Vessel (KRI)

4. CONCLUSION.

Conclusion of this research is the effort to prevent Natuna region into Grey Zone needs interoperability of Indonesian Navy-Indonesian Coast Guard as implementation of Total Defense Strategy at sea ordered by The Constitution of 1945. The Total Defense Strategy at sea contains of Indonesian Navy as representation of military force and Indonesian Coast Guard as representation of civilian force. The strategy also contains of multi-helix relation among national company, private company, research institution, the government, and funding institution in order to establish independency of national defense industry in producing necessary equipment (include surveillance equipment).

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6. ABOUT AUTHORS.

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FIELD IV

LOGISTIC MANAGEMENT

Indonesian Naval Technology College
Postgraduate International Conference, Vol. 8, No. 1, pp. 186-196
June, 27th 2024

THE DETERMINATION OF THE ARSENAL LOCATION IN AN EFFORT TO INCREASE THE CARRYING CAPACITY OF THE SEA FORCES IN CRITICAL AREAS OF THE NORTH NATUNA SEA

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ABSTRACT

The dynamics of the strategic environment in the North Natuna Sea area raises potential threat spots to the territory of the Republic of Indonesia where the Indonesian Navy needs to determine a marine security strategy where one of the things that must be prepared is the distribution of logistics in the form of musicians and weapons through the construction of the Arsenal warehouse. Through this research, an alternative strategic location as an Arsenal warehouse was determined as a storage place for ammunition supplies used to support KRI in carrying out operational tasks. Alternative locations for the construction of Arsenal are Lanal Bintan, Lanal Ranai Lanal Bangka Belitung and Lantamal IV Pontianak. Based on Perkasal No. 17 of 2008, the criteria used and are absolute requirements in determining the location are security, transportation access and supporting facilities. The data collection of this research was carried out using the questionnaire distribution method and conducting interviews with *experts*. The Delphi method is used in this research to determine and agree on relevant and valid criteria and sub-criteria to be researched to the next stage. Furthermore, the *Analytic Network Process* (ANP) method is used to determine the best alternative by processingdata using *Super Decision Software*. The results of this study were obtained The priority of the alternative location of the Arsenal warehouse is Lanal Bintan with a weight value of 0.536308.

***Keywords*:** Arsenal, Arsenal location selection, Delphi, ANP *(Process Analytics Network).*

1. Introduction.

The development of strategic environmental issues in the North Natuna Sea has raised potential threats to the territory of the Republic of Indonesia where the government needs to determine a national marine security strategy. One of the strategies is through the role of weapons and ammunition logistics support from Arsenal (arsenal and ammunition) in meeting the operational needs of KRI. Arsenal is a technical implementing element (UPT) of the Dissenlekal which is in charge of carrying out material support for weapons, ammunition and special weapons to all elements/units using the Indonesian Navy. (Kep Kasal number kep/31/VII/1997, 1997).

Currently, there is only one main Arsenal warehouse located in Lanal Batuporon Mako Koarmada II Surabaya. This is considered very ineffective in the event of a national conflict, especially in the critical area of the North Natuna Sea where the threat position is very far from Arsenal's main warehouse. This disadvantageous position is very vulnerable to threats if a conflict occurs, with one main *warehouse* it will be very easy to destroy and paralyze logistics lines, especially in ammunition.

In responding to these problems, it is necessary to add an Arsenal Warehouse in the northern Natuna Sea area (Theodora C. T., I W. G. Gunawan, 2019). If considered in light of the current threat, the placement of the Arsenal Warehouse location must be considered based on a critical area in the waters of the North Natuna Sea to facilitate the distribution of ammunition in anticipation of conflict. The addition of this location is expected to be able to overcome the problems that are currently occurring at Arsenal where the storage location will be wider and able to accommodate a larger amount of ammunition. Distribution time and *Loading* ammunition and missiles will also be shorter and faster and be able to accommodate many ships that will carry out *Loading* ammunition and missiles at the same time. In addition, the addition of this location is expected to be able to support the need for KRI ammunition and missiles in carrying out sea operations in an effort to anticipate the possibility of threats to critical areas in the future.

2. Methodology

2.1 Theoretical Basis

Ammunition is one part of the class V supply of the TNI Navy weapon system, so it needs to be prepared as optimally as possible in order to achieve a timely level of speed in the provision of class V supplies and operational effectiveness (Sudaryanto et al., 2020).

Location theory is a science that investigates the spatial layout of economic activities, or a science that investigates the geographical allocation of potential sources, as well as their relationship with or influence on the existence of various other kinds of businesses/activities, both economic and social. (Tarigan & Van De Geer, 2006).

2.2 Multi Criteria Decision Making (MCDM)

In daily life, humans are often faced with various problems and challenges. One of the challenges that is commonly faced is how to make the right decision in the midst of many options (alternatives) and criteria (attributes) that must be considered (Muanley et al., 2022). Humans are always looking for the best way or solution to solve this problem, and as a result, various methods and solutions have been developed. One of the methods that is often used to overcome this decision-making challenge is the Decision-Making Method with Multiple Criteria *(Multiple Criteria Decision Making* - MCDM) (Purnomo et al., 2020). This method helps humans to detail and understand in various factors that need to be considered when facing complex decisions. With MCDM, we can conduct a better and more informed analysis to choose the alternative that best suits our goals and needs (Ardielli, 2020).

2.3 Delphi Method

The Delphi method is by definition defined as a decision-making process in a group that involves interaction between researchers and a group of experts related to a certain

topic, which is usually carried out through the help of questionnaires. According to Scheele (1975), it describes the Delphi process with six stages as follows:

1) Identify the members of the group whose consensus is needed. The composition in the group must be able to represent various points of view proportionally.

2) The first questionnaire was conducted to ask each member to write down goals, considerations, or issues related to the expected consensus goals. Furthermore, the information that has been obtained is compiled so that it is easy to understand between group members. Next, prepare a second questionnaire with a more structured format so that assessments can be carried out.

3) In the second case, each group member is asked to give an assessment of the results of the information preparation in the first step.

4) Furthermore, the third questionnaire will show the results of the second questionnaire in the third questionnaire, including the consensus results of each section, and which parts are different from the group. In the third questionnaire, each panelist gave reasons and a brief explanation of their opinions.

5) In the fourth questionnaire, the results of the third questionnaire were displayed in the fourth questionnaire, including changes from the first consensus result, and each panelist was asked to give a third assessment and ranking which was the final assessment stage, as well as give reasons for deciding to be in a different position from the group.

6) The results of the fourth questionnaire were tabulated and presented as the results of the group consensus.

2.4 Process Analytics Network (ANP)

The Analytic Network Process (ANP) method is a development of the *Analytical Hierarchy Process* (AHP) method. The ANP method is able to correct structural differences in AHP in the form of the ability to accommodate the relationship between criteria or alternatives. There are two types of linkages in the ANP method, namely the linkage in a set of elements (*inner dependence*) and the linkage between different elements (*outerdependence*). The existence of this association makes the ANP method more complex than the AHP method (Saaty, 1998)

The *Analytic Network Process* (ANP) method in the decision-making process has stages or steps in making ANP. The following are the steps to make an ANP according to Saaty (1999):

a. Step One: Model construction and problem structuring. The construction of the model is made based on the existing problem, so it is necessary to clearly describe the problem, and form it into a network.

b. Step Two: A paired comparison matrix showing the linkages. The pairwise comparison of ANP was carried out by comparing the level of importance of each element to its control criteria.

c. Step Three: Calculate the weight of the element (Eigenvector Value). After the paired comparison matrix is carried out, the eigenvalue of the matrix is then determined. The eigenvector calculation is by summing the values of each column from the matrix then dividing each column cell value by the total column and summing the values from each row and dividing by n.

e. Step Four: Calculate the Consistency Ratio. After getting the eigen, then check the consistency ratio, the consistency ratio is a ratio that states whether the assessment given by the experts is consistent or not.

f. Fifth Step: Super matrix formation. A super matrix is a matrix consisting of sub-sub-matrices that are composed of a set of relationships between two levels contained in the model.

After obtaining the value of each element in the limit matrix, the next step is to perform a calculation on the value of these elements according to the ANP model created. The alternative with the highest global priority is the best alternative.

2.5 Methodology

This research uses a qualitative approach where in its implementation the data is taken from the measurement results and based on existing variables. The source of data from this study is sourced from primary data of all relevant officials who are still serving in the Arsenal Environment. Secondary data from this study is sourced from data that has been obtained or has been previously collected by other researchers from literature, articles, journals and sites on the internet related to the research being conducted.

The research began with the method used, the Delphi method as a tool to identify research criteria. The next step is to do weighting and ranking using the ANP method.

The subject of the study refers to an individual or group of people who are actively involved in the research, acting as a resource person, and providing data. The subject of the research is an agency or organization that is directly involved in the research. The objects in this study are KRI, Arsenal, and the Indonesian Navy Base in the area around the North Natuna Sea.

3. Results and Discussion

3.1 Identify Criteria

Table 4. 1 Table of Sub-Criteria

CRITERION	SUB-CRITERIA	REFERENCE
Security	Amana from enemy attacks	Kep Kasal No.17 of 2008

CRITERION	SUB-CRITERIA	REFERENCE
	Safe from border conflicts	Kep Kasal No.17 of 2008
	Safe from social conflicts	Kep Kasal No.17 of 2008
	Safe from natural disasters	Kep Kasal No.17 of 2008
	Safe from Illegal Activities	Interview, Turgut, et all, 2011
	Safe From Shipping Accidents	Interview, Turgut, et all, 2011
	Safe from the shipping lane	Interview, Turgut, et all, 2011
Transportation Access	Military Port Available	Kep Kasal No.17 of 2008
	Public Port Available	Kep Kasal No.17 of 2008
	Public Airports Available	Kep Kasal No.17 of 2008
	Pilot/Guide Available	Interview, Turgut, et all, 2011
	Public Transportation Available	Interview, Turgut, et all, 2011
	Tugboat Available	Interview, Turgut, et all, 2011
Supporting Facilities	Communication facilities available	Kep Kasal No.17 of 2008
	Electrical Facilities Available	Kep Kasal No.17 of 2008
	Water facilities available	Kep Kasal No.17 of 2008
	Transportation facilities available	Kep Kasal No.17 of 2008
	Available Fasharkan	Kep Kasal No.17 of 2008
	Heavy Equipment Available	Interview, Turgut, et all, 2011
	Public Workshop Available	Interview, Turgut, et all, 2011
	Shipyard Available	Interview, Turgut, et all, 2011
	Available Land	Interview, Turgut, et all, 2011

(Source: Author data processing)

In the last round of surveys, the opinions of the Experts led to compromised answers, showing that there was an *Accept for* several criteria. The average value obtained from the responses of these experts is extracted from the data. The results of this survey formulate the best 12 criteria out of 22 criteria based on the respondents' views/preferences. The statistical analysis of the implementation of this methodology as well as the opinion of the weights of importance for each criterion can be illustrated in the results of the Delphi method analysis conducted on the coesioner in Table 4.3 as follows:

Table 4. 2 Results of Data Processing of the 3-Stage Delphi Method

No	Dimension	Item	Round 1			Round 2			Round 3		
			Mean	CVI	Result	Mean	CVI	Result	Mean	CVI	Result
1	**Keamanan**	Aman Dari Serangan Musuh	4,14	0,86	Acceptep	15,10	1,00	Acceptep	4,14	0,86	Acceptep
2		Aman Dari Konflik Perbatasan	3,86	0,86	Acceptep	13,52	1,00	Acceptep	4,00	1,00	Acceptep
3		Aman Dari Konflik Sosial	4,43	0,86	Acceptep	14,98	1,00	Acceptep	4,43	0,86	Acceptep
4		Aman Dari Bencana	4,71	1,00	Acceptep	16,05	1,00	Acceptep	4,71	1,00	Acceptep
5		Aman Dari Kegiatan Ilegal	3,14	0,43	Rejected						
6		Aman Dari kecelakaan Pelayaran	4,29	0,86	Acceptep	3,14	0,57	Rejected			
7		Aman Dari Alur Pelayaran	3,14	0,57	Rejected						
8	**Akses Transportasi**	Tersedia Pelabuhan Militer	3,86	0,86	Acceptep	4,14	1,00	Acceptep	4,00	1,00	Acceptep
9		Tersedia Pelabuhan Umum	4,43	1,00	Acceptep	4,43	1,00	Acceptep	4,43	1,00	Acceptep
10		Tersedia Bandara Udara	4,43	0,86	Acceptep	4,43	1,00	Acceptep	4,43	1,00	Acceptep
11		Tersedia Pandu/Pilot	2,86	0,29	Rejected						
12		Tersedia Transportasi Umum	3,86	0,86	Acceptep	3,00	0,43	Rejected			
13		Tersedia Kapal Tunda	4,29	0,86	Acceptep	3,14	0,43	Rejected			
14	**Sarana Pendukung**	Tersedia Fasilitas Komunikasi	4,43	1,00	Acceptep	4,43	1,00	Acceptep	4,43	1,000	Acceptep
15		Tersedia Fasilitas Listrik	4,43	1,00	Acceptep	4,43	1,00	Acceptep	4,43	1,000	Acceptep
16		Tersedia Fasilitas Air	4,29	1,00	Acceptep	4,29	1,00	Acceptep	4,29	1,000	Acceptep
17		Tersedia Fasilitas Angkutan	4,29	1,00	Acceptep	4,29	1,00	Acceptep	4,29	1,000	Acceptep
18		Tersedia Fasharkan	4,57	1,00	Acceptep	4,57	1,00	Acceptep	4,57	1,000	Acceptep
19		Tersedia Alat Berat	4,00	0,86	Acceptep	3,14	0,43	Rejected			
20		Tersedia Bengkel Umum	3,14	0,57	Rejected						
21		Tersedia Galangan	4,14	0,86	Acceptep	3,14	0,57	Rejected			
22		Tersedia Lahan	3,00	0,43	Rejected						

(Source: Author data processing)

Table 4.3 above shows the criteria for the results of data analysis processing using the Delphi method from the Criteria for Perception of Security, Access to Transportation and Supporting Facilities. 12 (eight) criteria were obtained that are feasible to be developed in the next research analysis. The twelve sub-criteria are as follows:

a. Safe from enemy attacks
b. Safe from border conflicts
c. Safe from Social Conflict
d. Safe from disasters
e. Military Port Available
f. Public Port Available
g. Public Airport Available
h. Communication Facilities Available
i. Electrical Facilities Available
j. Water Facilities Available
k. Transportation Facilities Available
l. Available Fasharkan

3.2 Process Analytics Network (ANP) Relationship Structure.

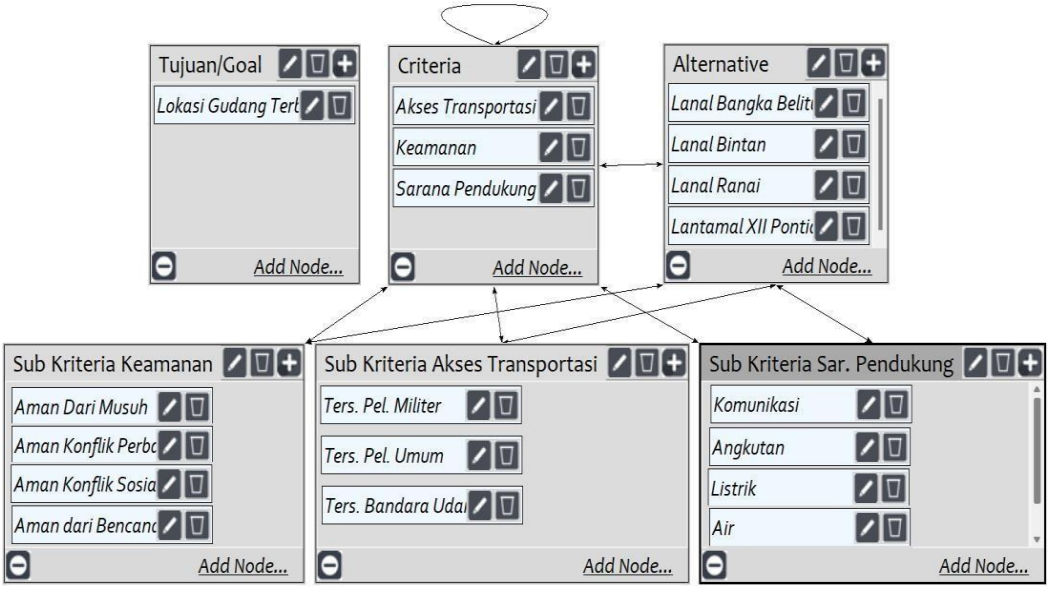


Figure 4. 1 ANP Model in *Softwere Super Decisions*

The author has carried out a model validation through expert validation carried out by experts in their fields, in this case the officials of the Batuporon Arsenal and the Headquarters Base Facilities Service in this case are represented by the Head of the Planning Section who is competent in the study of Arsenal Warehouse Standardization.

3.3 Geomatrix Mean Calculation

After the results of the questionnaire test from each *expert* are tested for consistency, then the results of filling in are worthy of being unified through the geometric average of each of these questions.

Table 4. 3 Results of Comparison of Values Between Criteria and Geomaen Values

No.	Security - Alternatives	E1	E2	E3	E4	E5	E6	E7	Geomaen
1	Lanal Bangka - Lanal Bintan	3	3	2	3	3	4	4	3
2	Lanal Bangka - Lanal Ranai	2	3	4	3	5	4	3	3
3	Lanal Bangka - Pontianak	3	3	2	2	3	2	2	2
4	Lanal Bintan - Ranai	3	4	3	3	4	3	4	3
5	Lanal Bintan - Pontianak	2	4	3	3	5	4	4	3
6	Lanal Ranai - Pontianak	5	5	5	3	4	4	3	4

3.4 Pairwise Comparation Value between Criteria and Sub-criteria

The *Pairwise comparison score* for each category was obtained from a questionnaire of experts in determining the Arsenal Warehouse. After obtaining one *pairwise comparison value* for each relationship, the local priority weight calculation is carried out. The local priority weighting that must be considered is that the value of

inconsistency cannot exceed the value of 0.1 The ANP questionnaire is processed using *super decision software version 3.2.0.* The output of the final calculation is in the form of the priority weight value of each alternative, as seen in Figure 4.6.

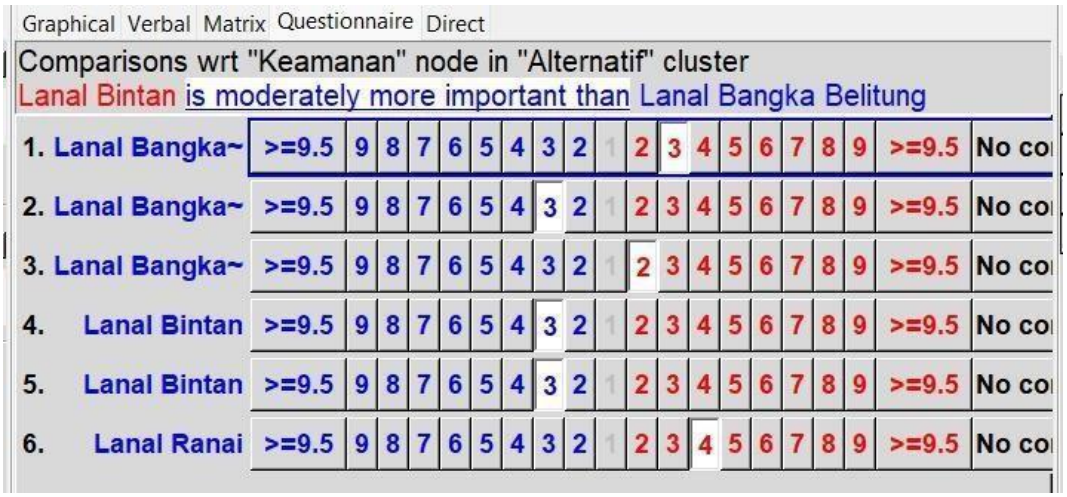
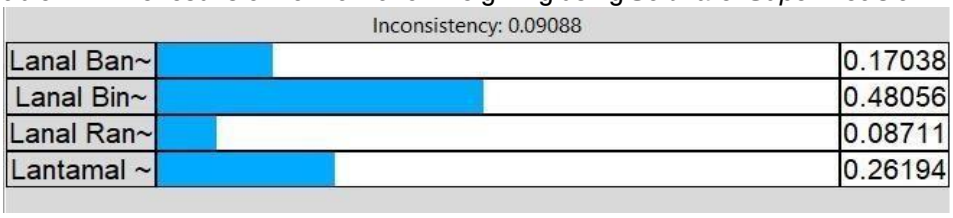


Figure 4. 2 Comparison of Security criteria with Alternatives
(Source: data processed with Super Decision)

From the comparison table of pairing between criteria and Alternatives in the Security criterion, the *inconsistency index* is 0.09088. Where the value is still below 10% or 0.1 which means that this shows that from all the answers given to the respondents in this research questionnaire are consistent.

Table 4. 4 The results of normalization weighting using *Software Super Decision*



3.5 Alternative Priority Determination of Arsenal Warehouse Location

After obtaining the results of the priority weights of the criteria, then from the results of processing the data in the form of questionnaires, as well as checking *the inconsistency* index of all criteria and subcriteria on the local priority weights, the software will work on all stages of the ANP method by running *Synthesize*, then it will obtain the criteria weights as exemplified in figure 4.9 below.

Table 4. 5 Alternative Weights

Name	Graphic	Ideals	Normals	Raw
Lanal Bangka Belitung		0.287890	0.154398	0.064794
Lanal Bintan		1.000000	0.536308	0.225064
Lanal Ranai		0.245919	0.131888	0.055347
Lantamal XII Pontianak		0.330789	0.177405	0.074449

After the results of the geometric average value are input or fully entered into the matrix format in the *Super Decision software*, and check the *inconsistency index* of all criteria and all sub-criteria on the local priority weights, the software will automatically perform or do data processing for all stages in the ANP method process, then the weight values from all criteria can be obtained by running *Computations*, as exemplified in table 4.7 below.

Table 4. 6 Criterion Weight Value on Alternative

	Transportation Access	Security	Supporting Facilities
Lanal Bangka Belitung	0,094248	0,110880	0,088213
Lanal Bintan	0,301525	0,312739	0,387505
Lanal Ranai	0,049930	0,056689	0,229600
Lantamal XII Pontianak	0,164622	0,170466	0,044500

From Table 4.8, the order of alternative priority is obtained based on the amount of weight value of each alternative as follows:

a. Priority 1 is an alternative to Lanal Bintan with a weight value of 0.536308.
b. Priority 2 is an alternative to Lantamal XII Pontianak with a weight value of 0.177405.
c. Priority 3 is an alternative to Lanal Bangka Belitung with a weight value of 0.154398.
d. Priority 4 is the Lanal Ranai alternative with a weight value of 0.131888.

4. Conclusion

From the results of data collection and processing, as well as the analysis and interpretation of the data processing results that have been carried out, the conclusions that can be drawn in this final project are:

a. The main criteria that are considered in determining the Arsenal Warehouse alternative are the Security criterion with a weight value of 0.43917,

then the second priority is the Transportation Access criterion with a weight value of 0.28482 and the third priority is the Supporting Facilities Criterion with a weight value of 0.27601.

b. The chosen alternative in determining the location of the Arsenal Warehouse from this article is Lanal Bintan with a weight of 0.536308. The bintan lanal is located in Bintan Regency within the working area of Lantamal IV Batam. Meanwhile, the second to fourth alternatives in a row are Lantamal XII Pontianak (weight 0177405), Lanal Bangka Belitung (weight 0.154398) and Lanal Ranai (weight 0.131888).

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Indonesian Naval Technology College
Postgraduate International Conference, Vol. 8, No. 1, pp. 197-206
June, 27th 2024

ANALYSIS OF DRY BULK CARGO LOADING AND UNLOADING PERFORMANCE AT TANJUNG TEMBAGA PORT (CASE STUDY : PT DELTA ARTHA BAHARI NUSANTARA)

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ABSTRACT
In recent years, loading and unloading activities at ports have shown a significant increase in line with the growth in global and regional trade volumes. However, the surge in loading and unloading activities poses serious challenges, such as limited infrastructure, stacking capacity, operational efficiency, the need for more and more qualified human resources, and compliance with increasingly stringent regulations, in addition to environmental impacts and safety aspects that need to be considered. The purpose of this study is to identify and evaluate the main obstacles that arise due to the increase in dry bulk loading and unloading activities at PT DABN Port, as well as strategic solutions to overcome these challenges in order to ensure the smooth operation and sustainability of the port environment. The research method used is a quantitative approach by conducting a survey using key performance indicators such as loading and unloading time, labor productivity, equipment utilization, and damage rate. Primary data used comes from questionnaire answers with a total of 30 respondents, while secondary data is obtained from company reports and official port documents. This research uses descriptive analysis using validity and reliability tests using a used trial. The results showed that the performance of dry bulk loading and unloading at PT DABN Port was in the good category, but from these indicators there were still obstacles for service users. These obstacles will be an evaluation for PT DABN to improve loading and unloading performance from the aspects of equipment utility, loading and unloading time, labor productivity and the level of damage to goods and make improvements as a determinant of the success of dry bulk loading and unloading so as to increase loading and unloading efficiency.

KEYWORDS : loading and unloading performance, dry bulk, Tanjung Tembaga Port, PT Delta Artha Bahari Nusantara, effectiveness, efficiency.

1. INTRODUCTION.

Ports are places for the exchange of goods and are important centers of logistics activities in the global supply chain. The role of ports as an important point in logistics activities continues to evolve along with changes in international trade and transportation technology.

One of the ports located in East Java is Tanjung Tembaga Port. Tanjung Tembaga Port is a port located in Probolinggo City, East Java. With the development of trade, economy and shipping, Tanjung Tembaga Port changed its position from a coastal port to a sea port, thus opening up trade to and from abroad. The existence of Tanjung Tembaga Port will reduce the number of ships that stop at Tanjung Perak Port in Surabaya.

In Tanjung Tembaga Port Probolinggo there are 2 types of ports, namely passenger ports and freight ports managed by the Port Business Entity (BUP) PT Pelindo and PT Delta Artha Bahari Nusantara (DABN). In addition, there is a special port owned by PT Kutai Timber Indonesia (KTI) which handles ship to ship loading and unloading activities in the form of plywood.

PT Delta Artha Bahari Nusantara (DABN) is a company owned by the local government of East Java and acts as the manager of loading and unloading activities at the public terminal at Probolinggo Port. PT DABN is committed to improving services at the port, one of the steps taken is the construction of port facilities including overlay yards, causeways, and trestles. Currently, the port has two operational piers. The first

pier measures 93 meters x 18.5 meters with a depth of -5 mLWS, this pier is used for tugboats to dock. The second pier has dimensions of 214 meters x 20 meters depth with -10 mLWS, used for cargo ships that carry out loading and unloading activities at the port.

At the Port of Probolinggo, especially at PT DABN, the volume of loading and unloading operations continues to increase from year to year. This is a response to the unstable domestic and international economic turmoil and the intense competition between loading and unloading companies at the port. Providing freight transportation at PT DABN Port is closely related to the improvement of services provided by this port through its infrastructure and supporting facilities. With significant growth in loading and unloading volumes, it is necessary to assess whether the existing facilities, infrastructure and operational systems have reached an optimal level or can still be improved. It is also important to consider whether additional infrastructure and vehicles are needed to anticipate future transportation needs.

Various obstacles are often encountered during loading and unloading activities, which can further hamper loading and unloading activities. Most safety issues occur during loading and unloading, especially on vessels carrying hazardous or highly sensitive materials. During the loading and unloading process, truck delays, dockworker performance, and weather conditions can also pose obstacles. Available facilities are also thought to affect the speed of loading and unloading activities (Taufik et al., 2023).

Based on the Decree of the Director General of Hubla No. UM.002/38/18/DJPL-11 concerning Port Operational Service Performance Standards, operational service performance is a measurable work result achieved by the port in carrying out ship services, goods and utilization of facilities and equipment within a certain period of time and unit. Operational service performance standards are the standard work results of each service that must be achieved by the terminal / port operator in the implementation of port services including the provision of port facilities and equipment.

In port management, monitoring dry bulk loading and unloading activities is a factor that has a significant impact on operational efficiency. An efficient loading and unloading process plays an important role in maintaining the smooth flow of goods at Tanjung Tembaga Port. Any delays or setbacks in dry bulk loading and unloading operations can adversely affect the supply and distribution chain, and potentially impact the overall productivity of the port.

2. MATERIALS/METHODOLOGY ;EXPERIMENTAL PROCEDURE.

2.1. Types of Research

The type of research used in this study is quantitative descriptive method. This method is in line with research variables, focuses on actual ongoing problems and phenomena, and presents research results in the form of meaningful numerical data. (Sugiyono, 2019).

2.2. Data Source

The data source of this research consists of primary data and secondary data. In this study, primary data was collected by researchers through filling out questionnaires given to service users and KSOP Class IV Probolinggo employees while secondary data sources include interviews, field observations, journals, articles, and books relevant to the research topic on loading and unloading performance.

2.3 Data Collection Technique

The data collection techniques in this research are field observations and questionnaires, Field observations are very effective for obtaining detailed and contextual data. The content of the questionnaire is based on

the dry bulk loading and unloading performance variable, which consists of four indicators.

In this study, sampling used random sampling technique, which is a random sampling technique from the population without regard to population strata. The population used in this study were service users and employees of the Class IV Probolinggo KSOP Office.

2.4 Data Analysis Technique

The data analysis techniques used include data instrument tests and descriptive statistics. Data instrument test consists of validity test and reliability test. In this study, the validity of the instrument was tested by comparing the total score with the sum of the values of each element. If there is a significant correlation between the values of each strong construction variable that shows 0.3 or more than >0.3. To evaluate the reliability of the study, Cronbach's Alpha coefficient was used. The set of statements used to measure the dimensions of a variable is considered accurate and successful if its reliability coefficient is at least 0.6. The research data were processed using the SPSS program. The validity and reliability of the thesis were tested through the Used Try Out test. Data will be organized, selected, analyzed, and interpreted using words and sentences to provide relevant explanations. The research variables will be divided into various frequencies and accurate percentages.

Summary descriptive statistics include:

a. Mean: the average value of the data.
b. Maximum: the highest value of the data.
c. Minimum: the lowest value of the data.

After knowing the average, maximum and minimum values, the researcher will calculate the percentage index using the formula:

$$\% \text{ Score Actual} = \text{Actual Score} / \text{ Ideal Score} \times 100\%$$

Description:

1. Actual score is the final score given by each respondent to the questionnaire.
2. The ideal score is the largest score that each respondent is expected to choose.

The percentage score assessment is categorized using the score assessment categorization theory according to Narismawati (2010).

Table 1. Interval Rating Score

No	percentage interval	Category
1	84.01-100	Very good
2	68.01-84.00	Good
3	52.01-68.00	Good enough
4	36.01-52.00	Not good enough
5	20.00-36.00	Not good

Source : (Narismawati, 2010)

3. RESULT AND DISCUSSION.

3.1 Research Results

a. Validity Test

Validity testing is applied as part of the analysis of the questionnaire data that has been conducted. This test aims to assess the precision and accuracy of the work being evaluated. A statistical process applied to assess the extent to which a measurement instrument, such as a questionnaire, actually measures what it is supposed to measure. In this study, the validity of the instrument was checked by observing the correlation between the score of each statement and the total score using SPSS software.

With the results of data calculation using SPSS software, it has a condition that if the value of calculated r is greater than table r, it is declared valid, if calculated r is not greater than table r, it is declared invalid. The acquisition of the r validity test table is 0.361. The following is the acquisition of validity test results in the table below.

Table 2. Validity Test Result

Variables	Item	Calculated r	Table r	Description
Readiness of Loading and Unloading Equipment	X1	0,680	0,361	Valid
	X2	0,772	0,361	Valid
	X3	0,843	0,361	Valid
	X4	0,824	0,361	Valid
Facilities and Infrastructure Readiness	X1	0,809	0,361	Valid
	X2	0,717	0,361	Valid
	X3	0,608	0,361	Valid
TKBM Performance	X1	0,826	0,361	Valid
	X2	0,851	0,361	Valid
	X3	0,791	0,361	Valid
	X4	0,726	0,361	Valid
Loading and Unloading Performance (seen from the timeliness of loading and unloading)	X1	0,797	0,361	Valid
	X2	0,774	0,361	Valid
	X3	0,671	0,361	Valid
	X4	0,628	0,361	Valid

Source : Data Processed (2024)

From table 2 above, it is known that the data on the results of determining the validity of each statement in the questionnaire is valid, it can be seen from calculated r greater (>) than table r. This indicates that all statement items can be used in the overall test model.

b. Reliability Test

Reliability test is a process to assess the consistency and reliability of a measurement instrument in measuring certain variables or constructs. This test aims to ensure that the instrument provides stable and repeatable results over time.

Table 3. Reliability Test Results

Variables	*Cronbach's Alpha*	Description
Readiness of Loading and Unloading Equipment	0,847	*Reliable*
Facilities and Infrastructure Readiness	0,911	*Reliable*
TKBM Performance	0,899	*Reliable*
Loading and Unloading Performance (seen from the timeliness of loading and unloading)	0,873	*Reliable*

Source : Data Processed (2024)

The results of the reliability test in table 3 above show that the loading and unloading performance variable for the loading and unloading equipment readiness component of the Cronbach Alpha coefficient for valid items is 0.847, the readiness component of facilities and infrastructure is 0.911, the TKBM performance component is 0.899 and the loading and unloading performance component seen from the timeliness of loading and unloading is 0.873. Each component of dry bulk loading and unloading performance shows results greater than 0.6. This shows that the measurement instrument provides reliable and consistent results or reliable.

c. Descriptive Statistics

Descriptive statistics are used to summarize and describe the information contained in a data set in a concise and informative manner. The information is processed using SPSS software, from the questionnaires that have been collected and then processed.

The values used are the minimum value, maximum value, average value (mean) and standard deviation for each component of dry bulk loading and unloading performance that will be known with data that has been processed using SPSS and includes components of loading and unloading equipment readiness, readiness of facilities and infrastructure, TKBM performance and loading and unloading performance. The following table displays the results of descriptive statistical analysis conducted with the help of SPSS software.

Tabel 4. Readiness of Loading and Unloading Equipment

	N	Minimum	Maximum	Mean	Std. Deviation
X1_1	30	1	5	3.46	1.041
X1_2	30	2	5	3.86	1.008
X1_3	30	2	5	4.10	.711
X1_4	30	2	5	3.93	.907
Total_X1	30	8	20	15.36	3.068
Valid N (listwise)	30				

Source : Data Processed (2024)

The statistical test results from table 4 show that the respondents from the data analysis of the readiness of loading and unloading equipment obtained the lowest score (minimum) 1, the highest score (maximum), the average (mean) 3.84 close to score 4. This shows that the assumptions given by the majority of respondents generally agree with the statements made in the questionnaire.

The results of the respondents' statistical data show that the tools used in loading and unloading activities at the Port of PT Delta Artha Bahari Nusantara are not damaged and take place efficiently and periodic maintenance of the tools.

Tabel 5. Facilities and Infrastructure Readiness

	N	Minimum	Maximum	Mean	Std. Deviation
X2_1	30	2	5	4.26	.639
X2_2	30	2	5	4.36	.668
X2_3	30	2	5	4.30	.794
Total_X2	30	6	15	12.93	1.94
Valid N (listwise)	30				

Source : Data Processed (2024)

The statistical test results of the table 5 above show that respondents from the data analysis of the readiness of facilities and infrastructure obtained the lowest score (minimum) 2, the highest score (maximum) 5, the average (mean) 4.31 and a score close to 5. This shows that the assumptions given by the majority of respondents generally agree with the statements made in the questionnaire.

The results of the respondents' statistical data show that the readiness of facilities and infrastructure is very important to support the smooth loading and unloading activities. Adequate facilities and infrastructure can speed up the loading and unloading process, increase efficiency, and reduce the risk of damage or accidents.

Tabel 6. TKBM Performance

	N	Minimum	Maximum	Mean	Std. Deviation
X3_1	30	2	5	3.96	.808
X3_2	30	2	5	4.10	.803
X3_3	30	2	5	4.36	.668
X3_4	30	2	5	4.40	.723
Total_X3	30	8	20	16.83	2.64
Valid N (listwise)	30				

Source : Data Processed (2024)

The results of statistical tests show that respondents from the analysis of TKBM labor readiness data obtained the lowest score (minimum) 2, the highest score (maximum) 5, the average (mean) 4.20 and a score close to 5. This shows that the assumptions given by the majority of respondents generally agree with the statements made in the questionnaire.

The results of the respondents' statistical data show that the performance of dry bulk TKBM (Labor Loading and Unloading) they are directly involved in the process of loading and unloading goods from ships or other means of transportation besides that TKBM can show discipline in accordance with the predetermined shift schedule. It is also important to have TKBM who are trained, experienced, and have good performance in dry bulk loading and unloading activities to ensure that the process runs smoothly, efficiently, and safely.

Tabel 6. Loading and Unloading Performance

	N	Minimum	Maximum	Mean	Std. Deviation
X4_1	30	2	5	3.73	.827
X4_2	30	2	5	3.70	.836
X4_3	30	2	5	3.73	.784
X4_4	30	2	5	3.66	.844
Total_X4	30	8	20	14.83	2.80
Valid N (listwise)	30				

Source : Data Processed (2024)

The statistical test results show that respondents from the loading and unloading performance data analysis obtained the lowest score (minimum) 2, the highest score (maximum) 5, the average (mean) 3.70 and a score close to 4. This shows that the assumptions given by the majority of respondents generally agree with the statements made in the questionnaire.

The results of the respondent's statistical data show that PT Delta Artha Bahari Nusantara has carried out dry bulk loading and unloading activities in accordance with a predetermined activity plan so that service users are satisfied with the services that have been provided in addition to the low level of damage to goods and delays rarely occur during the dry bulk loading and unloading process.

d. Precentage of Answer Score

Tabel 7. Precentage of Answer Score

No	Indikator	Actual Score	Ideal Scor	% Actual Score	Criteria
1	Readiness of Loading and Unloading Equipment	461	600	76,33%	Good
2	Facilities and Infrastructure Readiness	388	450	86,22%	Very good
3	TKBM Performance	505	600	84,17%	Very good
4	Loading and Unloading Performance	445	600	74,17%	Good
	Average	1799	2250	79,96%	Good

Source : Primary Data Processed (2024)

Based on the results of the study, each indicator is stated as follows:

1. Based on the results of the percentage of dry bulk loading and unloading performance seen from the loading and unloading equipment readiness indicator of 76.33%. According to Narismawati (2010) the percentage of 68.01-84.00% is stated that the loading and unloading performance is good. So the percentage value of dry bulk loading and unloading performance of 76.33% is included in the good category.
2. Based on the results of the percentage of dry bulk loading and unloading performance seen from the indicator of the readiness of loading and unloading facilities and infrastructure amounted to 86.22%. According to Narismawati (2010) the percentage criteria of 84.01-100% stated that the loading and unloading performance is very good. So the percentage value of dry bulk loading and unloading performance of 86.22% is included in the category of very good.
3. Based on the results of the percentage of dry bulk loading and unloading performance seen from the indicator of the readiness of loading and unloading facilities and infrastructure of 84.17%. According to Narismawati (2010) the percentage criteria of 84.01-100% stated that the loading and unloading performance is very good. So the percentage value of dry bulk loading and unloading performance of 84.17% is included in the category of very good.
4. Based on the results of the percentage of dry bulk loading and unloading performance seen from the loading and unloading performance indicators and amounted to 74.17%. According to Narismawati (2010) the percentage criteria of 68.01-84.00% are stated that the loading and unloading performance is good. So the percentage value of dry bulk loading and unloading performance of 74.17% is included in the good category.

Judging from the entire percentage of indicators, the highest percentage by respondents is the indicator of readiness of facilities and infrastructure of 86.22%. Indicators of readiness of dry bulk loading and unloading facilities and infrastructure have a high role in the smooth running of dry bulk loading and unloading activities. The indicator that has the lowest percentage is the loading and unloading performance indicator of 74.17%.

3.2 Discussion

Based on the results of the study, each indicator is stated as follows:

a. Indicator of loading and unloading equipment readiness

   Based on the results of the research conducted, the indicator of the readiness of loading and unloading equipment has a percentage value of 76.33%, therefore it is stated that the indicator of the readiness of loading and unloading equipment includes "good" criteria.

b. Indicator of readiness of facilities and infrastructure

   Based on the results of research conducted that the indicator of the readiness of facilities and infrastructure has a percentage value of 86.22%, therefore it is stated that the indicator of the readiness of loading and unloading facilities and infrastructure includes "very good" criteria

c. Performance indicators of TKBM (Unloading Labor)

   Based on the results of the research conducted, the TKBM performance indicator has a percentage value of 84.17%, therefore it is stated that the TKBM performance indicator includes "very good" criteria.

d. Loading and Unloading Performance Indicators

Based on the results of the research conducted, the TKBM performance indicator has a percentage value of 74.17%, therefore it is stated that the loading and unloading performance indicator includes the criteria "good".

The results of the calculation of the percentage of dry bulk loading and unloading performance with four indicators of loading and unloading equipment readiness, readiness of facilities and infrastructure, TKBM performance and performance in the dry bulk loading and unloading process which shows that the average percentage is in the "good" category, which indicates that the implementation of dry bulk loading and unloading performance has met or exceeded the expectations of service users.

Efforts made so that the performance of dry bulk loading and unloading can improve loading and unloading efficiency at the Port of PT Delta Artha Bahari Nusantara, all components of dry bulk loading and unloading performance at the Port of PT Delta Artha Bahari Nusantara according to respondents who showed a good category. This shows that although the loading and unloading performance is adequate and meets the standards, there is still room for improvement to identify areas that require improvement as a determinant of the success of dry bulk loading and unloading so as to increase loading and unloading efficiency, such as the addition and rejuvenation of loading and unloading facilities and equipment, continuous training for labor, and increased coordination and communication between related parties. The implementation of these recommendations is expected to improve the performance of dry bulk loading and unloading at PT DABN Port so as to support the smooth flow of goods and improve port competitiveness.

In order to achieve a more optimal or "very good" level. By evaluating the less than optimal activities of the indicator components.

4. CONCLUSION.

From all indicators of loading and unloading performance, it can be concluded that the average of all indicators includes "good" criteria as evidenced by the total percentage of the average of 79.96%. For the loading and unloading equipment readiness indicator with a percentage of 76.33%, it is included in the "good" criteria. For the indicator of the readiness of facilities and infrastructure with a percentage of 86.22% included in the "very good" criteria. For TKBM performance indicators with a percentage of 84.17% included in the "very good" criteria. For loading and unloading performance indicators with a percentage of 74.17% including the "good" category.

Efforts to improve the performance of dry bulk loading and unloading are carried out to evaluate the performance of dry bulk loading and unloading at PT Delta Artha Bahari Nusantara to improve factors that support loading and unloading activities and identify areas that require improvement as a determinant of the success of dry bulk loading and unloading so as to increase loading and unloading efficiency.

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Indonesian Naval Technology College
Postgraduate International Conference, Vol. 8, No. 1, pp. 207-217
June, 27th 2024

THE CONCEPT OF DIGITAL-BASED MILITARY LOGISTICS SUPPLY CHAIN MANAGEMENT: STRENGTHENING ACCURACY AND SPEED AS WELL AS TRANSPARENCY AND ACCOUNTABILITY

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ABSTRACT
Logistics supply chain management in the military context, especially in the Indonesian Navy, has not fully adopted the Logistics Supply Chain Management system. This paper aims to develop a digital-based military logistics supply chain management concept to strengthen accuracy and speed as well as transparency and accountability in a clear and realizable framework. The research method used is the qualitative descriptive analysis by building a digital-based military logistics supply chain management concept based on an in-depth analysis of reliable factors and strategies. This research produced findings in the form of a digital-based military logistics concept with significant factors, namely technology, and infrastructure, trained human resources, standardized processes, security and privacy, as well as effective collaboration and communication, all of which contribute to increasing accuracy, speed, transparency, and accountability. The final result of this research is to obtain strategies that include applying advanced technology, human resource development, process standardization, and collaboration between internal and external parties. By adopting these strategies, digital-based military logistics supply chain management can increase accuracy, speed, transparency, and accountability, strengthening operational readiness and overall military mission effectiveness.

KEYWORDS: Military Logistics, Supply Chain Management, Digital Concept Strategy.

1. INTRODUCTION

The development of an uncertain strategic environment at the global and regional levels has had a significant impact at the national level, especially in the field of a country's defense. Global uncertainty creates complex challenges that affect the way countries plan, implement, and maintain their defense policies. At the global level, international conflicts, changes in the policies of major powers, and economic uncertainty can change the dynamics and forms of state defense throughout the world. This ultimately forces countries to adjust a country's defense strategy, evaluate alliances and cooperation, and identify potential threats that arise from geopolitical and geostrategic shifts. At the regional level, geopolitical and geostrategic dynamics and relations between countries can create uncertainty regarding regional threats that may be faced. Countries may need to design defense policies that accommodate these dynamics and ensure that they can adapt to changes in the region. Meanwhile, specifically in the defense sector, technological developments, including advanced military technology, and changes in the character of threats such as cyber-attacks, terrorism, or non-conventional threats, can change the national defense paradigm. Countries must update their defense capabilities to address these new threats and ensure better resilience to various scenarios (Aitel et al, 2022)

Apart from that, the presence of the VUCA (Volatility, Uncertainty, Complexity, and Ambiguity) era plays a central role in determining the success of achieving national defense goals and interests. High levels of volatility create uncertainty in global political, economic, and security dynamics. A high level of uncertainty makes planning and implementing defense policy more complicated because challenges cannot be predicted. The complexity and ambiguity of today's strategic environment also add a layer of difficulty in identifying threats and opportunities that may emerge. So in general, the uncertainty of the international strategic environment directly or indirectly greatly influences each country's efforts to guarantee national defense, especially national defense interests (Acero et al, 2019).

For this reason, the Indonesian National Army (TNI), which is an integral part of the state institution and has duties in National Defense based on Law number 34 of 2004 concerning the Indonesian National Army in Article 7 has the main task of upholding state sovereignty, defending the territorial integrity of the Unitary State of the Republic Indonesia which is based on Pancasila and the 1945 Constitution of the Republic of Indonesia, and protects the entire nation and all of Indonesia's blood from threats and disturbances to the integrity of the nation and state. The main tasks as intended in paragraph (1) are carried out by: (a) military operations for war; (b) military operations other than war. "In carrying out these duties, as stated in Articles 8, 9, and 10, the implementation of national defense duties is carried out by 3 (three) TNI forces, namely the Army, Navy and Air Force.

The Indonesian Navy, which is one of the TNI Organizational units, has the main duties as intended in article 9, namely as follows: "carrying out TNI maritime duties in the defense sector; enforce the law and maintain security in the maritime area of national jurisdiction following the provisions of ratified national law and international law; carry out Navy diplomacy duties to support foreign political policies determined by the government; carrying out TNI duties in the construction and development of maritime forces; carry out the empowerment of maritime defense areas". From its duties, it is clear that the Indonesian Navy has a role in maintaining the defense and security of Indonesia's maritime areas and protecting all of Indonesia's bloodshed from threats, interference, and challenges from external parties, both direct and indirect. Carrying out these tasks is carried out through military operations for war and military operations other than war.

Supporting the implementation of the Indonesian Navy's duties, certainly requires qualified military logistical support, in terms of speed, accuracy as well as transparency, and accountability. Qualified military logistical support plays a central role in ensuring that the Indonesian Navy has the resources and support needed to carry out operational and non-operational tasks effectively and efficiently. Apart from that, the importance of qualified military logistical support for the Indonesian Navy can be seen from several aspects, namely:

First, military logistics ensures the availability and smooth running of supplies needed by the Indonesian Navy. These supplies include food, water, fuel oil and lubricants, individual and unit equipment, ammunition, medical equipment, ship spare parts, and various other necessities. With good logistical support, the Indonesian Navy can ensure that warships, aircraft, combat, and non-combat vehicles as well as supporting equipment or equipment as well as Indonesian Navy troops and units have adequate supplies to carry out national defense operations in Indonesian maritime areas. This is very helpful in maintaining high readiness and operational capacity to face various challenges in protecting Indonesia's maritime areas.

Second, logistical support is very important in supporting the mobility of the Indonesian Navy. With an effective transportation management system in the logistics support system, it is possible for troops and the main weapons systems and equipment of Indonesian Navy units to be moved quickly, precisely, and efficiently from one place to another. This is especially important in monitoring and securing maritime area operations which involve the movement of ships, defense equipment, and Indonesian Navy personnel to various strategic locations. Good mobility allows the Indonesian Navy to respond quickly and effectively to developing situations at sea.

Third, logistical support is also needed to support health and welfare service activities for Indonesian Navy personnel. Proper logistical support, especially in the medical field, and adequate supplies of medical equipment are very important in maintaining the health and fitness of personnel involved in the duties of the Indonesian Navy. Logistics support also includes the provision of equipment, protective equipment, and other welfare facilities necessary to maintain the physical and mental condition of personnel.

Finally, logistical support has a vital role in the maintenance, repair, and overhaul of the main and non-main equipment and tools of the Indonesian Navy's weapon systems. This involves providing spare parts, maintenance equipment, and technical support for ships, aircraft, vehicles, and weapons systems. With good maintenance, the Indonesian Navy can ensure that existing equipment is in optimal condition and ready to be used in any situation. So, logistics support has a very important role and therefore requires competent military logistics supply chain management. A capable military logistics supply chain can only be obtained if all activities in the supply chain process have been transformed into digital form. This will of course involve various activities including planning, procurement, management, and distribution of necessary resources, including personnel, equipment, fuel, and ammunition, to ensure readiness and smooth maritime operations. Meanwhile, military supply chain management in the Indonesian Navy currently refers to the Regulation of the Chief of Naval Staff Number Perkasal/69/XI/2010 dated 2 November 2010 concerning the main manual for the logistics development of the Indonesian Navy as well as Regulation of the Chief of Naval Staff Number Perkasal/103/ XII/2010 dated December 31, 2010, concerning Administration Guide to the Development of the Navy's Briefing. Where the regulation regulates the development of supplies for the Indonesian Navy which includes the development of material supplies and the development of provision support, which is an elaboration of the Master Guidebook for the Development of the Logistics Sector of the Indonesian Navy, which is a harmonious arrangement of all its functions to support supplies for maintenance and repair of material. others, provision for operational readiness, and personnel provision.

However, to date, regulations related to logistics supply chain management within the Indonesian Navy have not undergone changes or updates by the concept of modern, digital-based logistics supply chain management. This change is important considering advances in information technology and the concept of digitalization which can have a positive impact on accuracy and speed as well as transparency and accountability in the logistics supply chain process. Adoption of digital-based supply chain management principles can open up new opportunities to improve performance, minimize errors, and speed up responses to changing dynamics in military logistics operations. Therefore, regulatory updates that reflect the development of modern supply chain management concepts are expected to provide a stronger foundation for the Indonesian Navy to face today's logistics challenges and demands.

Logistics supply chain management in a military context, especially in the Indonesian Navy, currently has not fully adopted the system or term Logistics Supply Chain Management. This can be noted as an indication of

the differences in principles between military logistics and general practices in supply chain management in the civilian sector. Even so, there is consistency that underlies close relationships with users in the current logistics process. Despite differences in principles, these common threads suggest that a focus on user needs and engagement remains at the core of the military logistics process.

User involvement in every operational phase provides the basis for effective adaptation to changing requirements and situational dynamics, which is a critical aspect of military operations. Even though the terms and concepts may be different, the principles of logistics supply chain management can still be adapted to the military context to increase efficiency, involvement, and responsibility in supporting the Indonesian Navy's logistics operations. By identifying these common threads, further steps can be taken to integrate supply chain management principles in more detail, thereby improving the Indonesian Navy's military logistics capabilities to respond to and respond to ever-changing needs.

Supply chain management itself is the process of moving information and raw materials to the company's manufacturing and service processes. These processes include logistics processes that physically move products and warehousing and storage processes that control the location of products so they can be sent quickly. Ahmad, N.B. (2024) discusses current strategies and practices in supply chain management. He highlighted the importance of collaboration, transparency, and adaptability in facing modern supply chain challenges, including the integration of information or digital technology in the process of activities. Meanwhile, Michael Hugos provides a basic understanding of supply chain concepts, including the role of digital information technology in increasing efficiency and timeliness in logistics operations (Haelig, 2023). Based on the opinions of experts regarding the logistics supply chain, there is a core regarding the logistics supply chain which is very closely related to military activities in carrying out its main tasks which include logistics management processes and the use of digital technology with the hope of realizing speed and accuracy as well as transparency and accountability in the chain. logistics supplies.

Therefore, this research will discuss the two dimensions of the military logistics supply chain, namely to find out the role of logistics management concerning the extent to which the use of digital technology has increased speed and accuracy as well as transparency and accountability in the TNI's military logistics supply chain. The Navy is a vital element in supporting the implementation of the Indonesian Navy's duties. This is related to the effective operation of the Indonesian Navy's military and non-combat defense equipment, whether in the form of warships, aircraft, combat and non-combat vehicles, and other equipment.

Meanwhile, the role of logistics management concerning the extent to which digital technology has been used in increasing speed and accuracy as well as transparency and accountability in the military logistics supply chain, the Indonesian Navy needs to make innovative and adaptive breakthroughs by utilizing technological developments in the era of the industrial revolution 4.0 to achieve this. established goals. The use of a digital system aims to be the main media in the administration of logistics supply chain management, especially the logistics supply chain for fuel oil and lubricant materials, which up to now still uses a manual system. Apart from that, to realize efficiency, transparency, and accountability in the management of the TNI and real-time data control and monitoring systems, making it easier to check their use.

However, in its implementation, several problems were still found including human resource support factors which play an important role in managing logistics management, supporting infrastructure factors, collaboration factors between units and institutions, as well as periodic ongoing evaluation and monitoring. So to address the problems related to the extent to which digital technology is used in increasing speed and accuracy as well as transparency and accountability in the Indonesian Navy's military logistics supply chain as stated above, researchers see the need to strengthen the military logistics supply chain management to increase accuracy and speed as well as transparency and accountability by paying attention to human resource components, supporting infrastructure, collaboration and holistic evaluation and monitoring to address problems that arise.

So that the analysis carried out is more focused and follows the problems discussed, the problem formulation in this research is:

a. How to implement digital-based military logistics supply chain management to increase accuracy and speed as well as transparency and accountability in logistics support?
b. What are the influencing factors in implementing digital-based military logistics supply chain management to increase accuracy and speed as well as transparency and accountability?
c. What strategies can be used to implement digital-based military logistics supply chain management to increase accuracy and speed as well as transparency and accountability?

Based on the identification and problem formulation above, the aim of this research to be achieved is to examine the extent of success or failure in implementing digital-based military logistics supply chain management for the Indonesian Navy to increase accuracy and speed as well as transparency and accountability, especially in the material logistics supply chain. Apart from that, it is also to find out what factors influence the implementation of digital-based military logistics supply chain management for the Indonesian Navy to increase accuracy and speed as well as transparency and accountability, especially in the material logistics supply chain.

2. MATERIAL AND METHODS

2.1. Management

Kirkpatrick & Damp (2003) stated that management is the process of collaborating between individuals and groups and other resources in achieving organizational goals as a management activity; Managerial activities are carried out by managers so that they can encourage personnel resources to work utilizing other resources so that mutually agreed upon organizational goals can be achieved; In other words, managerial activities are only found within an organization, be it a business organization, government, school, industry and others.

Sobb, Turnbull & Moustafa (2020), state that management is the science and art of managing the process of utilizing human resources and other resources in an organization effectively and efficiently to achieve a certain goal. Furthermore, Chu (2022), stated that the development of management theory is increasingly providing various approaches that contribute to the development of human life. The implementation of various management approaches has been widely used in various fields and functions in organizations such as marketing, motivation, leadership, strategy, and making important decisions.

2.2. Logistics

Logistics is the art and science of moving goods, energy, information, and other resources, such as products, services, and people, from production sources to markets to optimize the use of capital. Logistics also includes information integration, transportation, inventory, warehousing, reverse logistics, and packaging. Etymologically, logistics comes from ancient Greek and consists of two syllables, namely "Logic" which means rational, reasonable, and accountable. The second syllable is "Thios" which means thinking. If the meanings of the two syllables are combined, they have the meaning of thinking rationally and being accountable Chu (2022).

As time progresses, the meaning of logistics has shifted. Etymologically, logistics comes from ancient Greek and consists of two syllables, namely "Logic" which means rational, reasonable, and accountable. The second syllable is "Thios" which means thinking. If the meanings of the two syllables are combined, they have the meaning of thinking rationally and being accountable (Cha, 2022). As time progresses, the meaning of logistics has shifted.

According to Egan et al (1991), "Logistics is all the materials, goods, tools and facilities needed and used by an organization to achieve its goals and various targets". The opinion above is reinforced by the opinion of Zheng & Carter (2015), who state "Logistics is anything or objects that are tangible and can be handled physically (tangible), whether used to carry out main activities or supporting activities (administration)". Meanwhile, Sobb, Turnbull & Moustafa (2020) see logistics from the business world perspective, namely "Logistics is part of the supply chain process which functions to plan, implement, control effectively, efficiently the process of procurement, management, storage of goods, services and information starting from the starting point (point of origin) to the point of consumption (point of consumption) to meet consumer needs.

2.3. Logistics Management

Melnyk et al (2022) define Logistics Management as follows: "Logistics management is part of Supply Chain Management which plans, implements and controls the flow of goods effectively and efficiently, including transportation, storage, distribution, and services as well as related information starting from the place of origin of the goods to the place of consumption to meet customer needs. Meanwhile, according to Zheng & Carter (2015), logistics management is "a series of planning, organizing and supervising activities for procurement, recording, distribution, storage, maintenance, and disposal of logistics to support effectiveness and efficiency in efforts to achieve organizational goals".

In this research, based on the expert's opinion, it can be concluded that logistics management is "goods flow activities which are divided into two, namely managerial activities and operational activities. Managerial activities of logistics include planning, organizing, and monitoring. Meanwhile, logistics operational activities include procurement, recording, storage, distribution, maintenance, and disposal of goods, both goods to be sold to consumers to meet customer needs and equipment that constitutes inventory for the company. "In logistics activities there is also information about company logistics which can make it easier for companies in their activities and also includes services to consumers directly in selling goods to consumers."

2.4. Supply Chain Management

Supply Chain Management is “the process of moving information and raw materials to a company's manufacturing and service processes. These processes include logistics processes that physically move products and warehousing and storage processes that control the location of products so they can be sent quickly” (Zheng & Carter, 2015). Meanwhile, Martin Christopher (1998), defines "Supply Chain Management (MRP) is a network of organizations involved in a business, through upstream and downstream linkages, in different processes and activities to produce value in the form of products and services into the hands of primary consumers". Furthermore, in Supply Chain Management, Christopher (1998) "highlights the importance of collaboration, transparency and

adaptability in facing modern supply chain challenges, including the integration of information technology". Meanwhile, Michael Hugos provides a basic understanding of "supply chain concepts, including the role of information technology in increasing efficiency and timeliness in logistics operations" (Hugos, 2003).

Based on the opinions of experts regarding the logistics supply chain, there is a core regarding the logistics supply chain which is very closely related to military activities in carrying out its main tasks which include logistics management processes and the use of digital technology with the hope of realizing speed and accuracy as well as transparency and accountability in the chain. logistics supplies.

2.5. Research Methods

In the realm of military logistics, the shift towards digital-based supply chain management requires a robust conceptual framework. Qualitative descriptive analysis serves as a vital methodological approach in shaping this framework by delving into nuanced aspects that quantitative methods may overlook. This method focuses on comprehensively describing and interpreting qualitative data to derive meaningful insights and inform strategic decisions.

Qualitative descriptive analysis involves a systematic exploration of textual or visual data to identify patterns, themes, and relationships. Unlike quantitative approaches that emphasize numerical measurement, qualitative methods prioritize depth and context. In the context of developing a digital-based logistics supply chain management concept, this method allows researchers to:

a. Capture Complexities: By engaging with stakeholders, including military personnel, suppliers, and technology experts, qualitative analysis captures diverse perspectives and contextual complexities. This holistic view is crucial for understanding the multifaceted challenges and opportunities in digital logistics.
b. Identify Key Themes: Through techniques such as thematic analysis, qualitative researchers identify recurring themes and patterns in data. These themes can range from operational efficiencies and technology integration to logistical resilience and cybersecurity.
c. Inform Conceptual Frameworks: Qualitative findings provide foundational insights for constructing conceptual frameworks. These frameworks outline the interconnected elements of digital logistics, such as data analytics platforms, real-time monitoring systems, and agile supply chain strategies tailored to military requirements.

Steps in Qualitative Descriptive Analysis

To effectively utilize qualitative descriptive analysis in developing a digital-based military logistics supply chain management concept, researchers typically follow these steps:

- Data Collection: Conduct interviews, focus groups, and document reviews to gather rich, qualitative data. Ensure diverse representation across military units, logistics providers, and technology vendors to capture comprehensive perspectives.
- Data Coding and Analysis: Employ coding techniques to categorize and organize qualitative data. Explore relationships between codes to uncover underlying themes and insights relevant to digital logistics management.
- Theme Development: Identify emerging themes and sub-themes through iterative analysis. Validate findings through member checking and peer debriefing to enhance credibility and reliability.
- Conceptual Integration: Integrate qualitative findings into a coherent conceptual framework for digital-based logistics supply chain management. Emphasize interoperability, scalability, and security considerations within military operational contexts.

Advantages of Qualitative Descriptive Analysis

- Rich Contextual Understanding: Provides in-depth insights into the human factors, organizational dynamics, and technological requirements influencing digital logistics.
- Flexibility and Adaptability: Allows researchers to adapt methodologies based on evolving research questions and emergent findings.
- Strategic Decision Support: Equips military planners and policymakers with evidence-based insights to optimize logistics operations, enhance resource allocation, and mitigate operational risks.

3. RESULT AND DISCUSSION

3.1. Framework Research

To increase speed and accuracy as well as transparency and accountability in the Indonesian Navy's military logistics supply chain, the Indonesian Navy needs to strengthen the role of digital-based military logistics supply chain management, especially in the era of Industrial Revolution 4.0 towards the era of society 5.0. Because in that era, military strength was not only determined by aspects of physical strength but also by the ability to manage information and technology. Strengthening the role of digital-based military logistics supply chain management is crucial for increasing speed and accuracy as well as transparency and accountability in the

Indonesian Navy's military logistics supply chain. So, to know what indicators according to the author's perception are not in line with expectations, it is necessary to carry out an analysis of the problems. which exists through research with a direct interview mechanism conducted with competent research informants library sources and other references such as articles, journals, or documentation. Based on this description, the thinking framework model in this research can be depicted schematically in the figure below:

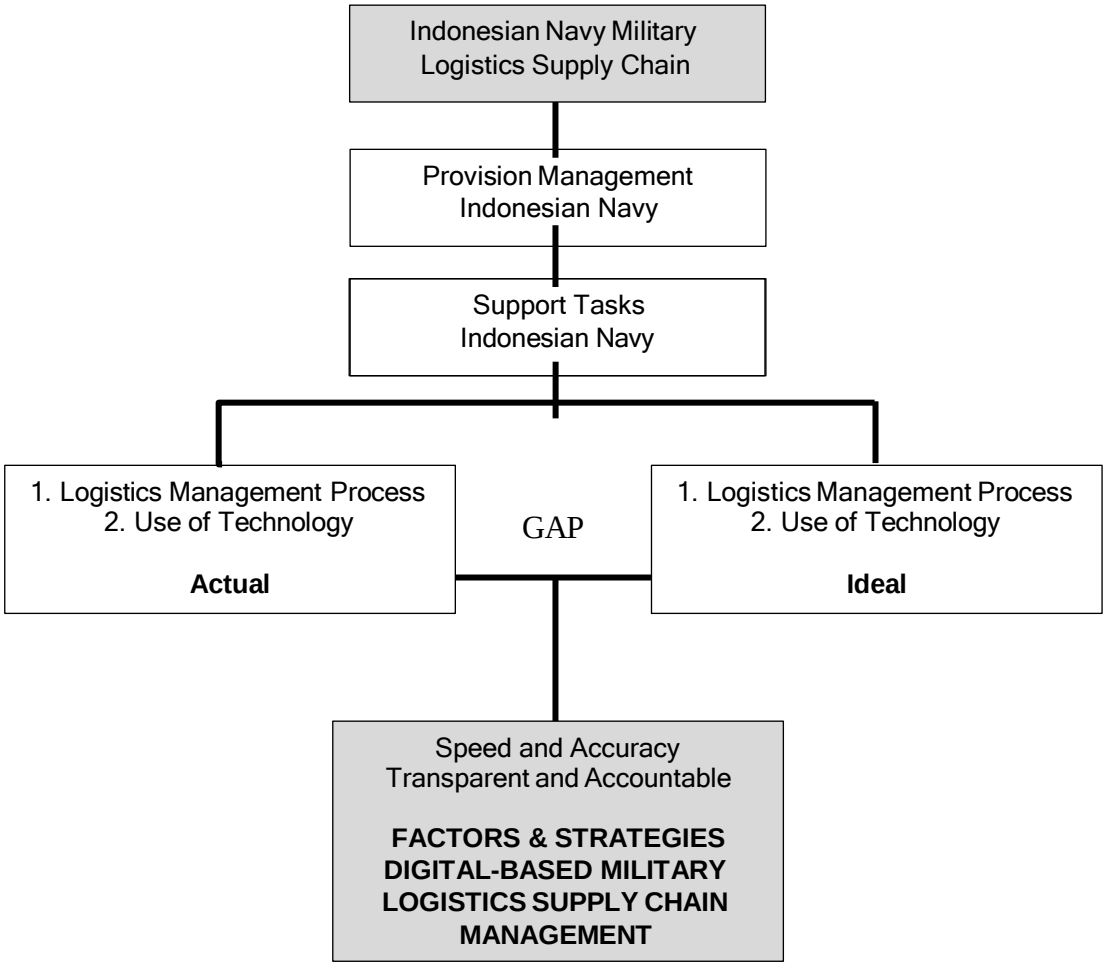

Figure 1. Research Framework

3.2. Key Components of Digital Military Logistics Supply Chain Management

Based on the results of this research, effective logistics management is crucial for ensuring operational readiness, responsiveness, and efficiency. The advent of digital technologies offers transformative potential for military logistics, enhancing precision, speed, transparency, and accountability. This article explores the implementation of digital military logistics supply chain management and the strategies that can be employed to achieve these benefits. **The Key Components of Digital Military Logistics Supply Chain Management:**

a. Integrated Information Systems
   - Enterprise Resource Planning (ERP): An ERP system integrates various logistical functions, providing real-time visibility and coordination across the supply chain. This integration facilitates seamless operations from procurement to distribution.
   - Logistics Management Systems (LMS): LMS tools help manage inventory, track orders, and monitor shipments, ensuring timely and accurate logistical operations.

b. Internet of Things (IoT)
   - Real-Time Tracking: IoT devices equipped with sensors can monitor the location and condition of equipment and supplies in real time. This capability improves the accuracy and speed of logistical responses.
   - Predictive Maintenance: Data from IoT sensors can be used to predict maintenance needs, preventing unexpected equipment failures and ensuring continuous operational readiness.

c. Big Data Analytics
    - Predictive Analysis: Leveraging big data analytics allows for the prediction of logistical needs based on historical trends and real-time data, ensuring that resources are available when needed.
    - Supply Chain Optimization: Analytics tools can identify inefficiencies within the supply chain and suggest optimizations, leading to cost savings and improved performance.
d. Blockchain Technology
    - Transaction Transparency: Blockchain provides a secure and immutable ledger for recording all logistical transactions, enhancing transparency and accountability.
    - Data Security: The decentralized nature of blockchain enhances data security, reducing the risk of data tampering and unauthorized access.
e. Human Resources Development
    - Continuous Training: Regular training programs for personnel on the use of digital tools and systems are essential. This ensures that they are proficient in utilizing new technologies effectively.
    - Competency Development: Focus on developing technical and analytical competencies among logistics personnel to handle digital systems efficiently.
f. Standardized Processes and Procedures
    - Process Standardization: Standardized procedures facilitate the integration of digital technologies and ensure consistent operational practices.
    - Security Protocols: Implementing robust security protocols to protect data and systems from cyber threats is critical in a military environment.
g. Cybersecurity Measures
    - Cybersecurity Strategies: Employing stringent cybersecurity measures, including encryption, firewalls, and intrusion detection systems, to safeguard the integrity and confidentiality of logistical data.
    - Risk Mitigation: Identifying potential risks associated with digital transformation and developing mitigation strategies to address them.
h. Mobile Technology
    - Mobile Applications: Develop mobile applications for field personnel to access logistical information, track shipments, and communicate efficiently.
    - Real-Time Communication: Utilizing mobile technology to enhance real-time communication across different levels of the military hierarchy.
i. Collaboration with Technology Providers
    - Partnerships: Collaborating with technology companies to develop tailored solutions for military logistics.
    - Research and Development: Investing in R&D to explore new technologies that can be applied to logistics management.
j. Continuous Evaluation and Improvement
    - Performance Monitoring: Regularly monitoring the performance of digital logistics systems to identify areas for improvement.
    - Feedback Mechanisms: Collecting feedback from users to understand challenges and opportunities for enhancement.

3.3. Factors Influencing the Implementation of Digital Military Logistics Supply Chain Management

Based on the results of this research, the successful implementation of digital military logistics supply chain management hinges on several critical factors. These factors collectively contribute to enhancing accuracy, speed, transparency, and accountability within the logistics framework. Here are the key factors, in Figure 2.

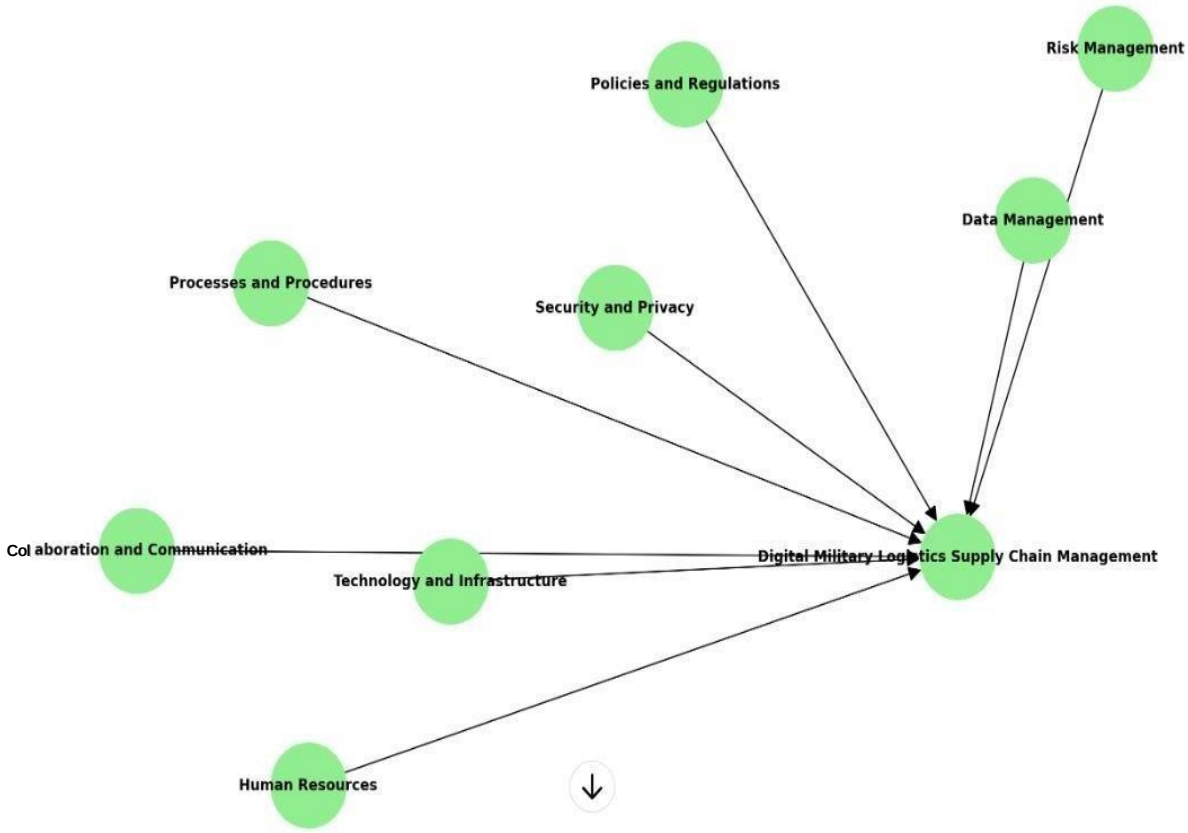

Figure 2. The Key of Factors -Digital Military Logistics Supply Chain Management
(Researcher Analysis, 2024)

a. Technology and Infrastructure
   - Integrated Information Systems: Adoption of Enterprise Resource Planning (ERP) systems that integrate various logistical functions, providing real-time visibility and coordination across the supply chain.
   - Internet of Things (IoT): Utilization of IoT devices to monitor and track equipment and supplies in real-time, ensuring precise and timely logistical operations.
   - Blockchain Technology: Implementation of blockchain for secure, transparent, and immutable transaction records, enhancing accountability and reducing the risk of data manipulation.
   - Connectivity and Network: Reliable and secure communication networks that support the seamless transfer of data and ensure constant connectivity between different logistical components.
b. Human Resources
   - Competence and Training: Continuous training programs to enhance the technical skills and competencies of logistics personnel, ensuring they are proficient in utilizing digital tools and systems.
   - Organizational Culture: Cultivating a culture that embraces innovation and the adoption of new technologies, facilitating smoother transitions and effective utilization of digital solutions.
c. Processes and Procedures
   - Standardization of Processes: Developing standardized procedures that facilitate the integration of digital technologies and ensure consistency across all logistical operations.
   - Security Procedures: Implementing robust security protocols to protect data and systems from cyber threats, ensuring the integrity and confidentiality of logistical information.
d. Security and Privacy
   - Cybersecurity Measures: Deploying comprehensive cybersecurity strategies, including encryption, firewalls, and intrusion detection systems, to safeguard against cyber threats.
   - Data Privacy: Ensuring that sensitive data is protected from unauthorized access and breaches, maintaining the confidentiality of logistical information.
e. Collaboration and Communication

- Interdepartmental Integration: Fostering effective collaboration between different departments to ensure seamless information flow and coordinated logistical efforts.
- Effective Communication: Establishing clear and efficient communication channels across all levels of the military hierarchy to facilitate quick decision-making and response times.

f. Data Management
- Data Quality: Ensuring that data used in logistical operations is accurate, up-to-date, and reliable, which is critical for effective decision-making.
- Data Analytics: Leveraging advanced data analytics to gain insights, predict logistical needs, and optimize supply chain operations.

g. Policies and Regulations
- Leadership Support: Securing commitment and support from military leadership to drive the adoption and implementation of digital logistics solutions.
- Regulatory Compliance: Ensuring that digital logistics operations comply with relevant regulations and standards, maintaining legal and operational integrity.

h. Risk Management
- Risk Identification and Mitigation: Proactively identifying potential risks associated with digital logistics and developing mitigation strategies to address them.
- Incident Response: Establishing robust incident response protocols to quickly address and resolve any disruptions in the logistics chain.

3.3. Strategies for Implementing Digital Military Logistics Supply Chain Management

Based on the results of this research, implementing a digital military logistics supply chain management system requires a strategic approach to ensure the enhancement of accuracy, speed, transparency, and accountability. Here are key strategies to achieve these goals, Figure 3.

Figure 3. Strategies for Implementing Digital Military Logistics Supply Chain Management (Researcher Analysis, 2024)

a. Adopt Integrated Information Systems
- Enterprise Resource Planning (ERP): Implement ERP systems to integrate various logistical functions, providing real-time visibility and seamless coordination from procurement to distribution.
- Logistics Management Systems (LMS): Utilize LMS for inventory management, order tracking, and shipment monitoring to ensure precise and timely logistics operations.

b. Leverage Internet of Things (IoT) Technology

- Real-Time Tracking: Deploy IoT devices with sensors to monitor the location and condition of equipment and supplies, enhancing logistical accuracy and responsiveness.
- Predictive Maintenance: Use data from IoT sensors to predict maintenance needs, preventing unexpected equipment failures and ensuring continuous operational readiness.

c. Utilize Big Data Analytics

- Predictive Analysis: Implement big data analytics to forecast logistical needs based on historical and real-time data, ensuring resources are available when needed.
- Supply Chain Optimization: Analyze data to identify inefficiencies within the supply chain and optimize processes for cost savings and improved performance.

d. Implement Blockchain Technology

- Transaction Transparency: Use blockchain to create a secure, immutable ledger for recording logistical transactions, enhancing transparency and accountability.
- Data Security: Leverage blockchain's decentralized structure to enhance data security, reducing the risk of tampering and unauthorized access.

e. Enhance Human Resource Capabilities

- Continuous Training: Conduct regular training programs to improve personnel skills in using digital tools and systems, ensuring effective utilization of new technologies.
- Competency Development: Focus on developing technical and analytical competencies among logistics personnel to handle digital systems efficiently.

f. Standardize Processes and Procedures

- Process Standardization: Develop and implement standardized procedures to facilitate the integration of digital technologies and ensure consistent operations.
- Security Protocols: Establish robust security protocols to protect data and systems from cyber threats, ensuring the integrity and confidentiality of logistical information.

g. Strengthen Cybersecurity Measures

- Cybersecurity Strategies: Implement comprehensive cybersecurity measures, including encryption, firewalls, and intrusion detection systems, to safeguard against cyber threats.
- Risk Mitigation: Identify potential risks associated with digital logistics and develop strategies to mitigate them, ensuring the resilience of logistical operations.

h. Utilize Mobile Technology

- Mobile Applications: Develop mobile apps for field personnel to access logistical information, track shipments, and communicate efficiently.
- Real-Time Communication: Use mobile technology to enhance real-time communication across different levels of the military hierarchy, facilitating quick decision-making and response times.

i. Foster Collaboration with Technology Providers

- Partnerships: Collaborate with technology companies to develop tailored solutions for military logistics.
- Research and Development (R&D): Invest in R&D to explore new technologies that can be applied to logistics management, ensuring continuous improvement and innovation.

j. Continuous Evaluation and Improvement

- Performance Monitoring: Regularly monitor the performance of digital logistics systems to identify areas for improvement and ensure they meet operational requirements.
- User Feedback: Collect feedback from system users to understand challenges and opportunities for enhancement, ensuring the system evolves to meet user needs.

4. CONCLUSION

Based on the results of this research, the following conclusions were obtained :

a. Implementing digital-based military logistics supply chain management brings many significant benefits, ranging from operational efficiency to increased security and rapid response to emergencies. By addressing existing challenges through innovative solutions and appropriate training, militaries can leverage digital technologies to improve their operational performance and readiness. Digitalization of the logistics supply chain is an important step toward a more efficient, responsive, and reliable military future.

b. The qualitative descriptive analysis method is a very effective tool for developing digital-based military logistics supply chain management concepts. With a holistic and in-depth approach, this method allows the development of systems that not only suit operational needs but can also adapt to changes and challenges in the field. Digital transformation in military logistics not only increases the efficiency and effectiveness of operations but also provides strategic advantages in supporting overall military missions and objectives.

c. Implementing digital-based military logistics supply chain management involves various interrelated factors. Technology and infrastructure, trained human resources, standardized processes, security and privacy, and effective collaboration and communication all contribute to increased accuracy, speed, transparency, and

accountability. By understanding and managing these factors, the military can maximize the benefits of digital transformation in logistics supply chain management.

d. Strategies include applying advanced technology, human resource development, process standardization, and collaboration with external parties. By adopting these strategies, digital-based military logistics supply chain management can increase accuracy, speed, transparency, and accountability, thereby strengthening operational readiness and overall military mission effectiveness.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

ACKNOWLEDGMENTS

The authors greatly acknowledge the support from the **Postgraduate Program Faculty of Social And Political Sciences Padjadjaran University Bandung** for providing the necessary resources to carry out this research work. The authors are also grateful to the anonymous reviewers and journal editorial board for their many insightful comments, which have significantly improved this article.

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A REVIEW OF COASTAL DEFENSE MANAGEMENT TO SUPPORT NATIONAL RESILIENCE

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ABSTRACT

The Surabaya Western Access Channel (SWAC) is a very congested, narrow channel but has several potentials for abundant natural resources. The problems in this Channel's areThe busy traffic of both military and civilian ships passing through this channel has resulted in damage to several ecosystems and threatens fishery cultivation. Under the channel there are also dangerous objects for navigation such as shipwrecks that have not been lifted, many pipe installations and underwater cables. The level of shipping safety in SWAC is also relatively low. Therefore it is necessary to have shipping management, shipping safety, ecological maintenance, coastal community life and defense and security governance. The purpose of this paper is to review the existing conditions of coastal defense governance that have been implemented before. The method in this article is the VOSViewer analysis which analyzes the relationship between several keywords related to coastal defense management.

KEYWORDS : Coastal defense, management, SWAC.

1. INTRODUCTION.

The Archipelagic State of The Republic of Indonesia (known as NKRI) comprises 17,504 islands and has the world's second-longest coastline, stretching 99,083 km. Because of this, ocean and coastal management focuses on the distribution of goods and people and the realization of regional connectivity. Transportation services are an important component for achieving inclusive growth, economic progress and the efficiency of the national logistics system (Malisan, et.al. 2023). These conditions make Indonesia rely on the maritime sector as a priority for its activities (Rizal, 2022). The advantage of Indonesia's geographical position invites threats such as piracy, piracy, terrorism and attacks from other countries. Therefore it is necessary to have a strong defense in the sea and coastal areas.

Management Indonesia's coastal defense is currently not optimal both in terms of infrastructure in supporting the economy and social life of the people. Maritime defense requires good management of sea and coastal areas (Sim, 2017). Integrated early detection by utilizing modern technology such as UAV and USV can provide advantages in coastal defense (Wu.et.al, 2023).

The Surabaya Western Access Channel is a very dense channel but has a narrow width and length. Erosion and sedimentation in coastal areas is very high so that it is detrimental to the economy and requires policies from stakeholders (Ballinger, 2017), (Dong, 2023). Sedimentation is affected by the very high activity of commercial ships and military vessels (Zuhri, et.al, 2019). Dense shipping traffic and ships anchored waiting for loading and unloading also result in ecological damage in coastal areas (Liu et al, 2021), (Philippe, 2023). The problems of rising sea levels and coastal erosion have a negative impact on the economy in coastal areas so that coastal defense is urgently needed (Xuan et.al. (2022), (Dong, 2023).

The current condition of SWAC governance is not optimal and can pose a threat to the sustainability of national resilience. Shipping governance policies, shipping safety, ecological systems and the welfare of coastal communities as well as defense and security systems require management planning policies that are proactive and oriented towards national development (Evans et al, 2017). This paper aims to analyze the factors that influence the management of coastal defense which creates national resilience through literature review of existing references.

2. MATERIALS/METHODOLOGY ;EXPERIMENTAL PROCEDURE.

2.1. Size of datasets

This research was carried out in SWAC Waters (figure 1) because it is one of the shipping lanes in Indonesia which is narrow, shallow, has lots of underwater cables and pipes. SWAC was chosen because it has a relatively narrow channel compared to other large ports facing the open sea. SWAC has a length of 25 Nm, a maximum width of 2200 m at the ninegan, a minimum width of 100 m at bouy 2 and 7, there are many unresolved problems that require a review of the research that has been carried out as material for making a decision.

Figure 1. SWAC Flow

2.2. Methods

This study uses a review from several trending articles and research focus on coastal management. The method used is Biometric and literature review using Vosviewer software. The link used to search for data is the ScienceDirect website. Articles were analyzed based on abstract, keywords, year and publisher. Bibiliometric studies use mathematical and statistical methods for books, articles and other information media (Jena, 2012). The purpose of this study is to analyze and study the map of the development of literature in a science. VOSViewer is software for creating, exploring and visualizing metadata network maps and then visualizing them (Van Eck NJ., Waltman L., 2002).

Article collection was searched from 2010 to 2023. Article data search techniques used the keyword coastal defense and management based on the title word category. Then the article data that meets these criteria is downloaded, then exported using the RIS format (Research Information System). After importing into the VOSViewer algorithm software (Visualization of Similarities). This is done to find out bibliometric maps and trends in scientific publications regarding coastal management in the world over the past 10 years. Furthermore, by using a literature review, the results of the VOSViewer software analysiswill describe the distribution of research topics, the number of studies and identify research gaps that need to be filled/completed around coastal management

3. RESULT AND DISCUSSION.

Research article results pesearches on the ScienceDirect Website are divided into 6 clusters as follows:

a. Cluster 1 consists of 22 topics, adaptive governance, adaptive management, agriculture, aquaculture, biodiversity, conservation, coral reefs, ecosystem services, ecosystem-based management, environmental management, eutrophication, fisheries, fisheries management, governance, management, mangroves, marine protected areas, marine spatial planning, policy, salt marshes, seagrass, stakeholders, sustainability

b. Cluster 2 consists of 16 topics, namely Beach, beach management, coastal defense, coastal dunes, coastal ecosystems, coastal erosion, coastal management, coastal protection, managed realignment, nature-based solutions, protected areas, restoration, salt marsh, sediment transport, tourism, vegetation, wetlands

c. Cluster 3 consists of 16 topics, Bioaccumulation, biomarkers, coast, coastal, coastal wetlands, estuaries, estuary, fish, heavy metals, mangroves, marine, oxidative stress, pollution, remote sensing, salinity, sediment

d. Cluster 4 consists of 16 topics, Adaptation, climate adaptation, climate change, coastal engineering, coastal hazards, coastal zone, coastal zone management, ecological engineering, flood risk management, flooding, integrated coastal zone management.

e. Cluster 5 consists of 14 topics, climate change adaptation, cost-benefit analysis, disaster risk reduction, exposure, flood, flood risk, hazard, natural hazards, resilience, risk, risk assessment, risk management, tsunami, vulnerability.

f. Cluster 6 consists of 10 topics, coastal adaptation, coastal flooding, erosion, gis, lidar, mitigation, monitoring, sea level rise, shoreline change, storm surge.

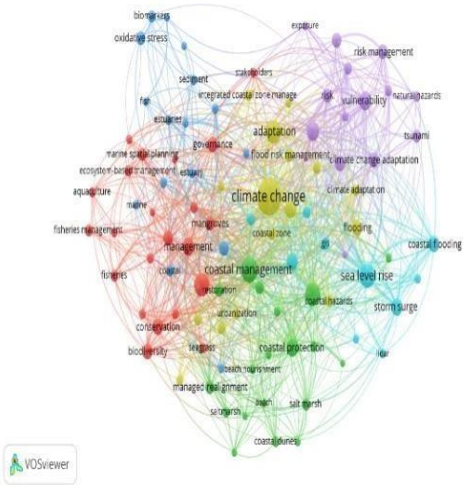

Figure 2. Network visualization of coastal defense management.

In Cluster 1 the word that stands out is ecosystem service where the article discussed is about how the government's policy on coastal defense management has damaged ecosystems. According to Cooper, et.al. 2022 entitled Coastal defenses versus coastal ecosystems: A regional appraisal Government policies in defending the coast for the benefit of humanity have resulted in the destruction of ecosystems on the Irish coast. The method used is using a GIS application with a scale of 1: 10,000 to map ecosystem damage due to coastal defense development. Build sea walls to prevent beach erosion, Groyn to trap beach sand, Sloping stone walls to hold waves against the beach.

According to Jacob et.al. 2021 with the title "Not just an engineering problem: The role of knowledge and understanding of ecosystem services for adaptive management of coastal erosion". In the article it is explained that ecosystems in coastal areas provide important services for humans such as increasing fish productivity, carbon storage and reducing sea wave energy and protecting land from climate change, coastal erosion and sea level rise. The method of analysis is using the Ecosystem Service application which evaluates stakeholder policies from a management perspective that can adapt to the socio-cultural and ecological dimensions of Quebec waters. The research samples were ecosystem areas around Quebec waters, namely beaches, eelgrass, tidal marshes (tidal swamps).The pattern of adaptive management government has a positive impact on the socio-ecological system in Quebec waters

In cluster 2 the dominant keywords are coastal erosion and coastal protection where many articles discuss how the management of coastal defense is focused on preventing erosion due to seawater and protecting coastal areas. According to Peter Bacopoulos,Ralph R. Clark (2021)with an article entitled Coastal erosion and structural damage due to four consecutive-year major hurricanes: Beach projects afford resilience and coastal protection. This research examines the analysis of coastal erosion and the impact of structural damage for 4 consecutive years on the Florida Coast. The research method is to use quantitative analysis of wind stress temporal assessment to identify the level of resilience and protection of the coast from various methods of coastal construction and coastal management programs in the face of

the impact of large storms. The results demonstrated a coherent relationship between observed peak storm tides and surveyed measures of coastal erosion and structural damage. From a socio-economic standpoint, Beach management projects by placing sand dunes are able to provide protection and become an embankment from mitigating damage to beach property and infrastructure. Other benefits are that it can be used as a tourism destination, protection of coastal populations and weak infrastructure, and being able to protect coastal erosion and damage caused by tropical cyclone storms.

The next article was written by Tussadiah, et.al (2021) with the title: Assessment of coastal ecosystem services and its conditions for policy management plans in East Nusa Tenggara, Indonesia. This research discusses the ecosystem service management framework and natural potential in the coastal areas of NTT. The research objective is to analyze the application of the InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) model in assessing the spatial distribution of ecosystem services for coastal protection and tourism in all coastal districts in the province of NTT. The results of research on the coastal areas of West Manggarai and West Sumba have high ecosystem services but low coastal protection and tourism services. NTT coastal management requires stakeholder policies that consider ecological aspects,

In cluster 3 the dominant keyword is remote sensing which relates to coastal and ecosystem management issues in coastal areas. Article written by Wu, et.al. (2022) entitled Increasing fragmentation and squeezing of coastal wetlands: Status, drivers, and sustainable protection from the perspective of remote sensing is relevant research. This study examines the wetlands in the coastal region of Fujian which have great ecological and economic value but are currently experiencing degradation and major losses due to human activities. The research method is to use an algorithm based on periodic tides and time series indices to map the status and trends of events on the Fujian coast from 1994 to 2018. The results of the research show that the wetlands consisting of tidal land and swamps have suffered a lot of damage due to reclamation, dredged and converted into inland areas for cultivation, ports and settlements. This damage causes the defense of sustainable coastal areas to be weak but has a positive impact on economic development.

Next is an article written by Ahmed, et.al. (2018) entitledWhere is the coast? Monitoring coastal land dynamics in Bangladesh: An integrated management approach using GIS and remote sensing techniques. The focus of this research is to examine the level of erosion in the coastal areas of Bangladesh. The research method uses the use of GIS and remote sensing techniques to map erosion that occurred from 1985 to 2015. The results show that the erosion rate in the western and eastern zones is very severe. The recommendation put forward is that stakeholders must carry out policies related to rehabilitation and resettlement in the management of the western and eastern coastal zones of Bangladesh.

In Cluster 4 the dominant keywords are Climate change where articles discuss how climate change can impact sea level rise, flooding, management of coastal areas and so on. An article written by Techera (2023) entitled The intersection of marine and coastal conservation and nature-based solutions to climate change: Governance insights from Indian Ocean small island States also discusses coastal environmental problems caused by climate change, global warming and damage to natural resources. living nature. The research method used is the analysis of exploration assessment of natural-based solutions (NbS) and measurements from Nationally Determined Contribution Documents (NDCs) on the basis of the Paris Agreement.

The next article is Robert, et.al (2023), entitled*Erritorial inertia versus adaptation to climate change. When local authorities discuss coastal management in a French Mediterranean region.*In this study discusses critical issues caused by climate change such as erosion, rising sea levels and tidal flooding from the sea in the French Alpes region. This area is a well-known tourism sector so that it is one of the economic supports in the Alpes Province. The research method is qualitative by interviewing stakeholders who deal with adaptation of the Alpes coast to climate change. Stakeholder research results seek to adapt to the impacts of climate change and highlight the attractiveness of tourism as the foundation of the economy. The problems of erosion, rising sea levels and flooding are the focus of the government to maintain tourism in the area as a support for the economy.

In Cluster 5 the dominant keyword is resilience where the article discussed is how the resilience of coastal areas to climate change, rising sea levels, risks and stakeholders. Article writtenBianco and Salvador. (2021) entitled Coastal resilience potential as an indicator of social and morphological

vulnerability to beach management focusing on coastal resilience in San Vincenso, Italy. This research discusses how coastal resilience strategies from the aspects of morphology, economic trends, sediment and erosion affect human life in coastal areas. The research method used is quantitative research based on ISMV (Social and Morphological Vulnerability Index), ISC (Index of Service's Cost) and CRI (Coastal Regeneration Index). The results of the study show that the ISMV approach is quite successful in determining government policies in increasing coastal ecosystem conservation. From ISC analysis, the strategy implemented by the government is not effective in supporting coastal resilience.

The next relevant article on Cluster 5 isArkhurst, et.al (2022) entitled "Perception on coastal erosion: An assessment of how national level resilience strategies promote indigenous knowledge and affect local level adaptation in Ghanaian communities". This research discusses coastal resilience strategies in managing the impact of earthquakes and climate change pressures that disrupt coastal areas globally. The research method uses qualitative by conducting interviews and FGDs with fishermen, residents and the government about 51 coastal areas affected by erosion in Ghana. The results of the research require innovation in an integrated coastal resilience strategy between people who depend on the sea and the government in developing coastal management strategies that can adapt to climate change and social life.

Whereas in Cluster 6 the dominant keyword is sea level rise where the article discussed is sea level rise on the resilience of coastal areas.The relevant article is research conducted by Rocha, et.al (2023) entitled*Coastal indices to assess sea-level rise impacts - A brief review of the last decade*. In this study discusses the vulnerability of coastal areas caused by rising sea levels. The method used is qualitative by studying 37 relevant studies of the concepts, methods, parameters and indices used by considering the time and space scale for coastal operations. The results of the study found that most of the research used the help of the CVI index but only discussed the economy and did not discuss the impact of economic activity on the coast. Rocha further said that there is no proper method for assessing risk factors in the management of coastal areas and their threats to the social life of the people living in the area.

4. CONCLUSION.

Based on the bibliometric analysis, the dominant themes discussed in each cluster are ecosystem services, sea level rise, climate change and costal management. These four keywords have a close relationship with the management of coastal defense. To get optimal management of coastal defense requires synergy between stakeholders who have authority over these four aspects and contribute to integrated and sustainable maritime national development. From the ecosystem service aspect, active participation from the government, ecosystem users and the socio-cultural environment around the area is needed. Because the maintenance of ecosystems in coastal areas will be able to provide great benefits from an economic point of view, so that it requires professional management and involves all stakeholders. From the aspect of sea level rise and climate change is to provide awareness of the possibility of a disaster that can harm national security. With good marine spatial planning, Indonesia will become a World Maritime Axis. From the aspect of coastal management, it requires a management system consisting of planning, utilization, supervision and control of coastal resources in a sustainable manner which integrates the government, maritime business, fishing communities and stakeholders related to the maritime sector. However, from all the research and aspects discussed, only a few discuss the role of defense and security in the management of coastal defense. The defense and security aspects must also be integrated with other indicators such as ecological, economic, socio-cultural,

The coastal defense management policy model based on the literature review is that it must involve government intervention in shipping management, shipping safety management, ecological system governance and community social life as well as defense and security system governance in the framework of supporting national resilience.

ACKNOWLEDGEMENT

The author would like to thank the Postgraduate Directorate of Brawijaya University, especially the National Defense Doctoral Study Program, which has provided access to the ScienceDirect website so that you can get up-to-date articles on the theme of coastal defense management.

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Indonesian Naval Technology College
Postgraduate International Conference, Vol. 8, No. 1, pp.225-233
June, 27th 2024

"ONLINE GAMBLING: WHAT IS IT AND HOW TO DEAL WITH IT?"

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ABSTRACT

Indonesia has been declared an emergency to deal with online gambling, many people are caught in online gambling, from children to adults, so the government has formed a special Task Force for Online Gambling since 2023 to eradicate the problem of online gambling in Indonesia. Online gambling addiction behavior does not recognize race, age, gender and occupation, including state officials, one of whom is an Indonesian Navy soldier. There has been an increase in violations committed by Indonesian Navy soldiers regarding online gambling issues in recent years. The negative impacts resulting from online gambling addiction include causing the risk of suicide, worsening financial conditions for oneself and one's family, triggering criminal acts and endangering others, destroying relationships with family and other parties, and being trapped in a vicious circle with online loans. This article discusses the history of gambling in Indonesia, the meaning of online gambling, types of online gambling, explanations from a psychological perspective, influencing factors and how to prevent online gambling addiction. Therefore, online gambling addiction needs to be discussed from a psychological perspective because it is a behavioral disorder that causes many problems and must be eradicated immediately.
Keywords: Indonesian Navy, Online Gambling

1 INTRODUCTION

In the last few months, we have heard that several Indonesian Navy Soldiers were caught in the problem of online gambling addiction which resulted in suicidal behavior when they were unable to pay their debts which reached hundreds of millions of rupiah and ended other people's lives to get money to use for playing online gambling. Of course, this problem is an alarm that must be immediately alerted and followed up by the Indonesian Navy because if prevention efforts are not made early on, it will affect the implementation of the main tasks of the Indonesian Navy. One important element in an organization is the human resources factor. Human resources are an important asset for an organization. If the organization's personnel commit many violations or are involved in problems, this will certainly affect the achievement of the organization's goals and the organization will not run well because it is busy resolving personnel problems.

Actually, gambling is not something new in Indonesia. Gambling has been part of Indonesian society since the early days of independence. Even though it was independent, it was recorded that from 1945 to 1960 Indonesia still did not have stability in the economic sector. As a solution to this problem, the government then launched a program called the Hope Fund Lottery under the auspices of the Social Rehabilitation Foundation, which is currently known as the Ministry of Social Affairs. Initially, the Hope Fund Lottery was a form of legitimizing gambling which was legalized by the government with the initial aim of raising the economic wheels in Indonesia and financing social problems (Zulfia et al., 2023)

In its development, this program continues to change names, such as SDSB (Social Generous Donations with Prizes) and continues to revise its regulations. Even though it was legalized by the government and regulated

in special regulations and had various positive influences on society, the government then realized that this legal gambling had more negative influences on the nation's morals. In the end, gambling in Indonesia reached a final decision which stated that all forms of gambling in Indonesia were considered illegal. This is then regulated in Law of the Republic of Indonesia no. 7 of 1974 concerning the Control of Gambling which is stated in Article 1 which reads "Declares all criminal acts of gambling as crimes" and explains the punishments determined for people who violate these regulations.

Since the law was passed, gambling has officially become absolutely illegal regardless of the form of the game. The government and competent authorities continue to strive to eradicate gambling by taking firm action against perpetrators and bookies. Even so, the practice of gambling continues to persist in society. Gambling remains the choice of some groups as entertainment to fill their free time. This behavior has even become embedded in some groups of society and has become part of their daily lives.

When the Covid-19 pandemic hit Indonesia, all humans adapted to a situation that required people to follow the government's recommendation not to do activities outside the home. In this situation, people then change all their activities online, from work, school, shopping, to entertainment. At that time, criminal activities such as gambling practices also contributed to the busy digital activity in Indonesia. Many bookies then developed and promoted gambling with a system similar to online games (Supratama, et al. 2022).

Online gambling then became widespread in society because it could be done more easily and practically. This is because most people need activities to fill their free time during the pandemic which requires them to stay at home. With just an internet quota and a smartphone, they can access sites that provide online gambling. Not only adults, children and teenagers can also access online gambling and play it as entertainment because online gambling games are designed to be attractive like online games in general (Sahputra et al., 2022). Not only in terms of how to use it, how to make transactions or deposit money into a gambling account as a bet is also very easy. Online gambling sites provide various payment methods, including credit transfers, transfers via digital accounts, or via e-wallet.

Even though there have been changes in the usage system, the perception of online gambling has not changed compared to conventional gambling. Online gambling continues to have many negative impacts on various aspects of life. The victory felt by online gambling players makes themthen obsessed with repeating or what is usually called preoccupation. Even though the victory presented was small in scale compared to the defeat experienced afterwards.

A report from Databoks (2023) shows that online gambling transaction activity in the country has continued to increase over the five years from 2017 to 2022. According to data from the Financial Transaction Reports and Analysis Center (PPATK), during the 2017-2022 period there were 157 million gambling transactions. online in Indonesia. The total circulation of money reaches up to 190 trillion.

The circulation of funds is the flow of funds for betting purposes, payment of winnings, costs of organizing gambling, transfers between bookie networks, as well as transactions suspected of money laundering by bookie networks. The data obtained is the result of searches and analysis of 887 parties included in the online bookie network.

Based on the latest data from the National Police Public Relations Division, there has been a significant decline in online gambling cases in Indonesia, recorded at 792 cases in 2024. In the previous year, online gambling cases were recorded at 1,196 cases in 2023. The Financial Transaction Reports and Analysis Center (PPATK) said there were 3.2 million Indonesians play online gambling with turnover reaching IDR 327 trillion in

2023. The majority of online gambling users are those with low incomes with profiles as students, students, workers, farmers, housewives.

The data above shows that quantitatively there is a decrease in the number of online gambling cases, however problems continue to emerge and are still worrying because many people are involved as online gamblers and have not been able to overcome them completely. Therefore, in this article we will review the meaning of online gambling, including its types, the factors that cause it and its impact, and how to prevent it (preventive measures) and how to overcome online gambling addiction from a psychological perspective.

2 PROBLEM FORMULATION

1) What is the meaning of online gambling?
2) What are the types of online gambling?
3) What are the factors that cause online gambling?
4) What are the impacts of playing online gambling?
5) How to prevent gambling behavior *on line*?
6) How to deal with online gambling?

3 RESULTS AND DISCUSSION

3.1 RESULTS

a. Definition of Online Gambling

According to Adli (2015) online gambling is a gambling game that uses the internet as a betting medium, where in the game the gambler makes an agreement on the terms of the game and what the bet will be. According to Kartono (2011), gambling is risking a value or something that is considered valuable by realizing certain risks and expectations in games, matches, competitions and events that cannot yet be determined. In Article 303 paragraph (3) of the Criminal Code, it is explained that "what is called a gambling game is any game, where in general the possibility of making a profit depends on "luck" or unpredictable luck, also because the player is trained and skilled.

From the definition above, it can be concluded that gambling is a game that uses money or valuables as bets. These bets can take the form of playing dice, cards, or scores). Online gambling is the practice of betting or gambling actions carried out by individuals online via the internet or web to applications that provide gambling content. Online gambling can take the form of gambling games such as slot machines, poker, Dominoes, Casino, Football, Capsa, and so on.

b. Forms of Online Gambling

The forms of online gambling mentioned by Ardiansyah, Sudarmanto, et al., (2023), include:

1) Gambling, namely gambling games in the form of online gambling such as online betting, online casino, online football, online poker and online lottery.

2) Sociable games, gambling where everyone who plays will win or lose together. For example, baccarat, pai gow poker, blackjack, craps.

3) Analytical Games, gambling that requires research and accurate information as well as analyzing various events. For example, horse racing and sports betting.

4) Patience Games, where patience gambling games are played in a relaxed manner without rushing to get results. Players are required to wait patiently for their numbers to come out. For example, lottery, keno, and bingo.

c. Causative factor

There are factors that cause someone to do gambing online, according to .Asriadi (2021) and Pratama (2022) describe and divide these factors into two types, namely:

a. Internal factors

1) Personality

A strong desire for online gambling games triggers individuals to be able to gamble. This is obtained because individuals feel obsessed and curious about gambling so there is a desire to try. Habits carried by individuals from childhood can also trigger the desire to play online gambling into adulthood.

2) Learning factors

The learning factor is considered reasonable because it has a big effect on gambling behavior, especially the desire to continue gambling. What has been learned and obtained produces something enjoyable for the individual so that it will continue to be stored and can be repeated at a later time.

3) Low human resources

Someone who enjoys gambling will have lazy, careless behavior, speculate easily and be quick to take risks without thinking twice.

4) Customs

Gambling behavior is considered to be a habitual behavior because it is considered a habit that has been carried out for a long time so it is believed to be a normal thing to do.

b. External Factors

1) Friends of the same age

Peer factors can also influence individuals playing online gambling. This behavior can arise if peers who are also "players" have encouraged and taught how to gamble. Thus, individuals will be more easily influenced by a friendship environment that has a negative impact on them and will imitate bad actions in their lives.

2) Family economy

Someone with a lower middle class economy tends to more easily fall into gambling to meet their daily needs. They think that by gambling someone can improve their economy quickly.

3) Community disobedience to the law

People have become addicted to gambling games so that their activities take place freely. Weak enforcement of gambling laws and lack of socialization of gambling regulations means that people are increasingly free to gamble.

d. Impact

All forms of gambling, including online gambling, certainly have their own impacts on the parties involved. These impacts can be classified into several aspects such as economic aspects, social aspects and psychological aspects. The impacts caused by online gambling games:

a. Economic Impact

To carry out online gambling, an individual must of course have money as capital costs for deposits and the main requirement is to be able to play the game. However, someone who plays online gambling more often experiences running out of capital rather than winning. Someone who is addicted to online gambling, then he will try to make money even by using any means including carrying out criminal activities such as fraud, money laundering, illegal gambling) which may occur due to debt, confusion about finding money, so he commits acts of robbery (Adli, 2015). Apart from that, the impact of playing online gambling can also cause unstable finances and possibly change in personality.

b. Social Impact

Indirectly, online gambling also affects the condition of the people around the online gambler himself.

1) Impulsivity and poor decision making

Limited thinking due to being crushed by debt. Individuals find it difficult to think and tend to rush when they see money.

2) Feelings of shame and guilt

Occurs because the individual feels he has neglected his family and spends his time gambling.

c. Psychological Impact

1) Addicted

A condition where individuals are encouraged to continue gambling despite experiencing negative consequences.

2) Anxiety and depression

Occurs because debts accumulate and worse, suicidal thoughts can arise. The suicide rate since 2023 has recorded 14 cases of attempted suicide due to online gambling. In 2023, 10 cases were recorded and 4 cases occurred between January - April 2024. Most of the victims were aged 19 to 30 years. This provides an illustration of the impact of online gambling (Vishnu, 2024).

3) Emotional problems

Online gambling also indirectly affects a person's emotional attitude. Constant defeat. Santoso (2019) in a journal on Domestic Violence (KDRT) against women from a social work perspective revealed that one of the impacts caused by online gambling is the emergence of an unstable emotional attitude. Furthermore, if left unchecked, this emotional attitude can even increase the potential for domestic violence.

2.2 GAMBLING MODELS ON LINE

The model that discusses the gambling decision-making model is from Clark, et al., (2013) explaining how someone decides to engage in gambling behavior. According to Clark, et al. (2013) when someone plays gambling for the first time, there is a feeling of excitement, curiosity and finally trying for the first time, a neuro-chemical process occurs in the brain. The brain releases "happy" hormones, namely dopamine and serotonin. Dopamine and serotonin play a role in a person's thinking function, when the individual feels "happy" and pleasant feelings arise

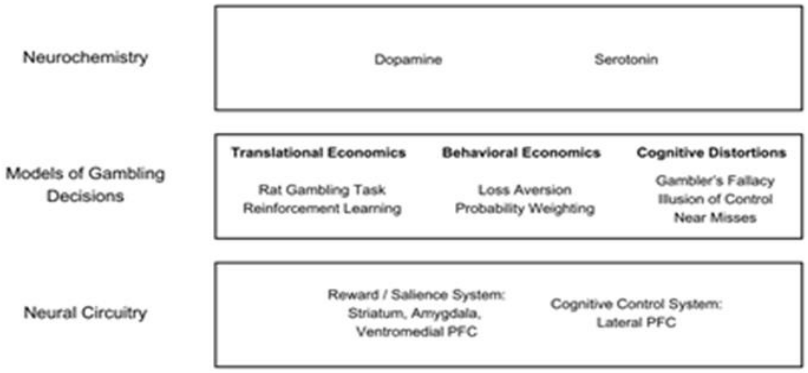

Fig. 1. Model of Gambling Decision dari Clark, et al. (2013

then behavior that creates feelings of "happy and enjoyable" will tend to be repeated. Serotonin plays a role in increasing impulsive behavior which results in Obsessive Compulsive Disorder (OCD). Gambling behavior will continue to be carried out repeatedly when the individual receives positive reinforcement, such as winning the lottery or getting a jackpot, or conversely, receives negative reinforcement, such as almost winning or when the individual actually experiences defeat. Gamblers experience errors in thinking when making gambling decisions, due to excessive production of neurotransmitters, namely dopamine and serotonin, which damages the function of the amygdala, which plays a role in controlling a person's emotions. The relationship between the amygdala and these brain structures links cognitive functions (thinking, learning, and remembering) to the physiological functions of the body. If there is a resistance response to overcome fear/anxiety, the amygdala will signal the hypothalamus to release the hormones cortisol and adrenaline. Apart from that, thinking becomes irrational and feels confident that the decisions taken will provide a great opportunity from failures in previous games. When they become addicted to gambling, individuals experience a loss of control over their behavior. Gamblers experience errors in the decision-making process and are more tolerant of losing. Basically, people are afraid of losses, but gamblers don't think too deeply about losing because it is considered a pure transaction. They feel like they almost won instead of experiencing defeat. Gamblers hate losing more than enjoying winning. Therefore, the aversion to losing influences the way he bets. The implication of loss aversion is one of the most important drivers in gamblers' decision making. In addition, gamblers experience the gambler's fallacy, namely a logical error or fallacy in which a person believes that the results of random events in the past influence the results of random events in the future, even though each of these events is actually independent. In the context of gambling, the gambler's fallacy can cause gamblers to continue betting in the belief that “their luck will change” or that it is “time for them to win” after a series of losses. This often leads to greater financial losses (Clark, et al., 2013).

2.3 MODELS OF ORGANIZATIONAL STIMULUS RESPONSE (SOR MODEL)

Model *Stimulus Organism Response*(McQuail, 2010) explains that humans as organisms receive stimuli and respond according to the stimuli received by the individual. This model explains the mechanism of influence of an individual's internal conditions and influences the behavior of the individual concerned. Stimulus means input that enters the five human senses such as smell, taste, sight, hearing, touch. Stimulus has three elements, namely ambient, design and social, when related to online gambling, it is a stimulus that includes these three elements.

*Ambient*is the comfortable atmosphere felt by gamblers when playing online gambling. Design is the physical design of an online gambling site which includes layout and function, signs and symbols, beauty such as color and game visualization and other elements. Related to social factors are factors related to the existence of gambling players and opponents in online gambling games. Social factors will have an impact on the quality of online gambling games. This model also describes the individual before displaying a response through a cognitive process, namely the gambler's judgment (perception) based on mental processes and knowledge structures as a person's response to the environment. Apart from perception, it also involves evaluation of an affective nature, namely based on feelings of pleasure as a gambler's motive. Feelings (affection aspect) select the quality of the game environment in terms of the enjoyment felt, the feeling of interest due to eye contact and the feeling of relief when playing gambling. Individuals become accustomed or experience habituation to playing online gambling games. The emergence of behavior will be stronger if given positive reinforcement or negative reinforcement. Addictive behavior towards online gambling is a response to stimuli originating from outside the individual, thus forming addictive behavior.

Based on the explanation above, it can be concluded that online gambling addiction behavior has a basic learning pattern in humans, namely stimulus and response and gets reinforcement from the response displayed.

3. DISCUSSION

Online gambling addiction behavior is included in obsessive compulsive behavior disorder, namely behavior that occurs intensely and repeatedly to reduce anxiety in the mind. The impulsive and obsessive behavior of online gamblers means they cannot let go easily when an intense habit has been formed. Of course, this behavior needs to be achievedspecial attention and must be prevented from an early age, because if TNI AL personnel are involved in online gambling they will show ineffective behavior when working. He just focuses and spends most of his time playing online gambling. Apart from that, what is most dangerous is when the individual has access or authority to misuse the agency's budget. When they experience an addiction to online gambling, all they think about is playing and how to get money, so it is not uncommon for any means to justify themselves.

Gambling behavior*on line*This is a behavior that is included in addictive behavior and is quite difficult to intervene. Therefore, preventive efforts need to be made to the wider community, because if viewed from a sociological perspective, giving prison sentences cannot be considered as the only way to solve the problem (Susanti, 2021). Efforts to prevent online gambling can be done in various ways. Efforts that can be made include preventive, pre-emptive and repressive methods. Preventive methods are efforts made by carrying out control and supervision measures, environmental development to reduce and suppress crime so that it does not spread further in society. Usually in this method, the authorities will patrol areas prone to gambling and provide legal education with other institutions.

Preventive methods are methods that eliminate elements of potential disturbance and focus on the root causes of crime using social, situational and community approaches. This method is more psychological in nature and has the aim of persuading or inviting people to comply with applicable norms. The next method is repressive, where this method is carried out by blocking and preventing gamblers from gambling again. Generally, the authorities will carry out raids on gambling places and arrest the perpetrators.Efforts that can be taken to prevent online gambling addiction :

1) Do not open and access online gambling advertisements.
2) Avoid joining communities that engage in gambling.
3) Avoid crowded places that can invite the desire to gamble online.
4) Spend more time with your family.
5) Stay away from bad company.
6) Do positive activities and hobbies

4. CONSCLUSIONS AND RECOMMENDATIONS

Based on all the explanations above, it can be concluded that gambling behavior*on line*is an addictive behavior that can be categorized as gambling disorder in DSM 5 (Petry, et al., 2013). including obsessive compulsive behavioral disorder (Ardiansyah, 2023). This addictive behavior towards online gambling is clearly dangerous not only for individuals but also their families. The war against online gambling should not only be carried out alone but together, in this case, especially the Indonesian Navy, also taking preventive measures as an effort to prevent the increasing number of violations due to online gambling. All unit commanders carry out outreach about the dangers of online gambling and carry out close supervision regarding the use of smartphones and other gadgets, especially for personnel who have access to finances. Apart from that, the Indonesian Navy also needs to immediately form a task force to handle online gambling consisting of health, legal, psychological, military, security and law enforcement personnel from the Indonesian Navy and carry out rehabilitation for online gambling perpetrators with the aim of overcoming the problems caused by online gambling perpetrators.

The task force for handling online gambling within the Indonesian Navy is an effort to prevent and eradicate the practice of online gambling within the Indonesian Navy and basically the handling of online gambling problems is not only carried out by sector but requires synergy from various fields which declare a joint war against online gambling. Steps for handling Indonesian Navy personnel who are caught in online gambling need to be considered immediately because the facilities and infrastructure for rehabilitation of online gambling perpetrators which aim to modify behavior and create an intention or commitment to change do not yet exist until now, the treatment carried out is more focused on handling the problem. law.

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