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ICMST 2023

INDONESIA NAVAL TECHNOLOGY COLLEGE

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The 7th ICMST - STTAL

FIELD :

1. Operation Research
2. Logistic Management
3. Policy and Strategy

SURABAYA MAY 17th , 2023

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POSTGRADUATE INTERNATIONAL CONFERENCE

"The 7th International Conference on Maritime Science and Technology"

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PREFACE

Dear Authors,

Congratulations on the acceptance of your paper, and thank you for your interest in the Postgraduate International Conference organized by Indonesian Naval Technology College STTAL in 2023.

On behalf of the Conference Committee, we cordially invite you to attend the STTAL Postgraduate International Conference on Maritime Science and Technology (ICMST) 2023, scheduled for Wednesday, May 17th, 2023.

This international conference aims to provide a platform for academics, scholars, researchers, and practitioners to present and disseminate their latest innovative ideas, research results, and findings on various aspects of Maritime and Management Science. Presenters will have the opportunity to include their submissions in the online conference proceedings.

The conference will be attended by educators, students, academic managers, quality assurance and education system leaders, as well as researchers. We encourage as many attendees as possible to join us. We eagerly anticipate meeting you on Wednesday, May 17th, 2023.

Best regards,

Surabaya, May 17th, 2023
Chairman of Committee,

Dr. Sutrisno, S.T., M.T.
Captain Navy


THE 7th INTERNATIONAL CONFERENCE ON MARITIME SCIENCE AND TECHNOLOGY
2023
ARTIFICIAL INTELLIGENCE UTILIZATION AND INDONESIA SEA POWER TO SUPPORT NATIONAL DEFENSE
KEYNOTE SPEAKER
Commodore
Dr. Muchlis, S.T., M.M., CHRMP., CACA., CRMP.
(Naval College of Technology Commander)
SPEAKER
Nick Bonser
Simulation & Autonomous Maritime Instructor
SPEAKER
Air First Marshall
Dr. Ir. Arwin Datumaya Wahyudi Sumari, S.T., M.T.,IPU,ASEAN Eng.,ACPE
Chief of ITD

SCHEDULE

International Conference on Maritime Science and Technology
ICMST 2023

Held in STTAL Surabaya, Bumimoro-Morokrembangan, On Wednesday,

May 17th 2023

WEBSITE : http://www.seminarpasca-sttal.ac.id/

08.00 - 08.10	Opening Remarks
08.10 - 08.12	National Anthem “Indonesia Raya”
08.12 - 08.15	Opening Prayer
08.15 - 08.30	Executive Remarks by Post-graduate Director
08.30 - 08.45	Keynote Speaker by Commander of STTAL
08.45 - 11.30	**International Conference** / **Seminary**
	Speaker I Nick Bonser
	Speaker II Dr. Arwin Datumaya Wahyudi Sumari, S.T., M.T., IPU, ASEAN Eng., ACPE.
11.30 - 12.00	Break
12.30 - 16.00	**Per-Room Seminary,** Presentation by Lecturers & students who send papers include: **Operation Research Field** **Logistics Management Field** **Policy And Strategy Field**
17.00 – 17.15	Symbolic Delivery of Certificates and Closing

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FIELD III: POLICY AND STRATEGY

SPEAKER 1

ARTIFICIAL INTELLIGENCE FOR AUTONOMOUS NAVIGATION

Nick Boncer

Instructor for AMC at the Australian Maritime College

Nick Bonsor is a simulation and autonomous Martin instructor for AMC Search at the Australian Maritime College. As part of my role, I am involved in bringing maritime autonomous systems into simulators to better understand their capabilities and build trust in their use. Today, I would like to explore the history of maritime autonomy and highlight the role of artificial intelligence (AI) in shaping the future of navigation and maritime autonomy.

Maritime autonomy is not a new concept, having been in existence for over a century. It began with the commercial use of autopilot systems in the 1920s, enabling vessels to maintain a steady course without constant manual steering. Radar systems, initially used by the military during the war, became commercially available with the development of automated radar plotting aids (ARPA) in the 1970s. The focus then shifted to positioning systems, with the advent of hyperbolic navigation systems like DACA and ORANSI in the mid-20th century, followed by the introduction of the United States Global Positioning System (GPS) in the late 1990s.

Over the past two decades, advancements in maritime autonomy have accelerated, setting the stage for the integration of AI and digital communication systems. The development of the S-100 dataset, a series of standards for data input into autonomous systems, is a crucial milestone. By 2025, this dataset will revolutionize maritime operations by enabling real-time data display on autonomous systems, such as accurate tidal information, weather updates, and navigational warnings. The integration of AI into navigation decision support systems and collision avoidance software will further enhance vessel safety and efficiency.

The Role of Artificial Intelligence in Navigation holds great potential for assisting in navigation and further developing maritime autonomy. One of the key areas where AI can make a significant impact is collision avoidance. Navigation decision support systems, driven by AI algorithms, analyze incoming data to determine the safest actions to take in various situations. These systems can suggest alterations to course, speed,

and other navigational decisions in accordance with international regulations such as the COLREGS (Convention on the International Regulations for Preventing Collisions at Sea).

AI-powered navigation systems can go beyond analysis and recommendation by sending suggested actions directly to the autopilot, enabling autonomous vessels to navigate and respond to potential collisions. This integration of AI with the autopilot system enhances vessel safety and reduces the workload on human operators.

Another area where AI proves invaluable is voyage planning. Like using a GPS navigation system in a car, voyage planning software, enhanced with AI, considers multiple variables such as weather forecasts, real-time current predictions, and route optimization to chart the most efficient course for a vessel. This technology streamlines the planning process for navigators, ensuring safer and more efficient journeys.

Furthermore, AI has significant applications in military contexts, including tactical navigation systems, intelligent battle information systems, and alternative futures planning systems. These AI-driven tools support mission planning and analysis by monitoring real-time events against mission objectives, providing valuable insights for strategic decision-making.

The Future of Maritime Autonomy, looking ahead to the end of the decade, we can envision a shipping industry transformed by advanced maritime autonomy. By 2030, it is conceivable that unmanned container ships will voyage across the seas with optimized routes determined by AI-powered voyage planning systems. Such vessels will integrate with underwater reef pilots and remote pilots, ensuring safe passage through critical areas like the Torres Strait and the Great Barrier Reef. Automated suction docking systems will facilitate smooth berthing operations, and shoreside monitoring centres will oversee vessel navigation during watch shifts, minimizing human fatigue.

SPEAKER 2

ARTIFICIAL INTELLIGENCE DEVELOPMENT FOR NATIONAL DEFENSE

Arwin Datumaya Wahyudi Sumari

Special Staff to Chief of Staff of the Indonesian Air Force
Rector, Adisutjipto Institute of Aerospace Technology
Adjunct Professor, Department of Electrical Engineering, POLINEMA
Head, Cognitive Artificial Intelligence Research Group (CAIRG)
Co-Founder and Board of Supervisors, Indonesia Artificial Intelligence Society (IAIS)

The development of Artificial Intelligence (AI) for national defense holds immense potential to revolutionize the way we protect and safeguard our nations. Throughout this presentation, we have explored the various aspects of AI development in the defense sector and its far-reaching implications.

Artificial intelligence has the capability to enhance situational awareness, optimize decision-making processes, and improve overall operational efficiency in defense operations. The utilization of machine learning algorithms, deep learning frameworks, and natural language processing techniques can enable us to extract actionable intelligence from vast amounts of data, aiding in the identification of potential threats and facilitating proactive measures.

By harnessing the power of AI, we can develop advanced autonomous systems, intelligent surveillance technologies, and predictive analytics models that enable real-time threat detection, mission planning, and predictive maintenance. These advancements not only strengthen our national security but also save valuable time, resources, and human lives.

However, it is essential to acknowledge the ethical considerations and potential risks associated with the deployment of AI in national defense. Robust measures must be implemented to ensure transparency, accountability, and the protection of privacy rights. Additionally, ongoing research, collaboration, and knowledge sharing among academia, industry experts, and defense organizations are crucial to continually improve and refine AI systems in this domain.

As we move forward, the continuous development and integration of AI technologies within national defense will require a skilled and diverse workforce. Investing in education, research, and training programs will be vital to nurture the next generation of AI experts who can address the evolving challenges and opportunities in this rapidly advancing field.

In conclusion, the development of artificial intelligence for national defense represents a significant leap forward in safeguarding our nations. By leveraging the potential of AI, we can enhance our capabilities, strengthen security measures, and foster a safer world for future generations. It is imperative that we embrace this transformative technology responsibly, with a commitment to ethics, collaboration, and innovation.

FIELD I

OPERATION RESEARCH

DEVELOPMENT MODEL OF INDONESIAN NAVAL CADETS IN THE FRAMEWORK OF CREATING RESOURCES SUPERIOR HUMAN

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ABSTRACT

Indonesian Naval Academy (AAL) is tasked with organizing the first education for Indonesian Navy volunteer officers at the academy level which produces Indonesian Navy officers who are tanggap, tanggon and trengginas. The purpose of education at AAL is to educate and train cadets to become future Indonesia Navy officers who are professional, able to adapt to science and technology, have a Sapta Marga spirit, and have the skills in accordance with the demands of the initial assignment on the Republic of Indonesia Warships (KRI) and Platoon Commander in the Marine Corps in order to support the duties of the Indonesian Navy. To realize Superior Human Resources, the Indonesian Naval Academy builds an Education system that is oriented towards the Tri Basic Patterns of Indonesia Armed Force Education, namely through Teaching, Training, and Nurturing Methods (Jarlatsuh) which cannot be separated from one another. Based on existing problems evaluation, assessment and development of the AAL education system need to be carried out. Evaluation is carried out using a system dynamic approach and Game Theory, namely by identifying the variables that affect Jarlatsuh and building a causal loop diagram followed by building the main model and its supporting submodels, to develop the AAL Graduate Quality model which consists of 4 (four) sub-models which include: AAL Graduate Quality Submodel. Teaching Submodels. Training Submodels. Nurturing Submodel. then implementing scenarios for intervening variables that need attention and determining policies using the Game Theory method with an approach to cooperative games by adopting the existing system in Japan's NDA.

Keywords: *Indonesian Naval Academy, NDA, system dynamics, Game Theory*

1. INTRODUCTION

The Indonesian Naval Academy, called AAL, is the Central Executive Agency of the Indonesian Navy which is directly under the Chief of Staff of the Indonesian Navy (Kasal). AAL is tasked with organizing the first education for Indonesian Navy officers at the academy level which produces Indonesian Navy officers who are responsive, responsive, and trengginas. The purpose of education at AAL is to educate and train cadets to become future Indonesian Navy officers who are professional, able to adapt to science and technology, have a Sapta Marga spirit, and have the skills in accordance with the demands of the initial assignment on the Republic of Indonesia Warships (KRI) and Platoon Commander in the Marine Corps in order to support the duties of the Indonesian Navy. (AAL, 2023)

The development of the world of education is increasing from time to time. This is marked by the many findings and innovations in the field of science and technology. These conditions require education practitioners to increase their contribution in an effort to produce quality and competitive resources, namely humans who have faith and devotion to God and mastery of science and technology in the future. However, to develop the quality of human resources, there are challenges and problems that must be faced by the nation, namely: the need to improve quality and added value, changes in the structure of society, increasingly fierce global competition, as

well as the influence and domination of developed countries in the mastery of science and technology.

To realize Superior Human Resources, the Indonesian Navy Academy builds an Education system that is oriented towards the Tri Basic Patterns of Indonesian Armed Force Education, namely through Teaching, Training and Nurturing Methods which cannot be separated from one another.

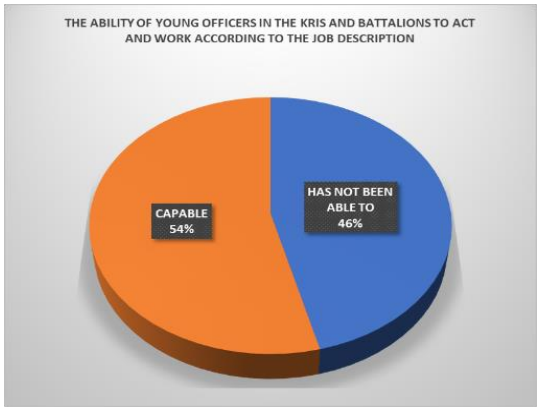


Figure 1. Diagram Based On Survey

Until now, the quality of AAL students is still not optimal. Based on survey data (observation and assessment) from users, namely the superiors of juvenile officers in the main command of the Indonesian Navy, it was found that 54% of

juvenile officers were still unable to meet the demands according to the Job description, while 46% of juvenile officers were able to meet the demands according to the Job Description. The survey results above indicate that the competency of AAL graduates' cadets must be increased so that they are able to support their main assignments in Indonesian War Ship and Marine Battalions. From some of the descriptions of the background and problems currently faced by cadets, it is necessary to evaluate, study and develop the AAL education system

2. LITERATURE REVIEWS

2.1 Character Building Theory

Character Building through Character Cultivation. The term cultivation is adopted from the word, cultivation means: "cultivation/work on agricultural land". Thus, character cultivation can be interpreted as an activity of cultivating character in a person according to the desired character. In terms of character empowerment, the term character cultivation is more appropriate than character building. In character cultivation, individuals are more positioned as the subject of activity and take an active role while in character building, individuals tend to be placed as objects of activity so that they are passive. (AAL, 2014)

2.2 System Thinking Theory

System Theory (System Theory) is a system term encompassing different machine, organism, psychological, and social systems with individual actions and parts. A system is a collection of elements and relationships separated by environmental boundaries that are always more complex than the system itself. (Hall, A. D., & Fagen, 1968)

Prahasta stated that the system can be interpreted as a set of components that are interrelated so that they can influence each other in a certain order/procedure in achieving a goal. In a large system, the smaller system will act as a separate component or sub-system. In a system, it will have characteristics including components, Environment (external entities expressed by system boundaries), Boundaries (which state which systems and which external entities), Interface (media that connects the system with its external entities), Input (data and commands/controls), Outputs (results of processing in the form of data/information, commands and the like), Procedures (which determine the relationships and work sequences/roles of the components), Objectives

(results/goals to be achieved by operating the system).(Prahasta, 2018)

2.3 Learning Theory

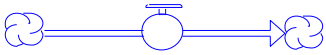
The learning theory put forward by Benyamin S, Bloom or better known as Bloom's Taxonomy theory is a theory that explains the domains of learning which consist of three domains, namely: cognitive, affective and psychomotor and each teaching domain has something different from the others.(Degeng, N. S., & Sudana, 1989)

2.4 Dynamic System.

Sterman (2000) defines that system dynamics is a method for enhancing learning in complex systems. Furthermore, this method is illustrated as a simulation in the cockpit of an airplane for management to understand in learning complex dynamics, understand the sources of resistance (barriers) in policies and design more effective policies. Understanding the complexity of the system dynamics is based on the theory of non-linear dynamics and feedback control developed in the disciplines of mathematics, physics and engineering.

One of *software* who can run a dynamic system simulation model by paying attention to the three types of variables above*System Thinking Educational Learning Laboratory with Animation* (STELLA).

Table 1. Symbol in STELLA software

NO	symbols	Explanation
1		*FLOW / RATE*
2		*LEVEL / STOCK*
3		*CONVERTER*
4		*CONNECTORS*

Below is an explanation of the terms and symbols used in the STELLA software:

a. Rate is activity, movement or flow that contributes to the change per unit time in the Level variable. Rate is the only variable that affects the Level variable.

b. Level is a variable that can accumulate over a period of time. The Level variable is influenced by the Rate variable. The symbol for Level is a rectangle with the variable name listed at the top of the symbol.

c. The converter holds constant values, defines external input to models, calculates algebraic relationships and serves as a repository for graphical functions. In general, converting inputs into outputs. NameThe converter is shown below the symbol.

d. Connectors are used to connect the various elements of the model. Connections can be between Levels, between Converters, Rate to Converter, Converter to Rate and Level to Converter.

3. RESULTS AND DISCUSSION

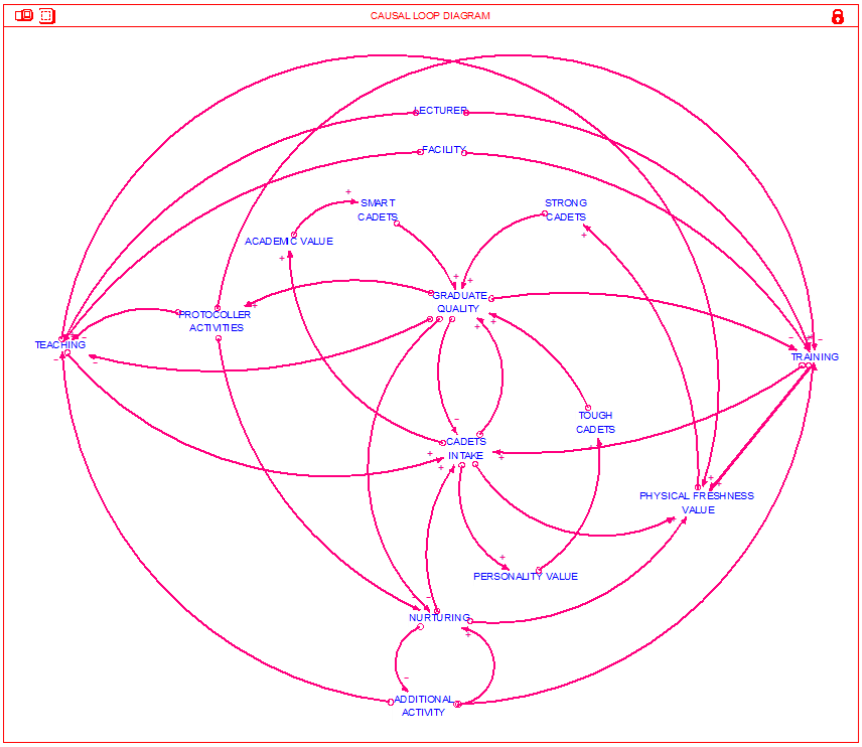
Data collection is carried out to obtain the information needed in order to achieve research objectives. In this research, data collection techniques were carried out through observation, interviews and documentation/literature study. Primary data through observation and interviews (in-depth interviews), namely data collected and processed by researchers from the subject or object of research. While secondary data through documentation/literature study is data obtained indirectly from the subject or research object.

The data collection techniques used in this study were divided into two, namely:

a. Primary data collection was obtained from informants who served in AAL, Disdikal, Dispsial, Disbintalal. This data was obtained by conducting interviews and administering questionnaires to informants/experts regarding the research problem, namely the Development Model for the Indonesian Navy Academy's Parenting System in Realizing the Vision and Mission of the AAL

b. Secondary data collection was obtained from literature, articles, journals and compilations of regulations relating to the research conducted.

The approach method used in this research is a quantitative approach. A quantitative approach was applied in this study through the results of a questionnaire which was then formulated mathematically the relationship between variables according to the specification structure in the System Dynamics Method. Through system dynamic modeling, stocks and flows can be identified that influence the formulation of scenarios and the Game Theory method is used to determine strategies and policies from the scenarios obtained.



Figures 2. Causal Loop Diagrams

In the figure 2 is the structuralization of the model and system that occurs in the AAL Cadets Development system. The structuralization is modeled in the form of a causal loop diagram (CLD) or a causal diagram of all the variables that affect the AAL Cadets Development system. From the conceptualization of the causal loop diagram model above, it can be seen that the AAL Cadets Development system is influenced by the development of system dynamics from 3 (three) variables, namely the Teaching, Training and Nurturning. The variables that affect the three variables are defined according to the identification of the variables that have been done before.

The initial step in conceptualizing AAL Cadets Development is identifying the variables that influence AAL Cadets Development. The purpose of identifying this variable is to deepen knowledge of the object under study. The variables identified are variables related to the level of implementation of the education system and interact with AAL Cadets Development.

Based on the AAL Cadets Education Implementation Program (Book IV) and the identification of all influential variables, the Cadets Development variables can be categorized as including 3 (three) sub-models namely: Teaching, Training and Nurtuning. The following is the identification of the variables shown in Table 1

3.1 Identification Of Variables

Table 2 Identification of Main Model Variables of AAL Cadets Development

The Main Model of AAL Cadets Development		
No.	**Variable**	**Description**
1.	Teaching	Methods of implementing education in the form of lectures/face-to-face and instructional in class with the aim of introducing/understanding/mastery of academic knowledge in the context of forming the personality of Sapta Marga warriors with an emphasis on intellectual aspects (intelligence)
2.	Training	Methods of implementing education in the form of field applications with the aim of strengthening understanding/mastery of academic knowledge in the context of forming Sapta Marga fighters with an emphasis on skill (psychomotor) aspects
3.	Nurtuning	The method of implementing education is in the form of guidance and counseling with the aim of instilling and strengthening cultural values and mastery of academic knowledge in the context of building the character of Sapta Marga warriors with an emphasis on aspects of fighting, character, behavior and ability to implement leadership and organize.
4.	Quality of AAL Graduates	Graduation Achievement Score obtained from the Cumulative Grade Point Average, Cumulative Personality Score and Cumulative Physical Competence Score from Semester 1 to Semester 8

The table above presented encompasses three crucial variables: teaching, training, nurturing, and the quality of graduates. Each of these variables plays a significant role in constructing a complex system within the framework of system dynamics, as illustrated in the diagram below. The interconnectedness and interdependencies among these variables form a dynamic network that influences the overall performance and outcomes of the system. The variable of teaching involves the methods, approaches, and effectiveness of imparting knowledge and skills to students. Training encompasses the development of practical abilities and specialized expertise relevant to the field of study. Nurturing entails the provision of guidance, support, and mentorship to foster personal and professional growth among learners. Lastly, the quality of graduates represents the overall competence, knowledge, and preparedness of individuals upon completing their education. Together, these variables interact and impact one another, shaping the dynamics of the system and ultimately influencing the outcomes of the educational process.

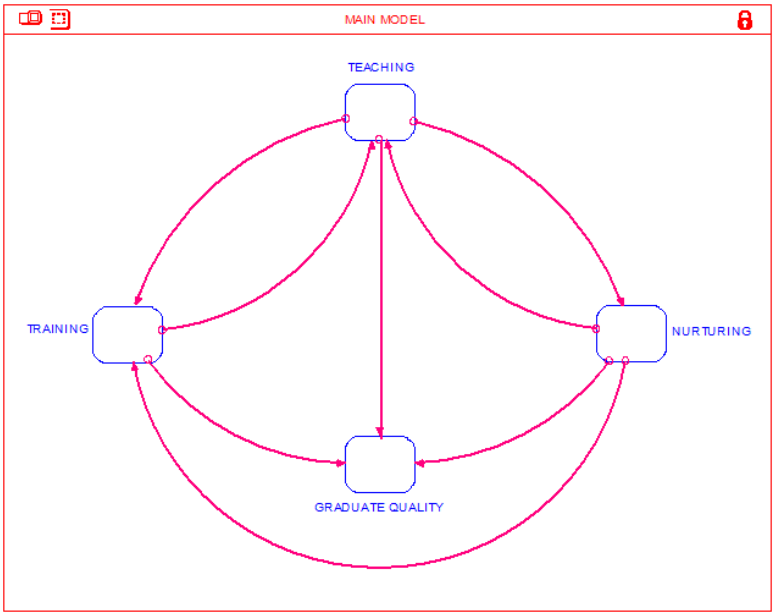


Figure 3. Main Model

Basically, the relationship between variables has been explained in the causal loops diagram. The purpose of building a causal loop diagram is to describe the relationship between each variable, while the purpose of the main model system is to simplify and explain the relationship of the stock and flow diagram. So as to provide an overview of the relationship between the major systems in a model. The objective system is modeling the teaching, training and upbringing of AAL cadets that affect the quality of AAL graduates. At this point it is explained that there are sub-models for each variable that influence one another. In each model, there are many variables that can affect other variables either inside the model or outside the model. The sub-model relationship variable is illustrated by the red line in Figure 4.

4. CONCLUSIONS AND SUGGESTIONS

After understanding the conceptualization of the system in the causal loop diagram model of AAL Graduate Quality as shown in Figure 3, the next step is to develop the AAL Graduate Quality model which consists of 4 (four) sub models which include:

a. AAL Graduate Quality Submodel.
b. Teaching Submodels.
c. Training Submodels.
d. Nurtuning Submodel.

In this section, a research discussion is carried out by displaying and translating the causal loops model into a stock and flow diagram model, followed by model verification and validation. After verification and validation, the next step is to create a dynamic model simulation to measure the Quality of AAL Graduates and look for the variables that have the most significant impact. After preparing scenarios and intervening variables that need to be improved, he implementation model for AAL Graduate Quality is made by compiling stock and flow diagrams based on the causal loop that has been prepared. The stock and flow diagram created is a more detailed description of the system previously shown by the causal loop diagram. In this diagram, the influence of time on the relationship between variables is considered, so that later each variable is able to show the accumulated results for the level/stock variable, and the variable which is the rate of system activity for each time period is called rate/flow. In this case the rate is the only variable that affects the level. While the converter is a variable that is a flow of information that has a constant value. Connectors are used to connect one variable to another, which connects the converter with the converter, connects the converter to the rate, connects the level to the rate and connects the level to the converter. The model compiled in this study uses time units of year to display changes to the current systemthe next step is to implement Game Theory on the intervening variables by adopting the situation applied in NDA.

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RISK ASSESMENT OF SAFETY AND SECURITY OF BALI MARINE COASTAL AND ASSIGNMENT OF DENPASAR NAVAL BASE ELEMENTS

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[2]Department of Industrial and Systems Engineering, Institut Teknologi Sepuluh November, Surabaya, Indonesia

ABSTRACT

The management of Bali's coastal waters is one of the priorities of the Bali provincial government as one of the drivers of the community's economy. The aspect of marine security and safety is one of the important factors that must be maintained to support the effective management of a waters. Therefore, mitigation measures are needed in dealing with various types of threats with the level of risk posed in the management of the Bali Coastal Sea waters. Denpasar Naval Base as one of the institutions tasked with maintaining security and safety in the territorial waters of Bali. The title of marine security operations element of the Denpasar Lanal is one of the main forces in maintaining security and safety stability in Bali's waters. In this research, identification of the types of threats and measurement of the risks posed will be carried out, which are measured from the perspective of maritime security and safety. From the results of the risk analysis, optimization modeling for the assignment of Denpasar Naval Base elements was carried out as a mitigation measure for various types of threats to be assigned to several Naval Post located in the coastal area of Bali. Identification of the types of threats is carried out by involving several experts in the field of maritime security and safety, measuring the value of risk is carried out using the Relative Comparison method. The assignment of Denpasar Naval Base elements is carried out using the Hungarian assignment method with the risk cost as a minimized aspect. The results of the risk assessment measurement show that the biggest risk faced in the management of the Bali Coastal is on the safety aspect of 67% and the security aspect with a proportion of 33%. The Assignment Optimization Model succeeded in optimizing the assignment of 6 (six) elements of the Denpasar Naval Base to 6 (six) Naval Post in the Bali Coastal Area.

***Keywords*:** Maritime Security and Safety, Risk Assessment, Hungarian Methods Assignment Model

1. INTRODUCTION.

The management of the Bali Coastal Area is regulated based on Law Number 1 of 2014 concerning the Management of Coastal Areas and Small Islands (PWP-3-K) and the Governor of Bali Regulation to regulate the planning of the Zoning Plan for the Management of Coastal Areas and Small Islands (RZPWP-3-K) in 2020-2040. Bali's coastal waters are managed in several management zones, namely the tourism zone, fishery zone, harbor zone, salt zone, mangrove zone, mining zone, energy zone and other zones (DPR 2014). The management of coastal areas is directed at achieving effectiveness and productivity in managing marine areas in encouraging economic growth in Bali, especially in the tourism industry sector. Because the tourism industry is the main driver of the economy in Bali (Central Bureau of Statistics 2022). To ensure the effectiveness of maritime management is heavily influenced by maritime security and safety factors. Security and safety at sea for tourists also influence the tourism industry sector in Bali (Sanjaya, Sumertha dan Nuriada 2018).

Maritime security and safety has different meanings depending on who uses the term or in

what context it is being used at the time. From a military point of view, maritime security has traditionally focused on national security in the sense of protecting a country's special territorial integrity from armed attacks or other forces and building state interests elsewhere (Natalie Klein, 2010). Threats to state security may not only be military, but also political, economic, social and ecological (Buzan 1991).. The International Maritime Organization (IMO) distinguishes between maritime safety and maritime security. Maritime Security is related to the protection of ships from unlawful actions, whether intentional or planned. Meanwhile Maritime Safety refers to preventing or reducing the occurrence of accidents at sea caused by ships whose conditions are below standard and crew members or operators who are incompetent.

Risk is uncertainty that comes that can disrupt, damage plans and cause losses due to unknown sources, delays prevent and sometimes too late to effectively reduce the impact (Sidorendko 2017). Risk management aims to create a system or mechanism so that risks that can be detrimental can be anticipated and managed (Hairul 2020). Risk management is basically carried out through the process of identifying sources, evaluating and measuring and managing risks (Hanafi 2017). Efforts to maintain the stability of the security and safety of the sea are steps to manage and control the risk of managing the sea. The risk management approach can be used to determine the right decisions in managing security and safety in the coastal waters of Bali.

Denpasar Naval Base has the function of supporting Navy operations and is also tasked with carrying out maritime security operations and assisting the National SAR Agency in rescue actions at sea (Putri Amelia 2022). In optimizing the assignment of patrol elements to Lanal Denpasar, it is necessary to calculate the ability of elements to deal with various types of threats that exist. In determining the capability of marine SAR elements, it is measured from the indicators of Speed, Endurance, Stability, Maneuver and Equipment (IAMSAR 2006) and the ability to deal with risks of other sea security threats. Types of threats to maritime security and safety can be in the form of interstate disputes, terrorism, piracy, smuggling, illegal activities, environmental pollution, accidents and natural disasters alam (Buzan 1991).

This research will identify the types of threats and measure risks from various sources of threats to the safety and security of the Bali coastal sea, followed by assigning elements of the Denpasar Naval Base to deal with various threats in the region. The Hungarian method can be used to select several workers who have different abilities to occupy a position optimally (Aritonang, Hasibuan dan Hondro 2020). This method can be used to assign Denpasar Naval Base elements to get element assignments with minimal risk costs.

2. MATERIALS.

2.1. Relative Comparison Analysis (RCA).

Relative Comparison Analysis is a technique that involves a comparison between the relative values of several objects to obtain a comparison of the interests and relationships between the objects being compared. The stages used in the use of relative comparison analysis techniques are as follows:

a. Specifies the object to be compared.
b. Define comparative indicators.
c. Determine the relative value intervals for each indicator.
d. Comparison value calculation.
e. Interpretation of the results of comparison values.

In this study, this method was used to compare indicator values to carry out a Risk

Assessment on maritime safety and security variables. The objects being compared are several sources of risks that pose a threat in managing and controlling marine security and safety. Furthermore, the calculation of the Relative Comparison value uses the Risk Assessment Worksheet formulation issued by NATO. From comparative calculations on each indicator can produce an assessment as well as the relationship between the objects being compared.

Indicators for assessing risk sources consist of*: Probability (P), Onset Speed (F1), Forewarning (F2), Duration (F3), Intensity (F4) and Impact (I)* (NATO 2015). Furthermore, the formulation used to determine the relative value of threats is the result of multiplying the Probability value by the SUM factor value and multiplied by the Impact value according to the following formula as follow:

$$RV=P\sum(F)I \quad \text{.....(i)}$$

2.2. Hungarian Methods.

The goal of developing an assignment model is to determine the minimum cost of assigning workers to jobs (Taha 2017). This method is the development of the transportation method. The assignment table shows the assignment of worker i to job j where i,,j =1,2,3.....n as shown in the following table:

Tabel.1 *Assigment Model*.

Assigment	***Job 1***	***Job 2***	***.....***	***Job n***
Worker 1	C_{11}	C_{12}		C_{1n}
Worker 2	C_{21}	C_{22}		C_{2n}
.....	.....	.....	.....	.....
Worker n	C_{n1}	C_{n2}	.....	C_{nn}

The Hungarian method is a classic method for solving assignment problems. There are several steps in solving problems with the Hungarian Method according to work (Taha 2017) as follows:

a. Step 1: Find pi, the minimum cost element of row i in the original cost matrix, and subtract all elements of row i, i = 1, 2, 3...n.

b. Step 2: For the matrix created in step 1, determine qj, the minimum cost element of column j, and subtract from all elements of column j, j = 1, 2, 3...n.

c. Step 3: From the matrix in step 2, try to find a feasible assignment among all the resulting 0 (zero) entries. If such an assignment can find the optimal/feasible solution then the process is declared complete. However, if no optimal solution is found, then additional calculations are needed in steps 4 and 5.

d. Step 4: Draw the minimum number of horizontal and vertical lines in the last reduced matrix to cover all zero entries.

e. Step 5: Select the smallest uncovered entry, subtract from each uncovered entry, then add to each entry at the intersection of the two lines.

f. Step 6: If no proper assignment can be found among the resulting null entries, repeat step 1.

The Hungarian Simplex explanation of the assignment formula where n workers are assigned to n jobs can be represented as an LP model in the following way:

Let Cij be the cost of assigning worker i to job j, and determine:

$$Xij=\begin{cases} 1, & if\ worker\ i\ job\ j \\ 0, & else \end{cases}$$

Then the LP model can be written as follows:

Minimize $Z = \sum_{i=1}^{n} \quad \sum_{i=1}^{n} cijxij$

Subject to :

$$\sum_{j=1}^{n} xij = 1, j = 1,2,3 \ldots\ldots n$$

$$\sum_{i=1}^{n} xij = 1, i = 1,2,3 \ldots\ldots n$$

Xij = 0 or 1

2.3 Method

The research procedures carried out in this study were divided into 2 (two) stages, namely the Risk Assessment stage and the Assignment Model

Stage. The risk assessment stage consists of identifying risk factors, determining risk assessment indicators, calculating relative comparison values and analyzing the results of calculations. It is continued at the stage of compiling the optimization model for the assignment of Lanal Denpasar elements starting with the identification of model variables, compiling the cost matrix, matrix iteration to get the minimum assignment cost and ending with the interpretation of the results of the optimization model. The research steps are shown in Figure 1.1 below:

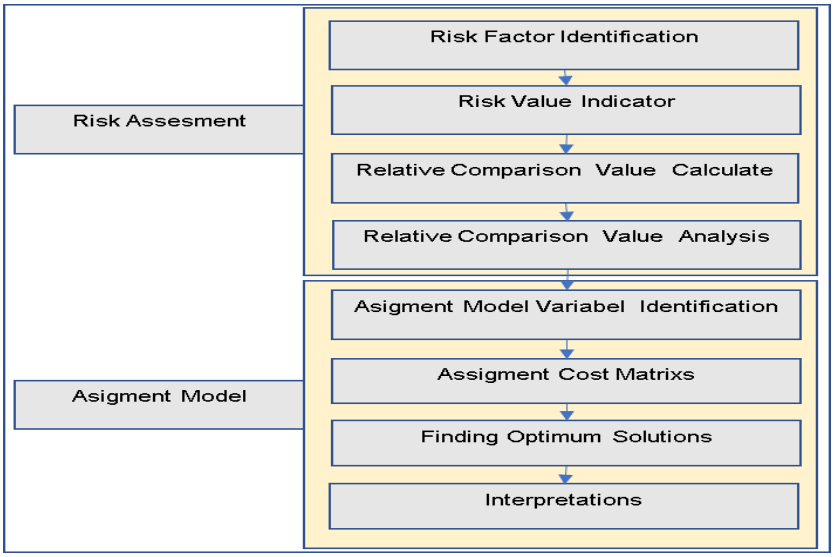

Figure 1. Research Method Algorithm.

3. RESULT AND DISCUSSION.

3.1 Risk Assessment of Marine Security and Safety Aspects.

Identification of aspects of the source of threats to sea security and safety was carried out by in-depth interviews with several experts and observation of data in intelligence analysis reports on operational areas and data on the results of SAR operations by the Denpasar SAR Agency. From the results of observational data and in-depth interviews with experts in the field of marine security and safety, it has been possible to identify the source factors of threat risk in the aspects of marine security and safety in Table. 2 as follows:

Table 2. Maritime Safety and Security Treats Factors.

Security Aspect	Safety Aspect
Illegal Fishing (SE1)	Ship Aground Hazards (SA1)
Illegal Oil (SE2)	Trouble Engine Ship Hazards (SA2)
Illegal Mining (SE3)	Lost Contak Ship Hazards (SA3)
Illegal Loging (SE4)	Medical Evacuatios (SA4)
Illegal Migran (SE5)	Lost Of Fisherman Hazards (SA5)
Illegal Survey (SE6)	Tourist Accidents at Sea (SA6)
Shipping Violations (SE7)	Man Over Board (SA7)
Destruction of natural resources (SE8)	Ship Fire Hazards (SA8)
Smuggling (SE9)	Angler Dragged by the Waves (SA9)
Fights between fishermen (SE10)	Danger of Ship Leakage (SA10)

Marine Pollution (SE11)	Ship Hit by Waves (SA11)
State Territory Violation (SE12)	Sinking Ship (SA12)
Sabotage From The Sea (SE13)	Ship Crash (SA13)

In this study the Relative Comparison method was used to calculate the relative risk value for each threat source in the aspect of maritime security and safety. The measurement indicators are taken from the NATO risk assessment worksheet model which consists of Probability, Factor Elements which consist of Onset Speed, Forewarning, Duration, and Intensity, and Impact. The computation of the relative risk value is generated by multiplying the probability value with the factor element SUM value and multiplied by the Impact value. Assessment of each indicator on the threat factor is carried out by interviewing and distributing questionnaires to the experts. The risk assessment indicators used in this study can be seen in Table. 3 as follows:

Table 3. Risk Assesment Value Indicator.

Indicators	Description	Relatve Value
*Probability (**P**)*	An assessment of the relative likelihood of the threat occurring.	1"Low" 2"Medium) 3"High"
*Onset Speed (**F1**)*	The speed between the warning/warning until the event occurs.	1"Low" 2"Medium) 3"High"
*Forewarning (**F2**)*	Opportunity to mitigate after a warning.	1"Adequate" 2" Enough" 3" Not enough"
*Duration (**F3**)*	The length of time an event takes place.	1"Short" 2"Medium" 3"Long"
*Intensity (**F4**)*	The intensity level of the hazard during the incident.	1"Low" 2"Medium) 3"High"
*Impact (**I**)*	The impact caused by the incident.	1"Low" 2"Medium) 3"High"

Risk assessment is divided into several value categories, namely low, medium, high and extreme. The risk category is "low" if the relative risk value is ≤ 337, the "medium" category is if the 338 ≤ relative value ≤ 728, the "high" category is if 729 the relative value is ≤ 1079 and the extreme category is if 1080 ≤ the relative value ≤ 1404. each assessment indicator on each source of threat/risk. The results of the assessment by experts and the results of calculating the relative risk values are shown in Table. 4 following:

Table 4. Relative Comparison Value.

Treat Factors	Rate (**P**)	Elements Factor Rate (**F1**)	(**F2**)	(**F3**)	(**F4**)	Rate (**I**)	Relative Risk (**P**)*SUM(**F**)*(**I**)	Weight
SA1	2,33	1,00	2,16	2,33	1,83	2,50	42,77	0,123
SA2	2,33	1,00	2,00	2,16	1,33	2,66	40,44	0,116
SA3	1,00	1,16	1,83	1,83	1,16	2,33	14,00	0,040
SA4	1,00	1,00	2,16	2,00	1,00	2,16	13,36	0,038
SA5	1,16	2,00	2,00	1,66	1,00	2,33	18,14	0,052
SA6	1,16	2,00	1,83	2,00	1,33	3,00	25,08	0,072
SA7	2,66	1,00	1,16	2,00	2,00	1,66	27,40	0,079

SA8	1,33	1,00	2,00	2,00	1,00	2,33	18,66	0,054
SA9	2,00	2,00	2,00	2,33	2,00	3,00	50,00	0,143
SA10	1,00	2,33	2,00	1,00	1,33	2,16	14,44	0,041
SA11	1,00	1,00	2,00	3,00	1,00	2,50	17,50	0,050
SA12	2,00	2,00	2,00	2,00	1,00	2,66	37,33	0,107
SA13	1,33	2,33	2,00	2,00	1,00	3,00	29,33	0,084
Total Relative Risk Security Aspects							**348,5**	
SE1	2,58	2,54	2,54	2,58	2,54	2,58	68,101	0,093
SE2	2,22	2,25	2,25	2,29	2,29	2,32	47,027	0,064
SE3	2,38	2,38	2,38	2,38	2,41	2,41	55,330	0,076
SE4	2,03	2,03	2,03	2,03	2,03	2,06	34,10	0,047
SE5	2,64	2,64	2,61	2,64	2,64	2,61	72,90	0,100
SE6	2,48	2,51	2,48	2,51	2,51	2,55	63,50	0,087
SE7	2,58	2,54	2,54	2,54	2,51	2,55	66,82	0,091
SE8	2,38	2,45	2,41	2,41	2,45	2,48	57,76	0,079
SE9	2,25	2,25	2,25	2,29	2,25	2,29	46,88	0,064
SE10	2,16	2,16	2,16	2,16	2,12	2,16	40,23	0,055
SE11	2,61	2,61	2,61	2,58	2,58	2,58	70,04	0,096
SE12	2,32	2,35	2,38	2,35	2,38	2,38	52,58	0,072
SE13	2,38	2,45	2,41	2,41	2,45	2,45	57,01	0,078
Total Relative Risk Safety Aspects							**732,305**	

Based on the results of measuring the risk aspects of the Maritime Security aspects of the Bali Coastal Waters using the Relative Comparison Method, it can be seen that Bali's waters are at risk of smuggling (SE9) with a relative score of 50.00 with a risk weight of 0.143, followed in second position Bali's Coastal waters are vulnerable to illegal fishing (SE1)) with a relative score of 42.778 with a risk weight of 0.123. In third place, the vulnerability that occurs is illegal oil (SE2) with a relative score of 40.44 and a weight of 0.116, followed by Regional Violations (SE12) with a relative score of 37.333 and a risk weight of 0.107. The risk category for marine security aspects is included in the "medium" category.

Furthermore, from the results of the safety aspect risk measurement, it can be seen that the Bali Coastal waters are at high risk of missing fishermen (SA5) with a relative risk value of 72.906 and a risk weight of 0.100. The second highest risk is Ship Accident due to Waves (SA11), with a relative risk value of 70.040 and a risk weight of 0.096. Followed by the third highest risk of Ship Aground (SA1) with a relative risk value of 68.101 and a weight of 0.093. Man Over Board/MOB (SA7) is in fourth place with a relative risk value of 65.115 and a risk weight of 0.099, and in fifth position is Tourist Accident (SA6) with a relative risk value of 63.503 and a weight of 0.093. The risk assessment category on the safety aspect is included in the "high" category with a relative risk value of 732.305.

The average aggregate relative risk value for security and safety of the Bali coastal sea is 540.4. This shows that the coastal waters of Bali have a risk in the "medium" category with the proportion of threats to security aspects being 33% and safety aspects 67%.

3.1 Assignment of Denpasar Naval Base Elements.

Based on the resulting risk identification, a model for the assignment of operational elements to the Denpasar Naval Base was developed as a mitigation and control measure for the risks encountered. The approach used in the preparation of the element assignment model is carried out by prioritizing the safety function in this case as a Search and Rescue element. Identification of

Assignment Variables in the Hungarian optimization model consists of Element Variables (Worker), Assignment Area (Job) and Assignment Cost aspects.

Element U1 is 47 m long and 1.5 m wide. This boat is equipped with a 40 PK outboard motor booster capable of traveling at a speed of 14 knots for 2 hours, and is capable of transporting 8 personnel. Currently, the U1 element is assigned to the territorial waters of Benoa Harbor. The U2 element is a boat that has a relatively shorter length than U1, which is 4.5 meters long and 2.1 meters wide. This boat is equipped with a 15 PK thruster and is only able to go at a speed of 12 Knots for 2 hours. Only able to carry 6 people. Currently the U2 element is assigned to Benoa Harbor. The U3 element is an element of the Denpasar Naval Base whose hull is made of aluminum which has a length of 18 meters and a width of 4.5 meters with a draft depth of 0.75 m. Equipped with 2 1136 HP Caterpillar thrusters. Able to go at a speed of 25 knots for approximately 10 hours. This ship is capable of carrying 16 people including the crew. Currently, the U3 element is assigned to the territorial waters of Benoa Harbour.

The U4 element is made of aluminum and is 7.5 meters long and 3 meters wide. In full loading condition it has a draft of 1.2 meters, this boat is equipped with 2 boosters, each with a capacity of 85 HP, has a maximum speed of 20 knots. RHIB 1 is currently assigned to Posal Gilimanuk, to be precise at the Gilimanuk Crossing port. The U5 Element is made of aluminum and is 7.5 meters long and 3 meters wide. In full loading condition, it has a draft of 1.2 meters, equipped with 2 thrusters, each with a capacity of 150 HP, has a maximum speed of 30 knots. Currently the elements are assigned to the territorial waters of the Port of Benoa. The U6 element is made of aluminum with a length of 12 meters and a width of 3.3 meters. In full loading condition, it has a draft of 1 meter, made in 2022. This boat is equipped with 2 thrusters, each with a capacity of 300 HP, has a maximum speed of up to 35 knots. This element is assigned under the Pengambengan Navy Post.

The overall data for elements of the Denpasar Naval Base which are currently in a ready-to-operate condition are shown in table below:

Table 5. Denpasar Naval Base Elements.

Elements	Tonage (ton)	Long (m)	Width (m)	Draught (m)	Speed (knot)	Endurance (hour)
U1	1,2	4.7	1.5	0,25	14	2
U2	1,1	4.5	2.1	0,25	12	2
U3	20	18	4.5	0,75	25	10
U4	3	7,5	3	1.2	20	4
U5	3	7.5	3	1.3	30	6
U6	4	12	3.2	1	35	11

The Variable Area Assignments are 6 (six) Naval Posts under the ranks of the Denpasar Naval Base, namely the Celukan Bawang Naval Post (W1), Karangasem Naval Post (W2), Nusa Penida Naval Post (W3), Benoa Naval Post (W4), Pengambengan Naval Post (W5)) and Gilimanuk Naval Post (W6). The Celukan Bawang Naval Post (W1) is a post located in the northern coastal area of Bali waters. The vulnerability of maritime security aspects that occur in this region include: illegal fishing, illegal oil, illegal migrants, illegal logging and smuggling. Meanwhile, the vulnerabilities in the aspect of marine safety in this region include tourist accidents, ship

engine failures, ship aground and missing of fishermen.

Karangasem Naval Post (W2) is the eastern coastal area of the northern part of Bali waters. The East Coast region is directly adjacent to the International ALKI II shipping lane which is also a busy sea traffic lane with a high risk of sea accidents, so IMO designated this strait as the TSS (Traffic Separation Scheme) to regulate the passage of ships. The vulnerability aspects of maritime security in this region include: illegal mining, illegal surveys, shipping violations, and illegal oil. Meanwhile, threats to the safety aspect of the sea consist of: ship collisions, ship aground, capsized ships due to crashing waves, missing fishermen, medevac, MOB, tourist accidents, lost contact ships and fires and leaks.

Nusa Penida Naval Post (W3) is located in the southeast of Bali waters which is bordered by the Lombok Strait on the east side and the Indonesian Ocean on the south side. Characteristically, the waters are similar to the working area of the Karangasem Naval Post. The vulnerability of sea security aspects in this region include: illegal fishing, illegal surveys, illegal oil, shipping violations, and territorial violations. Meanwhile, the threats to the safety aspect of the sea consist of: ship collisions, ship aground, ships overturned due to waves, missing fishermen, medevac, MOB, lost tourists as well as fires and leaks. Furthermore, the Benoa Naval Post (W4) is in the form of a beach tourism zone, a port zone, an aviation zone and a fishing zone. The vulnerability of sea security aspects in this region include: illegal fishing, illegal oil, shipping violations, destruction of natural resources, sea pollution, sea sabotage and smuggling. Meanwhile, the threats to the safety aspect of the sea consist of: ship collisions, ship aground, ships overturned due to waves, missing fishermen, medevac, MOB, lost tourists as well as fires and leaks.

Pengambengan Naval Post (W5). The vulnerability of sea security aspects in this region include: illegal fishing, illegal oil, shipping violations, and smuggling. Meanwhile, threats to the safety aspect of the sea consist of: capsized boats due to the crashing of the waves, missing fishermen, MOB, missing tourists as well as fires and leaks. Gilimanuk Naval Post (W6) is located on the west side of Bali waters. The character of the waters is a narrow strait that has heavy tidal currents. It has quite dense water traffic because it is the area of the Java-Bali crossing port and ship traffic in and out of the Banyuwangi public port. The vulnerability of maritime security aspects in this region include: illegal oil, illegal migrants, illegal fishing, shipping violations, destruction of natural resources, and smuggling. Meanwhile, threats to marine safety aspects consist of: ship aground, ship collision, MOB as well as fires and leaks.

The preparation of the Assignment Cost Matrix is carried out by measuring the ability aspects of the Denpasar Naval Base elements on several indicators, namely Speed, Endurance, Stability, Maneuver, and Equipment. The assessment is carried out by the Expert, with the results of the assignment cost matrix as shown in Table 6 below:

Table 6. Assignment Cost Matrix Hungarian Methods.

Unsur	**Naval Post under Denpasar Naval Base**					
	W1	***W2***	***W3***	***W4***	***W5***	***W6***
U1	13,00	18,00	17,75	17,25	14,00	12,25
U2	13,00	18,00	19,25	17,25	14,25	12,00

U3	13,00	13,25	14,25	13,25	13,25	10,00
U4	13,00	14,50	13,25	14,00	13,25	9,00
U5	14,00	15,25	14,00	14,25	13,00	11,00
U6	13,00	13,25	13,00	15,50	14,25	10,00

Calculation of the optimization model with the Hungarian method is carried out to get the assignment of elements of the Denpasar Naval Base with the minimum possible assignment cost. The model is declared optimal if 1 element is correctly assigned to 1 assignment place. The calculation of the Hungarian method uses the Exel Solver application with the assignment results as shown in Table 7. Based on the computational results of the Hungarian method on Microsoft Exel Solver, it shows that the Hungarian model has found an optimal solution, with a minimum relative cost of 76.75. Each element is appropriately assigned to 1 (one) area of operation.

Table 7. Computational Assignment Optimization Hungarian Method.

	Naval Post under Denpasar Naval Base								
Unit/Elements	***W1***	***W2***	***W3***	***W4***	***W5***	***W6***	Row Sum		Supply
U1	1	0	0	0	0	0	1	=	1
U2	0	0	0	0	1	0	1	=	1
U3	0	0	0	1	0	0	1	=	1
U4	0	0	0	0	0	1	1	=	1
U5	0	0	1	0	0	0	1	=	1
U6	0	1	0	0	0	0	1	=	1
Collum SUM	1	1	1	1	1	1			
	=	=	=	=	=	=			
Demand	1	1	1	1	1	1			
Objective (Z Min)	76,75								

The assignment of Denpasar Naval Base elements based on the computational results of the assignment model using the Hungarian method is as follows:

a. Element (U1) is assigned to the Celukan Bawang Naval Post (W1), with a relative cost of 13.00.

b. Element (U2) is assigned to Pengambengan Naval Post (W5), with a relative cost of 14.25.

c. Element (U3) is assigned to Benoa Naval Post (W4), with a relative cost of 13.25.

d. Element (U4) is assigned to Gilimanuk Naval Post (W6), with a relative cost of 9.00.

e. Element (U5) is assigned to Nusa Penida Naval Post (W3), with a relative cost of 14.00.

f. Element (U6) is assigned to Karangasem Naval Post (W2), with a relative cost of 13.25.

4. CONCLUSION.

This research has succeeded in identifying risk categories for the security and safety of the Bali coastal seas using the Relative Comparison Analysis method on the factors that are a source of threats. The calculation of the relative risk assessment of security and safety aspects shows that the Bali Coastal waters have a vulnerability with

an overall category of "medium" value. Aggregate relative risk value for security and safety of the Bali coastal sea is 540.4. This shows that if the risk is not managed and controlled properly it can become waters with a high risk. In an effort to manage and control threat risk, it is carried out by optimizing the assignment of Denpasar Naval Base Elements. The assignment model using the Hungarian method succeeded in placing 6 (six) elements ready for operation in 6 (six) areas of operation that had different threat characteristics. Element (U1) is assigned to the Celukan Bawang Naval Post (W1), with a relative cost of 13.00. Element (U2) is assigned to Pengambengan Naval Post (W5), with a relative cost of 14.25. Element (U3) is assigned to Benoa Naval Post (W4), with a relative cost of 13.25. Element (U4) is assigned to Gilimanuk Naval Post (W6), with a relative cost of 9.00. Element (U5) is assigned to Nusa Penida Naval Post (W3), with a relative cost of 14.00. Element (U6) is assigned to Karangasem Naval Post (W2), with a relative cost of 13.25. The total minimum relative cost value of 76.75.

Suggestions for further research can be carried out research to measure the set covering elements of the Denpasar Naval Base channel in carrying out marine security and safety operations in Bali waters. In addition, it is also possible to select the type of element that is suitable for carrying out operations based on regional characteristics in each Naval Post area, and analysis of the impact of maritime security operations on the growth of the tourism industry and the economy in Bali can also be carried out.

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FIELD II

LOGISTICS MANAGEMENT

IDENTIFICATION AND MAPPING OF THE RELATIONSHIPS BETWEEN CRITERIA IN DECISION-MAKING FOR THE SELECTION OF UNMANNED AERIAL VEHICLES USING THE DEMATEL METHOD

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ABSTRACT

Decision-making is the process of selecting from several alternatives. Decision-making in selecting an alternative is a series of long processes, starting with identifying problems, seeking information about the alternatives to be selected, and analyzing how good each alternative is, leading to alternative decisions to be made. At the stage of identifying the criteria of an alternative, it is not only about identifying these criteria but also knowing the interrelationships between the criteria of the alternative to be selected. The DEMATEL method is one of the methods in multi-criteria decision-making that can be used to identify the interrelationships between criteria. In this study, calculations were carried out using the DEMATEL method to identify twenty criteria used in the selection of unmanned aircraft. From the results of this study, the DEMATEL method was able to identify and describe the relationship between the criteria quantitatively in the form of a table of the number of relationships and an impact-digraph map. The results of this study indicate that of the twenty criteria, four of the most influential criteria were obtained in the decision-making process for selecting an unmanned aircraft, with the payload criteria being the most influential criteria with the largest value of 0.412, followed by the political criteria in second place with a value of 0.356, while the endurance criteria and range are in third and fourth place on the four criteria that most influence the decision-making process for selecting an unmanned aircraft with a value of 0.355 and 0.341, respectively.

Keywords**:** *Decision Making, MCDM, UAV, and DEMATEL*

1. INTRODUCTION.

At this time, the Indonesian Air Force plans to purchase unmanned aircraft defense equipment to be placed at the 53rd Air Squadron Anang Busra Tarakan Air Base in order to support defense in the Koopsud II air area. In making the decision to determine the aircraft, careful consideration is needed so that the aircraft or defense equipment to be purchased can truly support the operational needs carried out. One of the stages in decision-making is determining the criteria that influence the decision. Decision-making is a series of processes carried out by decision-makers to identify problems related to the need to find information about a problem faced, then analyze and solve the problem. The decision in purchasing or selecting the defense equipment to be purchased or selected is the stage of the decision-making process, namely when consumers know the problem in choosing the defense equipment to be purchased or selected and the criteria required in selecting the defense equipment. These criteria are used in the selection process to find information about alternative choices and to evaluate the advantages and disadvantages of each alternative before moving on to the decision-making process.

According to the definition, a purchasing decision is a process carried out to identify all possible options for solving a problem, assess the choices systematically and objectively, and determine the targets for the advantages and disadvantages of each alternative choice. In this

case, the product maker must be able to understand the various influences that can affect buyers and must be able to develop a model for understanding consumer decision-making. The product maker or manufacturer must be able to identify who is the decision maker, the types of purchasing decisions, and the steps in the buying process. In the research conducted (Do et al., 2017; Mulia et al., n.d.), it was found that technical factors such as aircraft quality and capabilities are factors that greatly influence a decision-making process in purchasing aircraft for military purposes. Based on the research data that has been processed, it can be concluded that the technical influence and capabilities of aircraft have a large or significant influence on decision-makers in determining the type of aircraft to be used or purchased to strengthen their military air power.

Meanwhile, in research conducted by (Do, 2019; Doži & Kali, 2014), the results of the analysis show that when purchasing aircraft for commercial purposes, non-technical factors such as brand image and price greatly influence the decision-making process. Based on the research data that has been processed, it can be concluded that the influence of the brand or type of aircraft and prices has a large or significant effect on the sale of airline tickets. So that this becomes one of the factors that influence decision makers, in this case the airlines, in determining or choosing alternative aircraft to buy. Based on the description above, there are two differences of opinion: the first opinion (Do et al., 2017; Mulia et al., n.d.) say that technical factors or criteria greatly influence the decision-making process in purchasing aircraft for military purposes. Meanwhile, the second opinions (Do, 2019; Doži & Kali, 2014) said that non-technical factors such as brand image and price greatly influence the decision-making process for purchasing an aircraft.

2. MATERIAL AND METHODS

2.1. *Decision Making Trial And Evaluation Laboratory* (DEMATEL)

The DEMATEL method was developed by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva between 1972 and 1976 in a Swiss Research Center project to evaluate and solve complex problems. In DEMATEL, visualization of the structure of complex causal relationships with a matrix or image is performed. The basis of DEMATEL is the theory of description, which allows us to realize the relationship between criteria based on the relationship of interests to cause and effect (Taghizadeh, 2021). In the DEMATEL structure, each factor or part can get influence either from other factors at a higher level or from a level below it. This technique is one of the best in decision-making methods that apply feedback. (Taghizadeh, 2021) recommends using the DEMATEL method for several reasons, one of which is as follows:

a. This method details the interrelationships with graph theory and displays the degree of association with a number or score.

b. This method uses a feedback relationship; each element can affect and be affected by other elements at the same level, either from the top level or from the bottom level.

c. The importance and weight of each element in the model are determined by all the factors contained in the model.

The steps in the DEMATEL method are as follows:

a. Determine the strength of association (evaluation scale) between criteria. At this point, the impact and potential linkages are evaluated by assessing the relationship between the criteria. The rating scale used varies according to the aims and objectives of the researcher himself. The larger the

rating scale, the greater the probability that experts will assess the DEMATEL questionnaire. The rating scale used in this study refers to (Taghizadeh, 2021) between criteria. At this point, the impact and potential linkages are evaluated by assessing the relationship between the criteria. The rating scale used varies according to the aims and objectives of the researcher himself. The larger the rating scale, the greater the probability that experts will assess the DEMATEL questionnaire. The rating scale used in this study refers to (Taghizadeh, 2021), which is 0-4. A value of 0 means no effect (no relation or effect), 1 means low effect, 2 means moderate influence (medium effect), 3 has a high effect, and 4 has a very high effect.

b. Create a direct-relation matrix. Based on the assessment obtained from the expert regarding the relationship of influence, the next step is to list it in the direct relationship matrix. In this stage, if more than one expert is used, the average value between experts is calculated. In the matrix, Gij is the impact of the consequences caused by i to j. While the main diagonal line of the matrix is set to 0.

$$G = \begin{bmatrix} 0 & g_{12} & g_{1n} \\ g_{21} & 0 & g_{2n} \\ g_{n1} & g_{n2} & 0 \end{bmatrix} \quad (1)$$

c. The direct relationship matrix is normalized. Equations (2) and (3) are used to normalize the resultant direct relation matrix G to become an X matrix. The largest number in each row and column is 1, and the main diagonal matrix remains 0.

$$X = v.G \quad (2)$$

where,

$$v = min_{ij}\left\{\frac{1}{max_i \sum_{j=1}^{n} g_c^{ij}}, \frac{1}{max_j \sum_{i=1}^{n} g_c^{ij}}\right\} i, j \epsilon \{1,2,\dots,n\} \quad (3)$$

d. Direct and indirect relation matrix After getting the X matrix build direct and indirect (Tc)

matrix relationship using equation 4.

$$T_c = (I - X)^{-1}\ , I_{=matriks\ Identitas} \quad (4)$$

d. Calculates row and column totals. After obtaining the Tc matrix, the next step is to calculate the total row (Di) and total column (Rj) with equations (5) and (6).

$$Di = \left[\sum_j^n T_{c_{ij}}\right]\ , i = 1,2,\dots,n \quad (5)$$

$$Ri = \left[\sum_i^n T_{c_{ij}}\right]\ , j = 1,2,\dots,n \quad (6)$$

e. Construction of the DEMATEL causal model The causal DEMATEL model is presented as a digraph. In a cause-and-effect diagram, the horizontal line is (Di+Ri), while the vertical line is (Di-Ri). The relationship (Di-Ri) shows that the various levels of variables affect and influence each other, while (Di+Ri) describes the overall level of variables that influence each other. A positive value (Di-Ri) indicates that certain variables have a stronger influence than others and therefore are given priority over others. These variables are referred to as dispatchers. Variables that have negative values (Di-Ri), which are usually referred to as beneficiaries, are given more weight and are considered to be given the last priority. The greater the value of a variable (Di+Ri), the greater the relationship between variables, which is indicated by its value.

f. Get the relationship in the form of an impact diagram. This map is obtained by converting the x and y coordinates into a Cartesian diagram. If y is positive, then the criterion is a causal group where the criterion affects other criteria and vice versa. If x is negative, then these criteria are influenced by other criteria.

2.2. Methodology

Prosedur penelitian yang dilaksanakan dalam penelitian untuk melakukan pemodelan DEMATEL ditunjukkan pada Gambar 1 berikut.

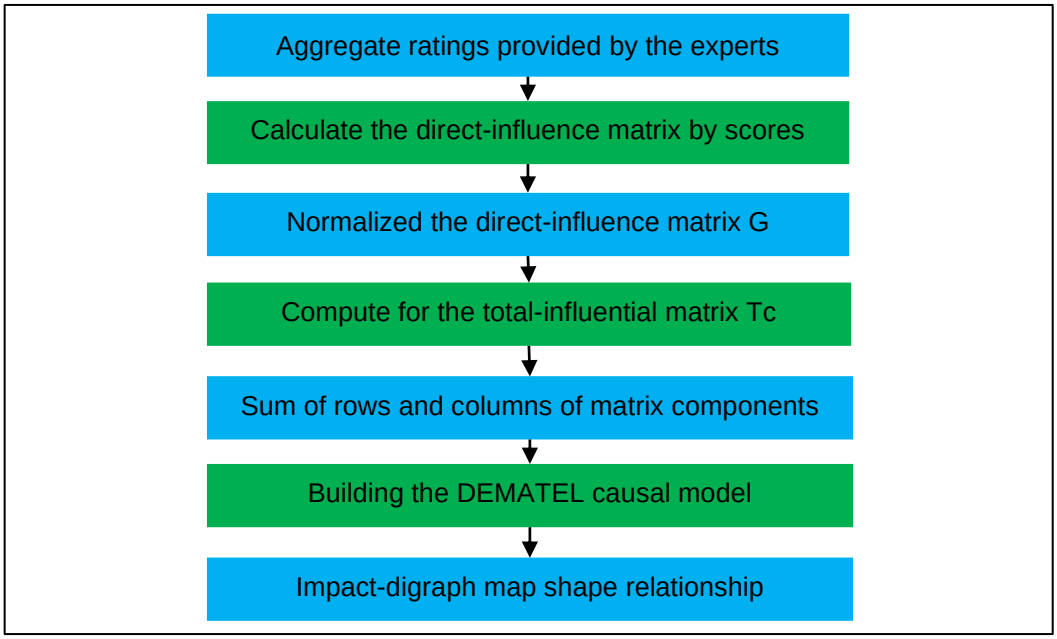

Figure 1. Step of DEMATEL Method

Figure 1 shows the steps for working with the Dematel method. The first step is to calculate the average value of the questionnaire obtained from experts. This average value is then used as input in the direct relationship matrix. The next step after obtaining the direct relationship matrix is to normalize the matrix. After getting the normalized matrix, calculate the total value of the relationship between the criteria. After obtaining the value of the total relationship between the criteria, the next step is to build the DEMATEL causal model, and the last step is to make a map of the relationship between the criteria in the form of an impact-digraph map.

5. RESULT AND DISCUSSION.

In this study, the DEMATEL method was used to describe the relationship that occurred between the criteria obtained by conducting a questionnaire with the experts. The assessment carried out is a pairwise comparison with a scale to describe the influence of the relationship between one criterion and other criteria, from a zero value indicating no effect to a maximum value of four, which indicates a very high influence of one criterion on other criteria. From the results of this assessment, it can be described how the causal relationship that occurs between these criteria The criteria used in this study were obtained based on references from several studies that have been conducted (Francisco et al., 2022; Hamurcu & Eren, 2020; Rodríguez, 2020), as can be seen in Table 1.

Table 1. UAV Selection Criteria

Criteria	Description
Altitude (C1)	Relating to the ability to fly the aircraft
Endurance (C2)	Relates to how long the plane can be in the air
Range (C3)	Relates to the minimum operating radius of the aircraft

Sensor system (C4)	sensor capabilities possessed to carry out observation, reconnaissance, recording and target action.
Communication system (C5)	completeness of the channel The frequency of the link used
Number of operators (C6)	the number of personnel required for the operation of the aircraft
Length (C7)	The length of the aircraft is measured from front to back
Wingspan (C8)	The length of the wing of the aircraft from the tip of the left wing to the right
Payload (C9)	the maximum weight of the weapon carried
Engine Power (C10)	maximum engine power that can be generate
Cruise speed (C11)	aircraft cruising speed that can be generated
Fuel capacity (C12)	the maximum amount of fuel that an aircraft can carry or transport
Maximum take off weight (C13)	the maximum weight of the aircraft for takeoff
GCS size (C14)	GCS control room dimensions
Spare parts (C15)	availability of spare parts and the impact of a possible embargo
Maintenance tools (C16)	availability of maintenance and care tools
Price (C17)	The budget for the purchase of 1 unit of aircraft
Political (C18)	bilateral and multilateral diplomatic relations that can influence decision making
Transfer of Technology (C19)	Complete packages offered such as training and manual books for maintenance
Strategic (C20)	deterrence effect or influence on military strength in regional countries

Table 1 is a collection of criteria that will be used in making decisions on the selection of unmanned aircraft for the 53rd air squadron of the Anang Busra Tarakan air base. Twenty criteria were used, namely: altitude (C1), endurance (C2), range (C3), sensor system (C4), communication system (C5), number of operators (C6), length (C7), wingspan (C8), payload (C9), engine power (C10), cruise speed (C11), fuel capacity (C12), maximum takeoff weight (C13), GCS size (C14), spare parts (C15), maintenance tools (C16), price (C17), political (C18), transfer of technology (C19), and strategic (C20).

After carrying out the initial identification regarding the criteria used, the next step is to evaluate the relationships and interactions between the criteria. Assessment of the intensity of the relationship (interaction) is carried out with the aim of determining the impact and effectiveness of the relationship or the influence of the relationship between one criterion and another. In accordance with the steps for working on the DEMATEL algorithm in Figure 1, The steps for working with DEMATEL according to the algorithm shown in Figure 1 are as follows:

a. Intensity Evaluation (Rating) Scale

Relations between criteria The size of the rating scale used in this study is a scale of 0–4. A value of 0 means no influence or interaction; a value of 1 means a small level of influence or interaction; a value of 2 means a moderate level of influence or interaction; a value of 3 has a strong influence or interaction; and a value of 4 has a very strong influence or interaction. The rating scale used refers to research by Li and Tzeng (2009). In Table 2, it can be seen that the meaning of the correlation assessment or influence relationship, namely (C2, C17), is rated 4, which means that criterion (C2) has a very large level of influence on criterion (C17). At (C1, C5), it is rated 3, which means that criterion (C1) has a strong degree of influence on criterion (C5). At (C4, C2), a score of 1 means that criterion (C4) has a small degree of influence on (C2). While the value 0 is given to mean that the risk event does not have the level of influence as in (C1, C14).

b. Direct Relationship Matrix

In this stage, the results of the assessment of risk events are summarized according to the rating scale. This matrix is then called matrix G. The main diagonal of the matrix is assigned a value of 0. Table 3 is a recap of the results of calculating the average result of a direct relationship between criteria.

c. The direct link matrix is normalized.

With equations (2) and (3), the direct relationship matrix (G) is then normalized to become a matrix (X). The maximum number of rows and columns in a fixed matrix is 1, while the main diagonal is 0. The all-relationship matrix equation (4) produces a total relationship matrix (Tc). Microsoft Excel software is used in this phase to assist with calculationsThe direct link matrix is normalized.

With equations (2) and (3), the direct relationship matrix (G) is then normalized to become a matrix (X). The maximum number of rows and columns in a fixed matrix is 1, while the main diagonal is 0. The all-relationship matrix equation (4) produces a total relationship matrix (Tc). Microsoft Excel software is used in this phase to assist with calculations.

d. Calculating the total number of rows and columns

After creating the Tc matrix, the total row (Di) and column total (Rj) calculations are performed with equations (5) and (6). The calculation of the total row (Di) and total column (Rj) is carried out with the aim of obtaining the importance and relationship of each criterion. Table 6 is a calculation of Di minus Ri (Di-Ri) and Di adding up Ri (Di+Ri).

Table 4. the value of the relationship between the criteria

Criteria	**Di**	**Ri**	**Di + Ri**	**Di-Ri**
Altitude (C1)	1.807	1.712	3.520	0.095
Endurance (C2)	2.020	1.665	3.686	0.355
Range (C3)	2.114	1.772	3.886	0.341
Sensor system (C4)	2.347	2.041	4.388	0.307

Communication system (C5)	2.060	1.989	4.049	0.071
Number of operators (C6)	1.108	1.008	2.116	0.099
Length (C7)	1.688	1.418	3.106	0.270
Wingspan (C8)	1.685	1.442	3.128	0.243
Payload (C9)	2.091	1.679	3.769	0.412
Engine Power (C10)	2.228	1.999	4.227	0.228
Cruise speed (C11)	1.769	1.813	3.582	-0.044
Fuel capacity (C12)	1.464	1.626	3.090	-0.162
Maximum take off weight (C13)	1.370	1.577	2.948	-0.207
GCS size (C14)	1.155	1.228	2.382	-0.073
Spare parts (C15)	1.975	1.912	3.887	0.063
Maintenance tools (C16)	1.378	1.924	3.302	-0.547
Price (C17)	2.343	2.764	5.107	-0.422
Political (C18)	1.966	1.611	3.577	0.356
Transfer of Technology (C19)	1.413	1.879	3.292	-0.466
Strategic (C20)	1.130	2.049	3.179	-0.919

The calculation results (Di-Ri) in Table 4 illustrate the magnitude of the influence between the various criteria. A positive score (Di-Ri) designates the criterion as a sender because it indicates that the criterion has more weight than the other criteria and should be given priority over the others. Negative scores (Di-Ri) designate criteria as recipients because they may be considered to have the lowest priority and receive more weight. The calculation results (Di+Ri) show how closely the criteria are related. A stronger association is indicated by a higher (Di+Ri) value.

e. Establish a causal relationship. DEMATEL

The DEMATEL causal relationship is made in the form of a diagram. Value (Di+Ri) is defined as importance or superiority, while value (Di-Ri) is defined as a relationship and shows priority. The mapping in the diagram uses (Di+Ri) as the horizontal line and (Di-Ri) as the vertical line. (Di+Ri) shows the overall level of criteria that influence each other, and (Di-Ri) shows a relationship that means different levels of criteria will be influenced and affect the others.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
C1	0	0.09649	0.100312	0.117932	0.11607	0	0	0	0.0899	0.1186	0.1026	0.0963	0	0	0	0	0.1436	0	0	0.1153
C2	0.105135	0	0.10405	0.11225	0.10992	0	0.099097	0.1	0.0883	0.1305	0.1132	0.121	0	0	0.1081	0.0885	0.1649	0.0949	0.0947	0.1333
C3	0.108121	0.10599	0	0.121437	0.11933	0	0.099088	0.1	0.1075	0.1362	0.1162	0.1078	0.095	0	0.1092	0.0949	0.173	0.1034	0.0986	0.1377
C4	0.123682	0.105506	0.115567	0	0.1375	0	0.088182	0.092	0.1084	0.1172	0.1032	0.0996	0.1079	0.1044	0.1363	0.1374	0.1919	0.1168	0.1439	0.1449
C5	0.114847	0.096738	0.116938	0.12891	0	0	0	0	0.0911	0.0933	0	0	0.0965	0.0983	0.1231	0.1263	0.167	0.0925	0.123	0.1286
C6	0	0	0	0.09201	0	0	0	0	0	0	0	0	0	0.0929	0	0.0918	0	0	0	0
C7	0	0	0	0.103073	0.09586	0	0	0	0.0935	0.1057	0.0947	0.0916	0.0935	0	0.1014	0.0964	0.125	0	0	0
C8	0	0	0	0.094628	0.09272	0	0	0	0.0988	0.111	0.0975	0.0946	0.0965	0	0.1006	0.1009	0.1216	0	0	0
C9	0.095648	0.101837	0.111242	0.114871	0.11537	0	0.103549	0.1045	0	0.1182	0.122	0.115	0.113	0	0.1069	0.1065	0.159	0	0.1017	0.1201
C10	0.128017	0.123821	0.130445	0.112077	0.10964	0	0.100142	0.1011	0.1217	0	0.1389	0.1209	0.1281	0	0.1182	0.117	0.1642	0	0.1051	0.1343
C11	0.096407	0.094743	0.097957	0.10041	0.0935	0	0	0	0	0.1066	0	0	0	0	0	0	0.15	0.0883	0.0921	0.1165
C12	0.088291	0	0.089837	0	0	0	0	0	0.0883	0.1081	0.1037	0	0.0968	0	0	0	0.106	0	0	0
C13	0	0	0	0	0	0	0	0	0.0953	0	0	0.0949	0	0	0	0	0.1005	0	0	0
C14	0	0	0	0	0	0.0906	0	0	0	0	0	0	0	0	0	0	0.0999	0	0	0
C15	0.10446	0.104708	0.108739	0.133548	0.12651	0	0	0	0	0.1294	0.1035	0	0	0	0	0.1189	0.1622	0.0961	0.1211	0.1179
C16	0	0	0	0.093249	0.09219	0	0	0	0	0	0	0	0	0	0.0901	0	0.1216	0	0.0955	0
C17	0.113129	0.110692	0.115428	0.145918	0.14392	0	0.096068	0.0972	0.1317	0.1536	0.1437	0.1132	0.0961	0.0913	0.1241	0.1284	0	0.1183	0.1217	0.131
C18	0	0	0	0.111742	0.10993	0	0	0	0	0.1062	0.0983	0	0	0	0.1493	0.1474	0.1805	0	0.1497	0.1537
C19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1019	0.1034	0.1235	0.0951	0	0.1044
C20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1209	0.0977	0	0

Figure 2. Network Relationship Map (NRM)

Figure 2 is a Network Relationship Map (NRM). To describe NRM, the threshold value of the total relationship matrix (Tc) is first calculated. The threshold value is the average value of all values from the total relationship matrix (Tc). In this study, the threshold value was 0.088. Values lower than the threshold value of 0.088 in the Tc matrix are treated as if there is no relationship, so that data can be deleted (replaced with zeros).

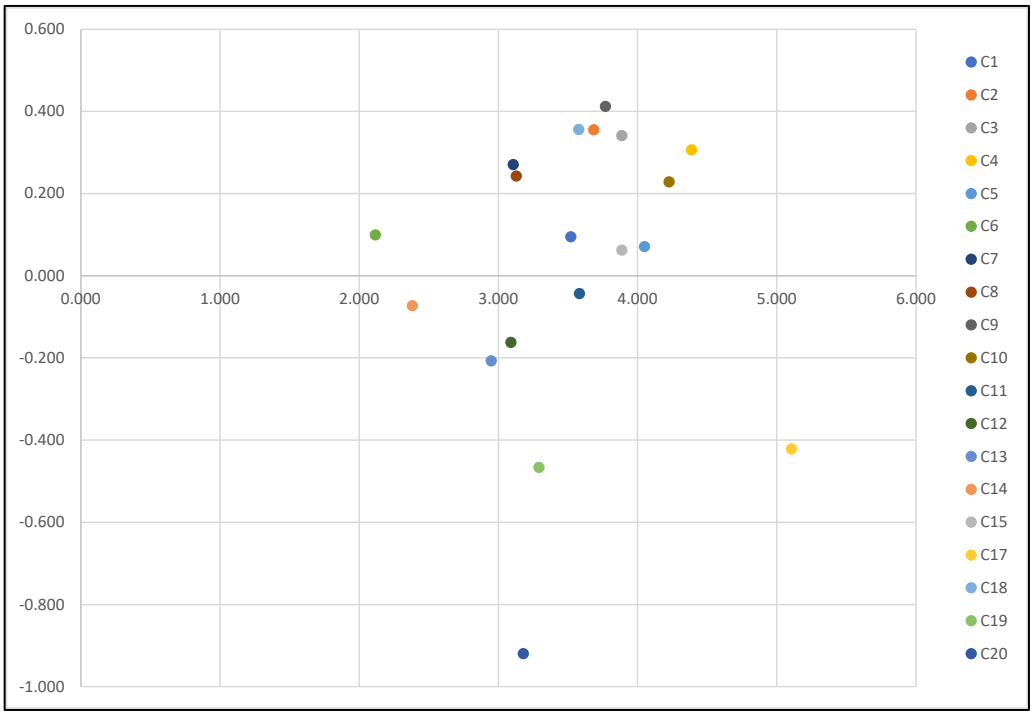

Figure 3. Impact Digraph Map

Figure 3 shows the overall distribution of criteria based on importance and relationship. The results (Di+Ri) of all criteria have a positive value on the X axis (horizontal), so all criteria can be said to have importance. In the causal matrix, the criterion that has the greatest relationship and is the first priority is the payload criterion (C9), which has a very large level of influence because it is also offset by a strong and positive value relationship. This payload criterion (C9) is referred to as a dispatcher and is a criterion with a high degree of interaction influence and a driving force for other criteria. This also applies to the criteria Altitude (C1), Endurance (C2), Range (C3), Sensor System (C4), Communication System (C5), Number of Operators (C6), Length (C7), Wingspan (C8), Engine Power (C10), Spare Parts (C15), and Political (C18). The criteria for cruise speed (C11), fuel capacity (C12), maximum takeoff weight (C13), GCS size (C14), maintenance tools (C16), price (C17), transfer of technology (C19), and strategic (C20) are called receivers because they have a negative level of influence, but the level of relationship is still relatively strong because they have a positive value.

6. CONCLUSION.

In this research, identification and mapping of interrelationships between criteria have been carried out in the decision-making process for selecting an unmanned aircraft. In this case, the study or case study is an unmanned aircraft that will be selected for military purposes (TNI AU). Criteria Altitude (C1), Endurance (C2), Range (C3), Sensor System (C4), Communication System (C5), Number

of Operators (C6), Length (C7), Wingspan (C8), Payload (C9), Engine Power (C10), Spare Parts (C15), and Political (C18) are dispatchers, namely the level of influence is very large because it is also offset by a strong and positive value relationship level. While receivers are other criteria. The findings of this study show that, out of the 20 criteria, four were found to be the most important in the decision-making process for choosing an unmanned aircraft. The payload criteria was found to be the most important, with a value of 0.412, followed by the political criteria in second place with a value of 0.356, and the endurance criteria and range in third and fourth place on the list of the four factors that most influence the decision-making process. The DEMATEL approach should be used in conjunction with a quantitative validation process, according to suggestions or recommendations for additional study.

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FIELD III

POLICY AND STRATEGY

SMART DEFENSE SYSTEMS FOR MARITIME SECURITY: PRIORITIES AND CRITERIA FOR NATIONAL DEFENSE DEVELOPMENT

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ABSTRACT

Force development is directed at meeting the needs of the 2020-2044 National Defense System Development The Indonesian Navy is capable of upholding sovereignty and law in the Indonesian National Jurisdiction area which is guided by the development direction of meeting the 2020-2044 national defense system development needs of the defense of large islands and clusters strategic islands and the surrounding waters within the framework of the Archipelago Marine Defense Strategy and the Indonesian Maritime Defense Strategy. Fulfilling the Needs for the Development of the National Defense System for 2020-2044 the required forces of the Indonesian Navy consist of KRI, aircraft, bases, The concept and strategy of national defense at sea that has been carried out above proves that the concept of national defense at sea has been implemented, and is in accordance with the threats faced. The concept and strategy of national defense at sea is also supported by relevant war strategy theories. The increasingly dynamic spectrum of threats caused by Indonesia's geographical constellation and developments in the global and regional strategic environment have been able to be answered by the national defense strategy as outlined in both national legislation and national defense doctrine. So in this research we need a strategic structure for the strength of the sea dimension that is able to carry out the defense of the archipelago to face every threat both actual and potential and will provide scientific studies by creating a dynamic system model of the SPLN smart defense to support the duties of the Indonesian Navy. In this study, the authors will use the Delphi method to determine the criteria for smart defense that have an effect on SPLN, then use Fuzzy Weighting to determine priorities in the development of smart defense systems.

Keywords:*Smart Defense, Delphi, Fuzzy Weighting.*

1. INTRODUCTION

Force development is directed at meeting the needs of the 2020-2044 National Defense System Development The Indonesian Navy is capable of upholding sovereignty and law in the Indonesian National Jurisdiction area which is guided by the development direction of meeting the 2020-2044 national defense system development needs of the defense of large islands and clusters strategic islands and the surrounding waters within the framework of the Archipelago Marine Defense Strategy (SPLN) and the Indonesian Maritime Defense Strategy (SPMI). Fulfilling the Needs for the Development of the National Defense System for 2020-2044 the required forces of the Indonesian Navy consist of KRI, aircraft, bases, and marine combat materials of various types including coastal defense systems and maritime monitoring systems that are deployed at choke points and strategic funnels throughout the territory of the Republic of Indonesia while remaining oriented towards synergistic integration of the Three Dimensions. The concept and strategy of national defense at sea is also supported by relevant war strategy theories. The increasingly dynamic spectrum of threats caused by Indonesia's geographical constellation and developments in the global and regional strategic environment have been able to be answered by the national defense strategy as outlined in both national legislation and national defense doctrine.

The maritime defense of the archipelago which is structured in layers of defense are action plans aimed at ensuring the sterility of the territory or territory from enemy forces. In order to carry out this defense strategy, sea dimension forces do not stand

alone, it is necessary to optimize the Integrated Fleet Weapon System (SSAT) as well as collaboration, integration and integration of the three dimensions of forces by involving all national resources to carry out sea control as well as anti-access and prevention. So in this research we need a strategic structure for the strength of the sea dimension that is able to carry out the defense of the archipelago to deal with every threat both actual and potential and will provide scientific studies by creating a dynamic system model of the smart defense system of the archipelago's sea defense strategy to support the duties of the Indonesian Navy.

2. MATERIALS/METHODS

2.1 Smart Defense concept

The existence of the national defense system is greatly influenced by the dynamics of the development of the strategic environment and the real conditions of the strength and capability of the national defense system itself. The development of a strategic environment at global, regional and national levels that moves quickly, complexly and dynamically is inseparable from the phenomenon of the rapid development of science and technology which has brought about the world civilization of the Information Age and Industrial Revolution Era 4.0 and Society 5.0. War and technology always have a causal relationship, meaning that war greatly influences the technological advances of war equipment and vice versa. Future battles will rely on the strength of combat units with a relatively smaller size than now, but far more effective and capable of operating against enemies with high capabilities. The main military equipment system will be more Unmanned Aerial Vehicle (UAV) or unmanned, but with a higher level of autonomy. Military technologies that will develop include: cyber warfare equipment for offensives, more advanced calculation systems, artificial intelligence, etc. (Work & Brimley, 2014). Artificial intelligence or Artificial Intelligence (AI) is an important element of the fourth industrial revolution era. AI technology and applications have a tremendous impact (Allen & Chan, 2017). Artificial intelligence or Artificial Intelligence (AI) is an important element of the fourth industrial revolution era. AI technology and applications have a tremendous impact (Allen & Chan, 2017). Artificial intelligence or Artificial Intelligence (AI) is an important element of the fourth industrial revolution era. AI technology and applications have a tremendous impact (Allen & Chan, 2017).

2.2 Delphi method

Delphi by definition is a group process that involves interaction between researchers and a group of experts on a particular topic, usually through the help of a questionnaire. Solver™, you can find the optimal (maximum or minimum) value for a formula in one cell called the objective cell that satisfies the constraint (constrain), or limit, value in another formula cell on a worksheet. The solver processes a group of cells called decision variable cells which are part of the calculation formula of the objective and constraint cells. In the early stages, the informants will answer based on the information, knowledge and experience they have. The informants provided their answers or opinions with a rating scale between 1 (one) to 9 (nine) based on the level of importance of the instrument to be developed as shown in table 2.1. With the information that the scale is 1 (very unimportant) and 9 (very important). Furthermore, the results of the assessment from the resource persons were tabulated and processed into the this method formula so that they became a presentation of the results of the agreement of the persons group.

Table 1. Delphi Rating Scale

Mark	Information
1-2	Very unimportant
3-4	Not important
5-6	Quite important
7-8	Important
9	Very important

2.3 Fuzzy Weighting Method

Processing data using Fuzzy weighting algorithm to with level 8 (eight) as follows (Liang & Wang, 1994):

a. Make the results of the weighting assessment of the qualitative aspect variable level.

b. Make the results of the weighting of the assessment of the level of qualitative criteria variables.

c. Determine the middle value of the fuzzy number (), by adding up the values that appear at each level of the linguistic scale and then dividing the sum by the number of aspects or criteria whose values enter that level of linguistic assessment. The mathematical notation is as follows:a_t

$$a_t = \frac{\sum_{i=1}^{k} \sum_j Tij}{\sum_{i}^{k}{}_{=1} n_{ij}} \text{.....(2.1)}$$

a_t = the mean value of the fuzzy number for the assessment level

Q = very low, low, medium, high and very high rating levels

N = the number of criteria aspects from the Linguistic T scale for the 1st aspect of the i criteria

T_{ij} = the numerical value of the T linguistic scale for the 1st aspect of the jth criterion

d. Determine the lower limit value (ct) and upper limit value (bt) of fuzzy numbers, where the lower limit value (ct = b(i - 1)) is the same as the middle value of the level below it, while the upper limit value (bt = b (i - 1)) is the same as the mean level above it.

e. Determining the aggregate weight of each qualitative criterion, because in this study a form of linguistic assessment was used which already had a triangular fuzzy number definition, the aggregation process was carried out by finding the aggregate value of each lower limit value (c), the middle value (a) and the upper limit value (b), which can be modeled as follows:

$$c_t = \frac{\sum_j^n{}_{=1} c_{tj}}{n}, a_t = \frac{\sum_j^n{}_{=1} a_{tj}}{n},$$

$$b_t = \frac{\sum_j^n{}_{=1} b_{tj}}{n} \text{ , ...(2.2)}$$

Ctj = the lower limit value of the t-th qualitative criteria by the j-th decision maker

a_{tj} = the median value of the t-th qualitative criterion by the j-th decision maker

b_{tj} = the upper limit value of the t-th qualitative criteria by the j-th decision maker

n = number of raters (decision makers) The aggregate score is N=(c_j, a_j, b_j)with Nt. = aggregation weight value for the t-th qualitative criteria.

2.4 Research methodology

An outline of all research activities is depicted in a flowchart as shown in Figure 1 below:

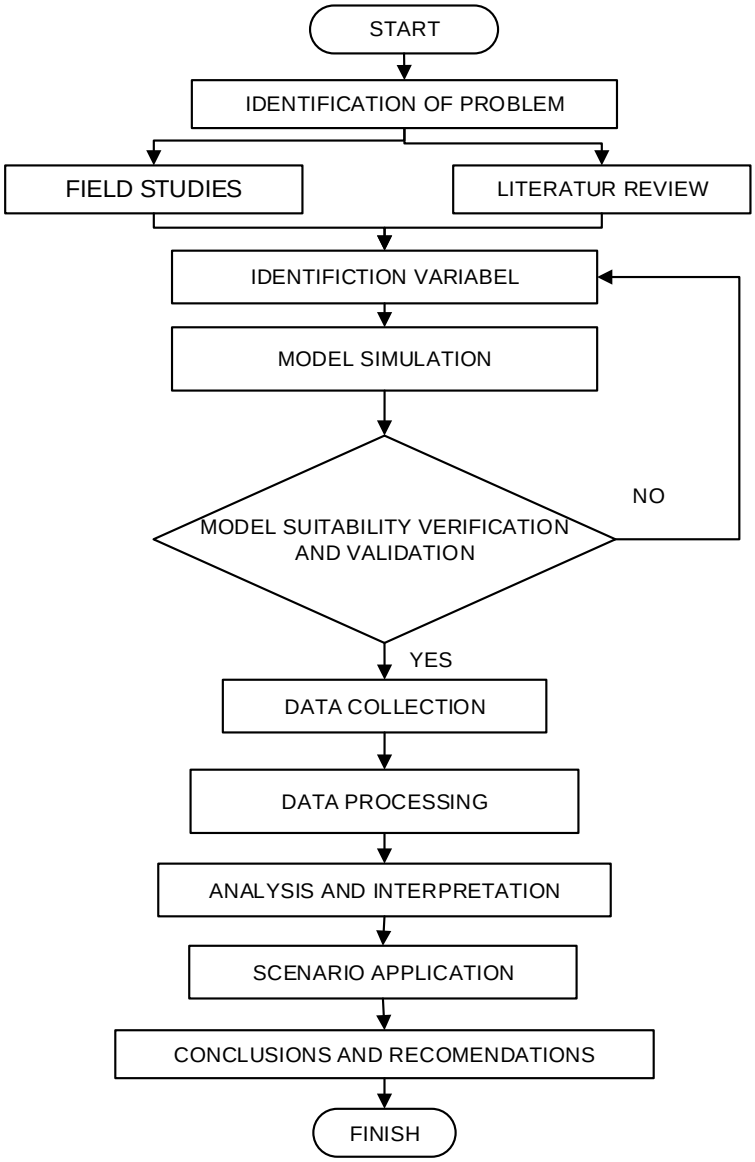

Figure2. Research Method Flowchart

3. RESULTS AND DISCUSSION.

In this section, data analysis and research results are carried out. The data obtained is in the form of data consisting of primary and secondary data obtained by conducting direct interviews with experts from relevant agencies and also with ship journals in the field. Efforts in data collection are aimed at obtaining valid data so that it can be used according to research objectives.

3.1 Identifying Variable Main Aspects of Smart Defense Nusantara Sea Defense Strategy

The initial stage in the series of developing a smart defense model for the archipelago's sea defense strategy (SPLN) is to identify and collect data on the main aspect variables that influence smart defense. The data was obtained from previous research references and the results of in-depth interviews with experts. Then the next process is to identify the main variables for the smart defense of the archipelago's sea defense strategy, the researcher proposes several aspects that influence the smart defense of the archipelago's sea defense strategy to the experts based on theories in books, previous research and phenomena that occur

regarding smart defense strategy maritime defense of the archipelago These aspects are as follows.

Table 2. Identification of The Main Aspects of Smart Defense In The Archipelago's Maritime Defense Strategy

NO	VARIABLE	DESCRIPTION	REFERENCE
1.	OPERATIONAL STRATEGY	The Operations Strategy uses the forces that have been prepared by the Military Strategy. So that the definition of Operations Strategy becomes the art and science of planning, coordinating and controlling military combat within an operational theater in order to achieve the National Goals.	K. Koesnadi, 2018.
2.	Indonesian Navy POSTURE	In an effort to organize national defense at sea, the Indonesian Navy carries out tasks which are the embodiment of three roles that are universal, namely the military role, the constable role and the role of diplomacy. The success of carrying out the tasks of the Indonesian Navy will depend on the posture it has.	Perkasal no.6, 2016.
3.	TECHNOLOGY	The future battlefield environment is increasingly network-based. Network Centric Warfare (NCW) Network War Center is expected to be converted to C4I-ISR-PGM (C4I(Command, Control, Communication & Computer, Intelligence), ISR (Intelligence, Surveillance & Reconnaissance), PGM (Precision Guided Munitions)). This means from detecting the enemy to attacking, consisting of cycles . For this reason, information and communication technology must be the basis, and it will be more effective if it is accompanied by a cyber battlefield environment that can simulate a real battlefield.	Kyo-il Chung, 2014.
4.	THREAT PERCEPTION	Threats that may be faced by the Indonesian Navy in enforcing the law and maintaining the security of the sea area include acts of violence at sea, accidents, navigation and weather, drug smuggling, illegal logging, illegal migrants, Illegal Unreported and Unregulated (IUU) fishing, illegal mining, pollution sea and fuel smuggling.	Perkasal no.5, 2016.
5.	POLITICAL	Politics comes from the Greek "polis". Aristotle called his work on state matters "Politikom", then politics means the art of governing and managing the state or state science. Politics includes all policies/actions in state/government affairs including the determination of the forms, tasks and scope of state affairs.	Kusmanto, 2014.
6.	SOCIAL AND CULTURE	In general, ISB (Social Science and Cultural Sciences) belongs to a group of knowledge, namely studying basic knowledge and general understanding of the concepts of human (social) and cultural relations that are developed to study human, social and cultural issues.	C. Basrun, 2016.
7.	NATURAL RESOURCES	Natural Resources (SDA) are the elements of the natural environment, both physical and biological, which are needed by humans to meet their needs and improve their welfare.	A. Winasis, 2016.

After the identification of the main aspect variables and their criteria has been carried out, the next step is to look for the weight of the influence of the importance level of the aspects and variables which constitute a qualitative data obtained from the results of interviews with experts/source persons along with questionnaires from each of these Experts.

3.2 Delphi Method Calculations

Based on the design of the Delphi method, opinions were drawn from 7 respondents who were experts related to determining the Smart Defense Strategy for the Archipelago's Marine Defense. From the answers to the opinion withdrawal, the answers from the sources were obtained as follows

Table 3. Expert Opinion Results/source persons

NO	EXPERT	CRITERIA						
		K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**
1	**E1**	8	8	9	9	6	5	5
2	**E2**	9	9	9	8	6	4	3
3	**E3**	7	7	9	9	3	1	1
4	**E4**	9	7	8	7	4	2	1
5	**E5**	9	9	9	8	5	4	4
6	**E6**	9	9	9	8	7	6	7
7	**E7**	8	7	7	6	5	4	6
SCORE		59	56	60	55	36	26	27
MARK		12.70	12.70	14,29	14,29	9.52	7,94	7,94
min		7	7	7	6	3	1	1
MAX		9	9	9	9	7	6	7
AVERAGE		8,43	8.00	8.57	7.86	5,14	3.71	3.86
STD DEV.		0.79	1.00	0.79	1.07	1.35	1.70	2.34
EVALUATION		**CON**	**CON**	**CON**	**CON**	**DIV**	**DIV**	**DIV**

From the results of the processing of the Delphi method above, there was a change in position from the previous criteria, namely at the beginning of data collection there were 7 (seven) criteria that became a factor of the smart defense of the archipelago's maritime defense strategy, but after undergoing data processing using the Delphi method it became 4 (four) criteria (average value or average > 7.00). The criteria for processing the Delphi method consist of Technology (K3), Operations Strategy (K1), TNI AL Posture (K2) and Threat Perception (K4) which will be used as the final data for further weighting processing using the next method.

Next, data processing and looking for weight values influence the level of importance of aspects and criteria in this thesis using a method called the Fuzzy Weighting method (Suharyo, 2017), where the processing has levels up to 8 (eight) processing levels. This method has the convenience of filling out questionnaires by Experts/source persons and has a fairly good level of objectivity in determining judgments.

Table 4. Aggregate Assessment on Technology Aspects

NO	CRITERIA	E1	E2	E3	E4	E5	E6	E7
1	Integrated Systems	9	9	9	9	9	8	9
2	Monitoring	9	9	9	9	9	9	9
3	Big Data (IoT, AI & Machine Learning)	9	9	9	9	10	8	9
4	cyber	9	9	9	9	9	8	9
5	Autonomous (Ride & Weapon)	7	9	8	9	9	8	9

Table 5. Aggregate Rating on Operational Strategy Aspects

NO	CRITERIA	E1	E2	E3	E4	E5	E6	E7
1	Command & control / maritime operation center (Puskodal)	9	9	9	9	9	9	9
2	Coastal watch system (radar, ESM electronic support measure, long range camera)	7	7	8	8	8	8	9
3	Mobile surveillance (air, surface, subsurface unmanned vehicle)	8	9	9	9	9	6	9

4	Coastal defense (fixed & mobile missile system, sonar and sonobuoy)	7	5	6	7	6	6	6
5	Integrated air defense (arhanud marines, KRI class PKR)	8	9	9	9	9	7	6
6	Anti Submarine Warfare (ASW) defense	8	7	9	8	8	8	7
7	Sea task force / sea control at ALKI I, II and III	8	7	9	8	7	9	8
8	Human Resources Development	8	7	7	8	8	9	9
9	Risk Management	7	7	7	5	7	9	8
10	Logistics	8	9	8	8	7	8	8

Table 6. Aggregate Assessment on Aspects of TNI AL Posture

NO	CRITERIA	E1	E2	E3	E4	E5	E6	E7
1	SSAT (KRI, Pesud, Marines, Base, Special Forces, Personnel)	9	9	9	8	9	9	9
2	Security, Defense, Intelmar, Diplomacy, Dawinhanla, Support	8	7	7	8	8	9	8
3	Degree of Operation (Degree of Harvesting/Deployment/routine ops & Degree of Enforcement/Employment/sat.siaga 3 trouble spot)	9	7	7	8	8	8	9

Table 7. Aggregate Rating on Threat Perception Aspect

NO	CRITERIA	E1	E2	E3	E4	E5	E6	E7
1	Air (Aircraft, Drones, Missiles)	8	9	9	8	7	9	7
2	Warships (Surface & Sub Surface)	8	7	7	7	8	9	8
3	Maritime Cyber Security	9	9	9	9	9	9	7

c. Determine the middle value of the fuzzy number (at), by adding up the values that appear at each level of the linguistic scale and then dividing the sum by the number of aspects or criteria whose values enter the linguistic assessment level. The mathematical notation is as follows:

$$a_t = \frac{\sum_{i=1}^{k} \sum_j T_{ij}}{\sum_{i=1}^{k} n_{ij}}$$

a_t = the mean value of the fuzzy number for the assessment level

Q = levelsvery low, low, medium, high and very high ratings.

N = the number of criteria aspects from the linguistic scale T for the 1st aspect of the i-criteria

Tij = numerical value of the T linguistic scale for the 1st aspect of the jth criterion

Table 8. Aggregate the value of the middle, lower and upper limits on expert 1 to expert 4.

NO	LEVELS	E1			E2			E3			E4		
	LINGUISTIC	ct	at	bt	ct	at	bt	ct	at	bt	ct	at	bt
1	VERY LOW												
2	LOW	0.00	3.00	6.00	1.00	4.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00
3	CURRENTLY	4.00	6.00	7,79	4.00	5.00	7,40	1.00	6.00	7,77	1.00	5.00	7.89
4	TALL	6.00	7,79	9.00	5.00	7,40	9.00	6.00	7,77	9.00	5.00	7.89	9.00
5	VERY HIGH	7,79	9.00	10.00	7,40	9.00	10.00	7,77	9.00	10.00	7.89	9.00	10.00

Aggregate the value of the middle, lower and upper limits on expert 5 to expert 7.

NO	LEVELS	E5			E6			E7		
	LINGUISTIC	ct	at	bt	ct	at	bt	ct	at	bt
1	VERY LOW									
2	LOW	1.00	3,33	5.91	0.00	0.00	0.00	0.00	0.00	0.00
3	CURRENTLY	3,33	5.91	7,79	3.00	5.69	7,63	3.00	6.00	7,21

4	TALL	5.91	7,79	9.00	5.69	7,63	9.00	6.00	7,21	9.00
5	VERY HIGH	7,79	9.00	10.00	7,63	9.00	10.00	7,21	9.00	10.00

f. The next step is to find the criterion defuzzification value, where the defuzzification method used is the centroid method. The formula for defuzzification criteria is as follows:

Defuzzifikasi N_t

$$= \frac{\left[\left[\int_{c_t}^{a_t} \frac{(x-c_t)}{(a_t-c_t)} x dx + \int_{a_t}^{b_t} \frac{(x-b_t)}{(a_t-b_t)} x dx\right]\right]}{\left[\left[\int_{c_t}^{a_t} \frac{(x-c_t)}{(a_t-c_t)} dx + \int_{a_t}^{b_t} \frac{(x-b_t)}{(a_t-b_t)} dx\right]\right]}$$

with : t = criteria 1,2,3.....n

Table 9. Main Aspect Defuzzy Value

No	Key Aspects	Defuzzy Value
1	TECHNOLOGICAL ASPECT	8,099
2	ASPECT OF OPERATIONAL STRATEGY	6,866
3	POSTURE ASPECTS OF THE INDONESIAN NAVY	7,623
4	THREAT PERCEPTION ASPECT	6,985
		29,574

Table 10. Technology Aspect Criteria Defuzzy Value

NO	CRITERIA	DEFUZZY VALUE
1	Integrated Systems	8,290
2	Monitoring	7,671
3	Big Data (IoT, AI & Machine Learning)	6,575
4	cyber	7,194
5	Autonomous (Ride & Weapon)	6,252
		35,982

Table 11. Defuzzy Value Criteria Aspects of Operations Strategy

NO	CRITERIA	DEFUZZY VALUE
1	Command & control / maritime operation center (Puskodal)	6,115
2	Coastal watch system (radar, ESM electronic support measure, long range camera)	4,060
3	Mobile surveillance (air, surface, subsurface unmanned vehicle)	6,020
4	Coastal defense (fixed & mobile missile system, sonar and sonobuoy)	6,194
5	Integrated air defense (arhanud marines, KRI class PKR)	5.185
6	Anti Submarine Warfare (ASW) defense	6,909
7	Sea task force / sea control at ALKI I, II and III	6,161
8	Human Resources Development	7,290
9	Risk Management	7,671
10	Logistics	6,877
		62,482

Table 12. Defuzzy Value of TNI AL Posture Aspect Criteria

NO	CRITERIA	DEFUZZY VALUE
1	SSAT (KRI, Pesud, Marines, Base, Special Forces, Personnel)	7,671
2	Security	6,575
3	Defense	7,194
4	Intelligence	6,252
5	Diplomacy	6,194
6	Dawinhanla	5.185
7	Support	6,909
8	Harvesting/Deployment/routine ops degrees	6,233
9	Degree of Enforcement/Employment/ sat.alert 3 trouble spot	7,433
		59,647

Table 13. Defuzzy Value of Threat Perception Aspect Criteria

NO	CRITERIA	DEFUZZY VALUE
1	Air (Aircraft, Drones, Missiles)	5,662
2	Warships (Surface & Sub Surface)	6,652
3	Maritime CyberSecurity	7,194
		19,508

g. The next step is processing the defuzzification value into the final weight value for each criterion, by dividing the weight value for each defuzzification criterion by the total number of weight values for all defuzzification criteria.

$$NB\ t = N\ t / \Sigma Nt(1\text{-}n)$$

NB t = The final weight value of each criterion
Nt = Defuzzification criterion weight value
Σ*Nt(1-n)* = Sum of the weight values of all defuzzification criteria

Table 14. Main Aspect Weighting Value

NO	MAIN ASPECT	FINAL WEIGHT
1	TECHNOLOGICAL ASPECT	0.27
2	ASPECT OF OPERATIONAL STRATEGY	0.23
3	POSTURE ASPECTS OF THE INDONESIAN NAVY	0.26
4	THREAT PERCEPTION ASPECT	0.24

Table 15. Technology Aspect Criteria Weighting Value

NO	CRITERIA	FINAL WEIGHT
1	Integrated Systems	0.230
2	Monitoring	0.213
3	Big Data (IoT, AI & Machine Learning)	0.183
4	cyber	0.200
5	Autonomous (Ride & Weapon)	0.174

Table 16. Operational Strategy Aspect Criteria Weighting Value

NO	CRITERIA	FINAL WEIGHT
1	Command & control / maritime operation center (Puskodal)	0.0979
2	Coastal watch system (radar, ESM electronic support measure, long range camera)	0.0650
3	Mobile surveillance (air, surface, subsurface unmanned vehicle)	0.0963
4	Coastal defense (fixed & mobile missile system, sonar and sonobuoy)	0.0991
5	Integrated air defense (arhanud marines, KRI class PKR)	0.0830
6	Anti Submarine Warfare (ASW) defense	0.1106
7	Sea task force / sea control at ALKI I, II and III	0.0986
8	Human Resources Development	0.1167
9	Risk Management	0.1228
10	Logistics	0.1101

Table 17. Indonesian Navy Posture Aspect Criteria Weighting Value

NO	CRITERIA	FINAL WEIGHT
1	SSAT (KRI, Pesud, Marines, Base, Special Forces, Personnel)	0.129
2	Security	0.110
3	Defense	0.121
4	Intelligence	0.105
5	Diplomacy	0.1039
6	Dawinhanla	0.0869
7	Support	0.1158
8	Harvesting/Deployment/routine ops degrees	0.104
9	Degree of Enforcement/Employment/ sat.alert 3 trouble spot	0.125

The value of the weight of influence (final weight) the level of importance of all aspects and criteria for the Smart Defense of the Archipelago Marine Defense Strategy:

1. **0.27** = Technology Aspect Constant Value
2. **0.23** = Constant Value of Operational Strategy Aspect
3. **0.26** = Constant Value of TNI AL Posture Aspect
4. **0.24** = Threat Perception Aspect Constant Value

7. CONCLUSION.

After carrying out the entire research process using the Delphi and Fuzzy Weighting methods, conclusions can be drawn based on the results of the data analysis and discussions that have been carried out.Indonesian Navy, namely in the order of: 1) Technology Aspect; 2) Aspects of TNI AL Posture; 3) Threat Perception Aspect and the next is 4) Operations Strategy Aspect.

Variables on the main aspects that influence the Smart Defense model of the Nusantara Sea Defense Strategy are as follows:

a. On the Technology Aspect with integrated system key variables.

b. In the Operations Strategy Aspect where the key variable is sea control/sea task force at ALKI I, II and III. c. In the Indonesian Navy's Posture Aspect where the key variable is Operational Degree which is influenced by the variables Harvesting / Deployment / routine operations and Enforcement / Employment / Standby Unit 3 (three) trouble spots.
d. On the Threat Perception Aspect where the key variable is Maritime Cyber Security.

This research shows the important role of several variables to increase the Smart Defense value of the Nusantara Sea Defense Strategy and also emphasizes the importance of efforts to overcome maritime security threats, including cyber threats.

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CYBER WARFARE THREATS AND ANALYZING READINESS OF THE INDONESIAN NAVY IN PRIORITIZING VARIABLES

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ABSTRACT

The advancement of information technology has greatly impacted various aspects of human life, including the Indonesian Navy. This progress has given rise to the concept of Cyber Warfare, which involves conducting warfare through information technology. Cyber warfare refers to actions taken by a country or international organization to attack and undermine another country's computer or information networks, typically through means like viruses or denial of service attacks.In light of these circumstances and challenges, the authors undertook an analysis to assess the readiness of the Indonesian Navy in dealing with the threat of cyber attacks, both domestically and internationally. This research employed cyber warfare threat modelling, which involved weighing and prioritizing key variables such as offensive cyber operations, cyber espionage operations, and cyber support. The objective of this study was to develop a Cyber Warfare threat model to support the responsibilities of the Indonesian Navy. Data processing for this research involved collecting relevant data from activities conducted at Satsiberal Headquarters, which was then analyzed using Fuzzy weighting. Additionally, the Dynamic System modelling method was employed to ascertain the interrelationships between variables and simulate the best alternative scenario. The results of the modellingg and simulation provided valuable insights for addressing the cyber warfare threat effectively

Keywords**:** *Cyber Warfare Threats, Indonesian Navy, Dynamic System*.

1. INTRODUCTION.

Based on Law Number 34 of 2004 concerning the TNI (Indonesian National Army) Article 7 discusses the main tasks of the TNI, namely upholding state sovereignty, maintaining the territorial integrity of the Unitary State of the Republic of Indonesia based on Pancasila and the 1945 Constitution of the Republic of Indonesia, and protecting the entire nation of Indonesia and all of Indonesia's bloodshed from threats and disturbances to the integrity of the nation and state. The main tasks referred to in paragraph (1) are carried out through military operations for war and military operations other than war, namely to overcome armed separatist movements, overcome armed rebellions, and overcome acts of terrorism. The Navy as an integral part of the TNI, carries out the duties of the TNI in the field of defense, including uphold the law and maintaining security in the sea area of national jurisdiction in accordance with ratified national and international legal provisions, carrying out naval diplomacy tasks in order to support foreign policy policies set by the government, carry out TNI duties in building and developing maritime dimension forces, and carry out the defense of maritime defense areas. The Indonesian Navy is always required to be able to adapt to changes in the environment that occur, especially in facing increasingly severe threats, disturbances, challenges and obstacles in the future. carry out the diplomatic duties of the Navy in order to support the foreign policy policies set by the government, carry out the duties of the TNI in the development and development of maritime dimension forces, and carry out the empowerment of the maritime defense area. The Indonesian Navy is always required to be able to adapt to changes in the environment that occur, especially in facing

increasingly severe threats, disturbances, challenges and obstacles in the future. carry out the diplomatic duties of the Navy in order to support the foreign policy policies set by the government, carry out the duties of the TNI in the development and development of maritime dimension forces, and carry out the empowerment of the maritime defense area. The Indonesian Navy is always required to be able to adapt to changes in the environment that occur, especially in facing increasingly severe threats, disturbances, challenges and obstacles in the future.

Based on the situation and problems above, the authors conducted an analysis regarding the readiness of the Indonesian Navy in facing the threat of cyber attacks, both from within the country and from abroad. Where in this research carried out using cyber warfare threat modeling by carrying out weighting and prioritization on the variables of offensive cyber operation (aspects of enforcement), offensive cyber operations (aspects of defense), espionage cyber operations (aspects of intelligence), cyber support using a system approach and modeling dynamic. The advantage of using the system dynamic approach is that the dynamic system has a very good ability to explain the behavior and characteristics of the system being observed and can explain the causal relationship and consequences of changing the state of each variable properly and with the simulation concept it has. Modeling using a dynamic system also has flexibility in its application and also does not interfere with the real system being observed.

2. MATERIALS/METHODS

2.1 Cyber Theory.

The government needs to cooperate with other countries to build global security. One country may not be able to protect itself in dealing with this global threat. Cooperation between countries is also expected to be able to trigger a regulation in the field of cyber or cyber law that is stronger and has a global effect. With the existence of strict cyber laws in the international world, it would be possible to reduce the rampant crime in the cyber world. Before this is implemented, it would be wiser for Indonesia to reorganize its mastery of technology and make specific laws regarding cyber threats. Several countries already have special units of cyber troops in the defense and security of a country. The agency or organization is tasked with compiling all defense efforts and counterattacks against security in the cyber world and its network systems. Seeing the strengths and threats that can occur due to advances in information technology, many countries have begun to build cyber warfare naval forces.

2.2 Cyber Warfare.

Cyber warfare is hacking or data theft through internet/computer/cyber networks based on political motivation with the aim of sabotage or espionage against certain interests. Meanwhile, according to Richard A. Clarke in May 2010 in his book Cyber Warfare is an action by a state/nation to penetrate another nation's computer or network with the aim of causing damage or disruption. While cyber warfare in the global political sphere can be understood as a political action that involves the ability of computer hacking to achieve the goals of the owner of the interest, which among other things can be done through activities such as sabotage and espionage.

Cyber warfare is the latest form of war that uses computer networks and the internet or cyberspace in a strategy of defense or attack on the opponent's information system. Cyber warfare is also known as war which refers to the use of www (world wide web) facilities and computer networks to wage war in cyberspace. Today's cyber warfare activities can be included in the category of low-level

information warfare, which in the next few years may be considered as true information warfare. As a form of information warfare and cyber warfare activities is the use of information technology, communications and the internet to wage war in cyberspace. The internet system is strategically very vulnerable to disruption or attack, and it is very difficult to defend against attacks and distractions, so preparation, vigilance and layered defense are needed. The tactics and strategies used can be in the form of espionage, propaganda, stopping internet operations, modifying data and manipulating infrastructure, and will continue to grow, all of this will be very detrimental and weaken a country.

2.3 Cyber Warfare Threats

Until now cyber security experts in various parts of the world continue to try to defend computer systems from online crime. Cyber attacks attack business and personal systems every day. The number and types of cyber security threats continue to grow every day. Cyber security threats refer to possible criminal acts or attacks that attempt to legitimately access data, disrupt digital operations or damage information. These cyber threats can come from a variety of things, including corporate spies, hackers, terrorist groups, criminal organizations to employees who are dissatisfied with the company. These cyber attackers can use sensitive data belonging to individuals or companies to steal information or gain access to their financial accounts. Those are just a few examples of harmful hacker acts. That is why the role of professionals in the field of cyber security is urgently needed at this time to keep personal data protected. A cyber security expert must have an in-depth understanding of the various types of security threats on the internet, including:

a. Malware (Malicious Ware).

Malware is malicious software including viruses, worms, ransomware and spyware. The malware is activated when a user clicks on a link or attachment from an unsafe source.

b. Emotet.

The Cybersecurity and Infrastructure Security Agency (CISA) describes Emotet as an advanced modular form of Trojan development that works as a downloader or penetrates other Trojan developments. Emotet continues to be one of the most expensive and destructive pieces of malware today. Emotet spreads through e-mails, e-mail attachments, and even masquerading as one of the windows applications.

c. Denial of service (DoS)

DoS is a type of cyber attack that attacks a computer or network so that it cannot fulfill requests from users, causing the computer to not function normally or even cause damage.

d. Man In the Middle (MITM).

MITM Is a type of cyber attack, in which the hacker is in the middle of a conversation or data transmission process that occurs between the user (victim) and a website or application, without the victim knowing about it. Simply put, hackers intercept conversations and exchange data that should be confidential. Not only tapping, hackers can also disguise their identity as one of the parties involved. So as if the process of exchanging data or information occurs normally without any irregularities.

2.4 Systems Thinking

System thinking is a way of looking at something as a whole, where the parts are interconnected. Seeing as a whole means learning to understand every part involved in a system. System thinking is one of the important competencies for leaders to have. This competency allows leaders to more effectively handle and

examine the complexities of both external and internal organizations, spot problems, and recognize where changes are needed.

System thinking has its basis from various sources such as the Hollis concept of Jan Smuts in the 1920s, systems theory proposed by Ludwig von Bertalanffy in the 1940s, and cybernetics proposed by Ross Ashby in the 1950s. This field was later developed by Jay Forrester, a professor at MIT in 1956. In the book The Fifth Discipline by Peter Senge, he explained that system thinking is a pillar/basic concept of learning organization. The character of System Thinking is being able to solve difficult problems very effectively especially those involving complex problems, having a lot of feedback both internal and external and problems that are very dependent on past events or other events, so that problem solving becomes more systematic.a.

Complex, namely the interaction between elements is quite complicated.

b. Dynamic, namely the factors that change according to time.

c. Probabilistic, namely the need for a chance function in inference, conclusions and recommendations. According to Kast and James (2001), general concepts in systems science are as follows:

a. The system is comprehensive.

b. Open systems view (a relatively open system view).

c. The system receives various inputs, transforms various inputs and produces outputs in relation to the environment.

d. System boundaries (the system has boundaries).

e. Negative entropy (the system is made from a heterogeneous and sometimes negative environment).

f. The system can reach a stable position if the system is in dynamic equilibrium because negative environmental influences are minimized.

2.5 Modeling Theory.

Modellin, in general, is understood as a process of representing real objects or reality as a set of mathematical equations, graphics or charts so that it is easily understood by interested parties. More specifically, the term is often used for the process of describing the concepts that represent objects in the development of information systems. Modeling in the development of information systems, evolves in line with technological developments and development methodologies. With an object approach known as UML (Unified Modeling Language) which produces representations that can be verified through logical reasoning, testing, or even simulation.

If the model formulation is carried out, the next step will be to evaluate the system model including accuracy, availability of estimates of variables, interpretation, and validation. In this case the model formulation is always carried out based on the prevailing theories in the area where the system is located. Some of the steps that are usually carried out to carry out model formulation are from the point of view of the system and its environment. From the point of view of the level of system certainty. From the point of view of system dynamics. From the point of view of the continuity of the system. Furthermore, data processing uses the Fuzzy weighting algorithm up to level eight (Liang & Wang, 1994), Make the results of the weighting assessment of the qualitative aspect variable level. Make the results of the weighting of the assessment of the level of qualitative criteria variables. Determine the middle value of the fuzzy number (at), by adding up the values that appear at each level of the linguistic scale and then dividing the sum by the number of aspects

or criteria whose values enter that level of linguistic assessment. Determine the lower limit value (ct) and upper limit value (bt) of fuzzy numbers, where the lower limit value (ct =b(i - 1)) is the same as the middle value of the level below it, while the upper limit value (bt = b (i - 1)) is the same as the middle value of the level above it.

Determining the aggregate weight of each qualitative criterion, becauseIn this study a form of linguistic assessment was used which already had a triangular fuzzy number definition, so the aggregation process was carried out by finding the aggregate value of each lower limit value (c), middle value (a) and upper limit value (b). Look for the criterion defuzzification value, where the defuzzification method used is the centroid method. The next step is processing the defuzzification value into the final weight value for each criterion, by dividing the weight value for each defuzzification criterion by the total number of weight values for all defuzzification criteria. After implementing the Fuzzy weighting algorithm, then carry out data processing using dynamic system modelling, namely a methodology for understanding a complex problem. This methodology focuses on policymaking and how these policies determine the behavior of problems that can be dynamically modeled by systems (Richardson and Pugh 1986). The purpose of a dynamic system methodology based on a causal philosophy (cause and effect) is to gain a deep understanding of how a system works (Asyiawati, 2002, Muhammad, 2001). The stages in the system dynamic approach are:

a. Identification and definition of the problem.
b. System conceptualization.
c. Model formulation.
d. Model simulation.
e. Model verification and validation.
f. Policy analysis.
g. Policy implementation.

2.6 Research Flowchart

The stages in this research were carried out in several sequences, namely by identifying problems from several variables, followed by searching for literature sources from literature studies and from field studies that had been carried out. then carrying out data collection, identification of variables followed by carrying out processing of the data that has been obtained. To further carry out the verification and validation stages of model suitability, scenario application, and analysis so that conclusions can be obtained from the research that has been carried out

3. RESULTS AND DISCUSSION.

In this section, data analysis and research results are carried out. The data obtained is in the form of data consisting of primary and secondary data obtained by conducting direct interviews with experts from relevant agencies and also with ship journals in the field. Efforts in data collection are aimed at obtaining valid data so that it can be used according to research objectives.

3.1 Identification and Weighting of Major Cyber Warfare Threat Variables.

The purpose of identifying this variable is to deepen knowledge of the object to be studied. The identified variables are variables related to the level of threats to cyber warfare in supporting the tasks of the Indonesian Navy, then weighting is carried out in order to find the influence of the level of importance of the variable aspects and criteria.

Table 1 Identification of Main Model Variable Threats of Cyber warfare

Principal Cyber Warfare Threat Models		
No	**Variable**	**Description**
1.	Defensive Cyber Operations	Operations to protect data and information infrastructure as a matter of mission assurance.
2.	Offensive Cyber Operations	Operations to penetrate systems, exploit software weaknesses, and identify security holes that allow access.
3.	Cyber Operations Intelligence	Activities and actions carried out based on a plan to achieve a routine goal in relation to space and time are carried out on the basis of orders from superiors in authority.
4.	Cyber Support	Supporting activities carried out to assist in the smooth implementation of cyber tasks and missions.

After the identification of the influential variables in the cyber warfare threat model is carried out, then the research is continued by looking for the weight of the influence of the importance level of the aspect variables and criteria. The initial stage in the preparation of the model is the identification and data collection of the main aspect variables that influence the threat of cyber warfare obtained from previous research references and the results of Depth Interview interviews with experts. The purpose of identifying this aspect variable is to sharpen the researcher in processing and compiling the model to be studied which will later be used as a constant in the System Dynamic modeling formulation to determine values.

E1 : Expert 1
E2 : Expert 2
E3 : Expert 3
E4 : Expert 4
E5 : Expert 5

Table 2 Aggregated Assessment Criteria for Defensive Cyber Ops Aspects.

NO	**CRITERIA**	**E1**	**E2**	**E3**	**E4**	**E5**
1	Monitoring	8	9	9	9	9
2	Observation	8	8	7	7	7
3	Identification	8	8	9	9	9
4	Protection	8	5	8	6	7
5	Mitigation	9	8	8	9	8
6	Investigation	8	9	9	9	8
7	Countermeasures	9	9	9	7	9
8	Recovery	8	7	8	9	8

Table 3 Aggregated Assessment Criteria for Aspects of Offensive Cyber Ops.

NO	CRITERIA	E1	E2	E3	E4	E5
1	Exploitation	8	9	9	9	9
2	Forensics	8	8	6	8	8
3	Counter Exploitation	9	9	9	8	8
4	Information and Network Attacks	9	4	7	8	7

Table 4 Aggregate Criteria Assessment Aspects of Support Cyber.

NO	CRITERIA	E1	E2	E3	E4	E5
1	Development Planning	9	9	9	9	9
2	System Development	7	7	8	8	8
3	Cyber Certification	8	8	9	9	9
4	Implementation of Training	8	5	7	7	5
5	Cyber Workshops	8	9	9	9	9
6	Operations Support	8	7	9	8	9

Table 5 Aggregated Assessment of Cyber Ops Intelligence Aspect Criteria.

NO	CRITERIA	E1	E2	E3	E4	E5
A	**TACTICAL**					
1	Security Operation Center/SOC	9	9	8	9	8
2	Security Information Event Management/SIEM	9	9	8	9	9
3	Firewalls	8	8	9	8	9
4	End Points	9	9	9	8	8
5	Instruction Detection System/IDS & Instruction Prevention System/IPS)	7	9	8	7	8
B	**OPERATIONAL**					
1	Threat Hunter	9	8	7	9	9
2	SOC Analysist	8	9	9	9	8
3	Vulnerability Management	8	9	8	8	8
4	Incident Responses	9	8	9	9	9
5	Insider Threat	9	9	9	8	8
C	**STRATEGIC**					
1	Chief Information Security Officer/CISO	8	9	9	8	9

NO	CRITERIA	E1	E2	E3	E4	E5
2	Chief Information Officer/CIO	8	9	9	8	9
3	Chief Technology Officer/CTO	9	9	9	8	8
4	Executive Board	9	8	8	9	9
5	Strategic Intelligence	9	9	9	8	9

Table 6 Main Aspect Weighting Value.

NO	MAIN ASPECT	FINAL WEIGHT
1	The aspect of Defensive Cyber Operation	0.27
2	Offensive Aspects Of Cyber Operation	0.24
3	Aspect Of Cyber Support	0.25
4	Intelligence Aspect Of Cyber Operation	0.24

Table 7 Defensive Cyber Ops Aspect Weighted Values

NO	CRITERIA	FINAL WEIGHT
1	Monitoring	0.1391
2	Observation	0.0774
3	Identification	0.1273
4	Protection	0.1229
5	Mitigation	0.0998
6	Investigation	0.1523
7	Countermeasures	0.1246
8	Recovery	0.1567

Table 8 Offensive Cyber Ops Aspect Weighted Values

NO	CRITERIA	FINAL WEIGHT
1	Exploitation	0.292
2	Forensics	0.260
3	Counter Exploitation	0.208
4	Information and Network Attacks	0.240

Table 9 Aspect Weighting Value of Cyber Support.

NO	CRITERIA	FINAL WEIGHT
1	Development Planning	0.1051

2	System Development	0.1669
3	Cyber Certification	0.1729
4	Implementation of Training	0.2068
5	Cyber Workshops	0.1356
6	Operations Support	0.2128

Table 10 Aspect Weighting Value of Cyber Ops Intelligence.

NO	CRITERIA	FINAL WEIGHT
A	**tactical**	
1	Security Operation Center/SOC	0.0396
2	Security Information Event Management/SIEM	0.0651
3	Firewalls	0.1669
4	End Points	0.0511
5	Instruction Detection System/IDS & Instruction Prevention System/IPS)	0.0779
B	**OPERATIONAL**	
1	Threat Hunter	0.0779
2	SOC Analysist	0.0637
3	Vulnerability Management	0.0801
4	Incident Responses	0.0511
5	Insider Threat	0.0779
C	**STRATEGIC**	
1	Chief Information Security Officer/CISO	0.0511
2	Chief Information Officer/CIO	0.0779
3	Chief Technology Officer/CTO	0.0637
4	Executive Board	0.0801
5	Strategic Intelligence	0.0801

3.2 Main Concept of a Threat Model.

The causal loop model is made to show the variables described in the model, in this case, it has been compiled based on the initial variables that have been identified.

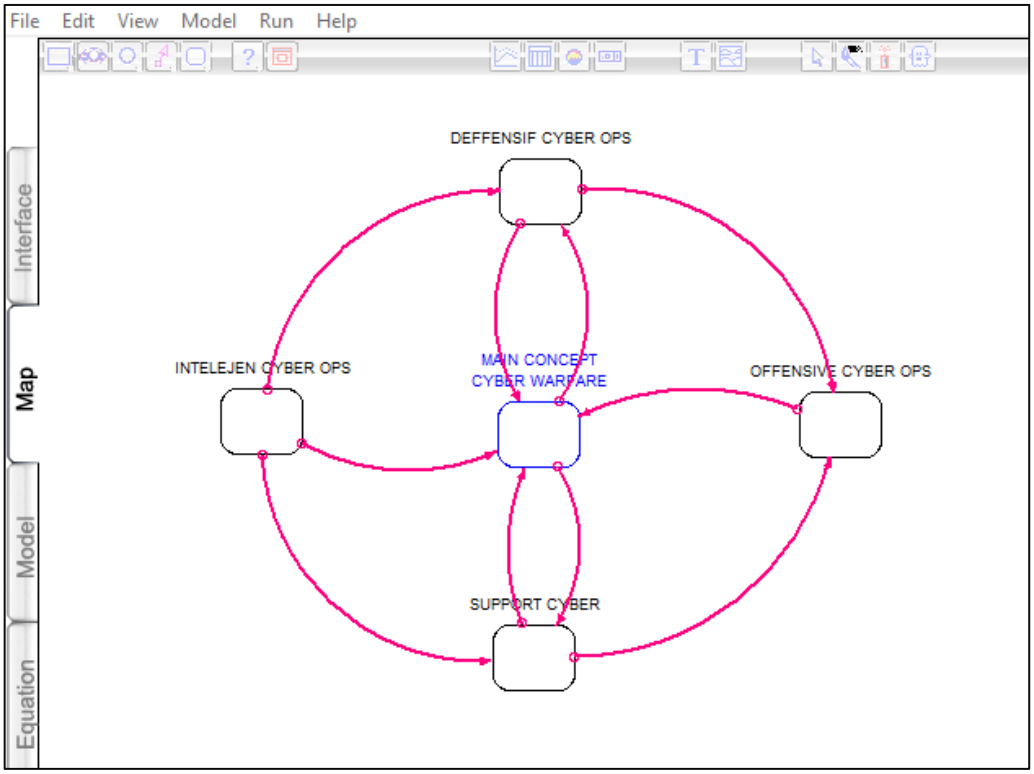

Figure 1 Main Concept

Figure 3.1 is the structuralization of models and systems that occur in the cyber warfare threat model system. From the conceptualization of the causal loop diagram model above, it can be seen that the cyber warfare threat system is influenced by the development of system dynamics from 4 (four) variables, namely Defensive Cyber Operation, Offensive Cyber Operation, Intelligence Cyber Operation, and Cyber Support.

CONCLUSION.

After carrying out the entire data processing process in working on the thesis, conclusions can be made based on the results of data analysis and discussion that have been carried out. There are 4 (four) main variables of the cyber warfare threat model, namely Defensive Cyber Ops, Offensive Cyber Ops, Espionage Cyber Ops, and Cyber Support. Where each variable influences each other on threats so that this can be implemented as a consideration for the leadership of the Indonesian Navy in making decisions.

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CAUSAL ANALYSIS OF INDONESIA ARCHIPELAGO MARINE DEFENSE SYSTEM: A DELPHI-DEMATEL APPROACH

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ABSTRACT

The development of science and technological advances as well as the era of globalization encourage the emergence of new layers and dimensions of shifting perceptions of threats as well expanding scale and destructive power for increasingly complex state life. With these changes affecting the policy of the national defense strategy which has an impact on the role and approach of the Indonesian Navy towards the concept of the archipelago's maritime defense and security system (SPLN). A country's maritime defense strategy is no longer limited to its territorial waters or the surrounding sea, but also oriented both regionally and globally. The Indonesian Navy's strength posture plays an important role for the Indonesian Navy in determining the strategy to be implemented to address the problems. This research uses the DELPHI-DEMATEL framework which aims to identify and provide an overview of the relationship between variables from the Indonesian Navy's Posture and the development of the strategic environment in the implications of the Archipelago Sea Defense System (SPLN). The methodological design of this study identified several variables from TNI AL and the development of the strategic environment posture through a literature review resulting in 10 main variables, using the DELPHI method analysis obtained 8 variables that were feasible for further analysis. DEMATEL was used to process and interpret the collected data and cause-effect relationships were established between variables. DEMATEL's analysis shows that the variables Technology, Socio-Cultural, Strength, Capability, Operational Degree, and Potential Threats fall into the causal group. These factors are very important because they directly affect the Real Threat, Economy, Politic and Defense factors.

Keywords: DELPHI-DEMATEL, Archipelago Marine Defens System (SPLN), Indonesian Navy Posture.

1. INTRODUCTION.

The science and Technology Developments, which was marked by the rapid exchange of information and communication, these advances have had positive and negative impacts on the life of the nation and state(Ellitan, 2020). This also has an impact on the National Interest which includes all important matters for the survival and welfare of the Indonesian state in the aspects of security, defense, economic stability, foreign policy, and people's welfare. With changes in threat perception that are increasingly dynamic, this paradigm also influences national defense strategy policies that have an impact on the role and approach of the Indonesian Navy towards the concept of the archipelago's maritime defense and security system. A country's maritime defense strategy is no longer limited to its territorial waters or the surrounding sea but is also oriented both regionally and globally. According to Ugur Yetkin, the modern Navy has multiple missions: nuclear deterrence and ballistic missile defens, control of the sea, projection of force, order at sea and maritime consensus (Yetkin, 2013).

With the development of warfare technology and weaponry pioneered by the superpowers and their allies, this has further expanded the scale, dimensions of war and the destructive power caused by war for the survival of the state. Competition for the military strengthening of a country in a region has contributed to the escalation of tensions due to the emergence of a feeling of insecurity and friction between the interests of each country (Posen, 1993). To balance this progress, the Indonesian Navy's posture is required to continue to experience

modernization and adjustments in line with advances in weapons technology, also in proportion to the actual and potential threats that pose a challenge in realizing the interests of the state and maintaining of Indonesia sovereignty and the Unitary State (Cordesman et al., 2015)

2. MATERIALS AND METHODOLOGY.

2.1. Maritime Security

Zumwalt classifies naval missions: Strategic deterrence, Force projection, Naval command, and Naval presence. Thus, a theoretical understanding of naval capabilities and the use of military force in a state's efforts to preserve its existence and protect its interests is developed (Geoffrey Till, 1982). Currently various things appear to pose a threat to the use of the sea in Indonesia. Indonesia, which has so far maintained its image as an "honest broker" in the maritime structure in the South China Sea, has experienced many challenges to its territorial claims. Under President Jokowi, Indonesia's approach to the South China Sea conflict has changed. The initial intention to find a peaceful solution to the dispute in the area has become a policy that serves Indonesia's national interests in Natuna waters, much to the displeasure of China. (Connelly, 2015). As a marine military force in Indonesia, the Indonesian Navy is expected to be able to direct its focus and capabilities in securing Indonesian waters.

2.2 Delphi

Delphi is a group process that involves communication between a researcher and a group of experts on a particular topic, usually using a questionnaire. (Yousuf, 2007). This method is used to build consensus on future predictions/trends using a systematic data collection process. This method is useful when the opinions and judgments of experts and practitioners are needed to solve problems. This is especially useful when experts cannot be present at the same time (Renalda et al., 2021). The Delphi method aggregates decisions on complex questions when relevant information is not available (Skutsdh et al., 1973). The Delphi process describes with the following six stages (Linstone et al., 2002):

a. Identify group members whose consensus opinion is needed. The group must be able to represent a variety of viewpoints that are proportionally represented.

b. First questionnaire. Ask each member to write down goals, considerations, or issues related to the expected consensus goals. Next, arrange the information so that it is organized. Then prepare a second questionnaire with a more structured format so that an assessment can be carried out.

c. Second questionnaire. Each member was asked to provide an assessment of the results of the first recap, each panelist gave a reason/brief explanation. The results of the first questionnaire were displayed in the second questionnaire, and each panelist was asked again to provide an assessment and ranking and to give reasons for deciding to be in a different position from the group.

d. The results of the second questionnaire were tabulated and presented as group consensus results.

In the early stages, the informants will answer based on the information, knowledge and experience they have. The informants provided their answers or opinions with a rating scale between 1 (one) to 9 (nine) based on the level of importance of the instrument to be developed. With the information that the scale is 1 (very unimportant) and 9 (very important). Furthermore, the results of the assessment from the resource persons were tabulated and processed into the Delphi method formula so that they became a presentation of the results of the agreement of the resource persons group.

The instruments that have converged or reached a consensus from sources who consider it important to develop are using statistical analysis with the following approaches (Linstone et al., 2002):

a. Standard deviation. A criteria is stated convergence or reach the consensus rating is when the standard deviation of all responses or ratings from all sources is <1.5. The formula is below:

$$S = \sqrt{\frac{\sum(xi - x)2}{n-1}} \sqrt{\frac{\sum xi^2 - \frac{(\sum x1)2}{n}}{n-1}} \ldots\ldots (2.1)$$

b. The interquartile range is a measure of convergence or other consensus judgment when the responses or estimates from all sources have an interquartile range less than 2,5. The formula for the interquartile range is:

$$Q1 = \frac{x\left(\frac{n-1}{4}\right) + x(\frac{n+3}{4})}{2} \ldots\ldots\ldots\ldots\ldots (2.2)$$

$$Q2 = x\ \frac{2(n+1)}{4} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.3)$$

$$Q3 = \frac{x\left(\frac{3n-1}{4}\right) + x(\frac{3n+5}{4})}{2} \ldots\ldots\ldots (2.4)$$

A criteria is stated convergence or reach the consensus rating is when the standard deviation of all responses or ratings from all sources is <1.5 and the interquartile range is < 2.5. If neither the standard deviation nor the interquartile range is < 1.5 and < 2.5, then the instrument is declared not convergent or there is no consensus that the instrument is not important and has the potential to be developed. After an evaluation has been carried out which states that the instrument is convergent or it is agreed (consensus) that the instrument is important and has the potential to be developed, the next step is to rank it with the highest average value for each convergent instrument.

2.3. DEMATEL

DEMATEL is a method used to describe the correlation of complex cause-effect connection between variables of a system and obtain the level of influence of these variable. Complex interactions between system components can be visualized in DEMATEL (Zhou et al., 2011). The steps taken in carrying out the analysis using the DEMATEL method, shown the below:

First Step is Determind the avg Matrix. We have several experts (H) to give their opinions and N reasons to consider. each stakeholder was asked to explain his belife that factor i affects factor j. The pairwise comparison of the i-th factor with the j-th factor is given by the k-th expert, which is indicated by b_{ij} which in integer starting from following below:

Table 1. The Value of Importance Level

Mark	Information
0	No effect
1	Low impact
2	Moderate impact
3	High impact
4	Very high impact

.

Scores of each an expert constructs a non-negative matrix with answer an xn. So, ,... is the response matrix of H experts. The diagonal elements of each response matrix are all set to zero, which means there is no effect by itself.

$$B^k = \left[b_{ij}^{(k)}\right]_{n \times n} B^1 B^2 B^{(H)} B^k$$

$$a_{ij} = \frac{1}{H}\sum_{k=1}^{H} b_{ij}^{(k)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.5)$$

For the next step, we know the causal relationships between each pair of factors by visualize a influence map (Chang et al., 2018). Arrows in influence maps indicate the value and strength of influence. DEMATEL can transform the structural relationships between system factors into understandable system maps (Hsu et al., 2014).

Second Step:Determine the initial normalized direct relationship matrix.The initial normalized correlation matrix is obtained by normalizing the average matrix A in the following way (Yang and Tzeng, 2011): $D = \left[d_{ij}\right]_{n \times n}$

$S = \max\left(max \sum_{j=1}^{n} a_{ij}\ max \sum_{i=1}^{n} a_{ij}\right)$.....(2.6)

$D = \frac{A}{S}$

The sum of each row in the direct relationship matrix are show the total direct effect of factor to another factor. The positive scalar S takes the greater of the two as the scale factor, and matrix D is obtained by dividing each element of A by scalar S. Note that each element of matrix D is between 0 and 1 (Ilham and Asvial, 2022).

$\sum_{j=1}^{n} a_{ij}\ \sum_{i=1}^{n} a_{ij}\ d_{ij}$ .....(2.7)

Third Step is Determine the Total Relation Matrix. The normalized strength the beginning direct relationship matrix, called the indirect effect, can be used to represent the Length of effects. The total effect can be determine by summing DEMATEL assuming it will be converted to a zero matrix and the total relationships matrix (Calderbank et al., 1986). It can be obtained by

$D, D^m\ D, D^2, D^3 \ldots D^\infty\ D^m D + D^2 + D^3 + \cdots + D^\infty$

$T = \lim_{n\to\infty}(D, D^2, D^3 \ldots D^\infty) = D(1-D)^{-1}$.....2.8)

However, if it is assumed that , is wrong, then T = may not be obtained, then the total relation matrix T is as follows:

$\lim_{n\to\infty} D^m = [0]_{n\times n}\ D + D^2 + D^3 + \cdots + D^\infty$

$r = [r_i]_{n\times 1} = \left(\sum_{j=1}^{n} t_{ij}\right)_{n\times 1}'$..... ....(2.9)

$c = \left[c_j\right]_{1\times n} = \left(\sum_{j=1}^{n} t_{ij}\right)_{1\times n}$..... ....(2.10)

Fourth Step is Determine the threshold velue and impact digraph. In order to determine the structural relationship between factors while keeping system complexity at a manageable level, it is necessary to set thresholds to filter out some of the smaller effects of the T-matrix. Although each variable in the T-matrix provides information about how one variable affects the other, decision makers must set thresholds to reduce the complexity of modeling the structural relationships in the T-matrix. The effect ratio map shows only a few variables with an effect greater than the threshold value (Tzeng et al., 2007).

The steps of the DEMATEL method can be seen clearly in the summary diagram of work steps as follows:

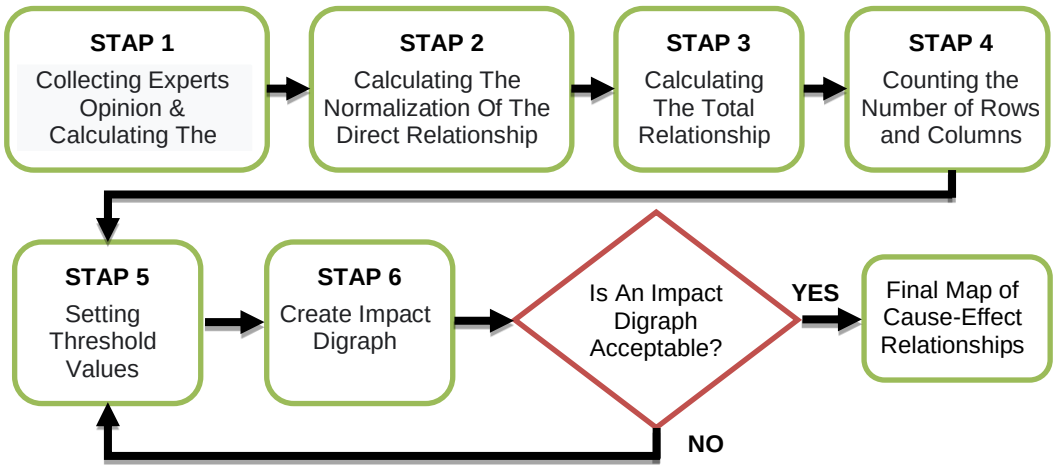

Figure 1. Steps in the DEMATEL Method

2.4. Frameworks Methodology

This study uses a four-step methodology to answer the research objectives. Studies using the multicriteria decision analysis (MCDA) method Delphi and DEMATEL are summarized in the Framework Diagram below.

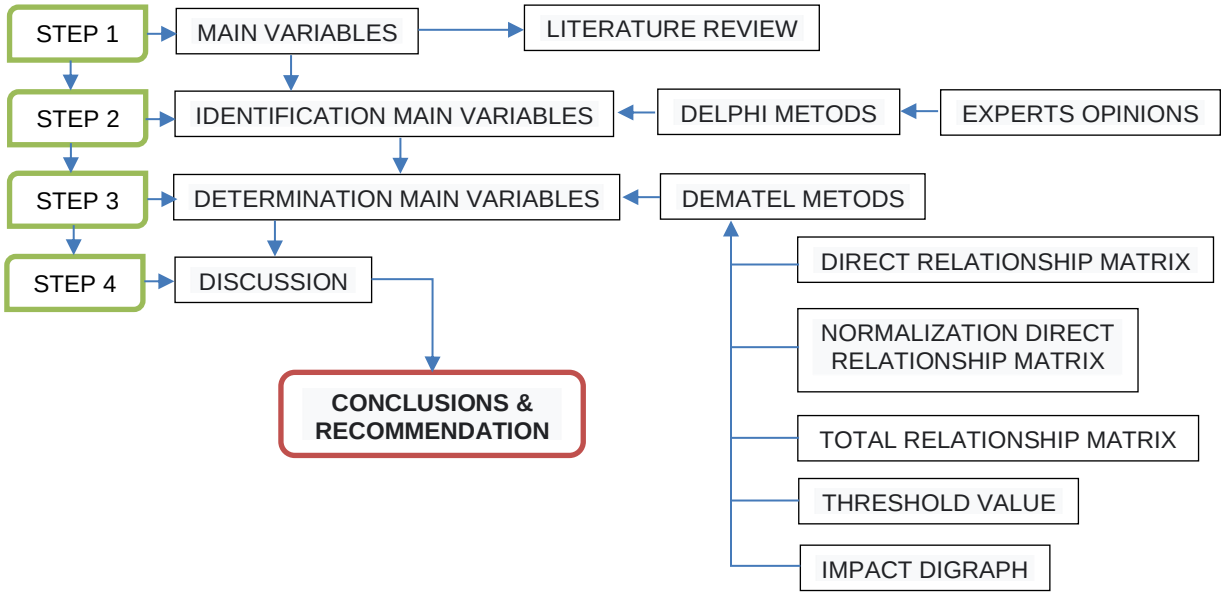

Figure 2. Research Framework

3. RESULTS AND DISCUSSION.

In this section, the results of the data processing performed in this study are displayed, while the results of data processing are as follows.

3.1. Key Variable Identification

Questionnaires were administered to several Experts to provide an assessment of the main variables obtained based on the literature review carried out based on the knowledge, experience and understanding of the Experts. The main variables of the criteria for the archipelago's marine defense system can be seen in the Table 2 below:

Table 2. Main Variable Criteria

CRITERIA	CODE	VARIABLE	REFERENCE
Threat Perception	K1	Real Threat	Decision head of the Indonesian Navy No. 6, 2016
	K2	Potential Threats	
Indonesian Navy Posture	K3	Capability	Decision head of the Indonesian Navy No. 6, 2016
	K4	Strength	
	K5	Power Projection	
Strategic Environmental Development	K6	Political	Decision head of the Indonesian Navy No. 6, 2016
	K7	Economy	
	K8	Socio-cultural	
	K9	Defense & security	
	K10	Technology	Experts Interview

Analysis of the Delphi method was carried out in 2 (two) rounds which were used to identify the relevant main variables to be developed into the next analysis model. The results of the questionnaire to 5 (five) Experts were then processed using the Delphi method with the results that can be seen in Table 3 as follows:

Table 3. Results of the Delphi Method Analysis

NO	EXPERT	CRITERIA									
		K-1	K-2	K-3	K-4	K-5	K-6	K-7	K-8	K-9	K-10
1	E1	5	8	9	9	8	8	6	6	8	9
2	E2	7	9	9	8	8	9	8	6	9	7
3	E3	8	7	9	9	7	7	7	3	7	8
4	E4	6	7	8	7	8	8	7	4	8	9
5	E5	7	9	9	8	6	8	8	5	8	9
SCORE		33	40	44	41	37	40	36	24	40	42
MARK		7,94	12.70	14,29	14,29	12.70	12.70	9.52	9.52	12.70	14,29
MIN		5	7	8	7	6	7	6	3	7	7
MAX		8	9	9	9	8	9	8	6	9	9
AVERAGE		6,60	8.00	8.80	8,20	7,40	8.00	7,20	4.80	8.00	8.40
STD DEV		1.14	1.00	0.45	0.84	0.89	0.71	0.84	1.30	0.71	0.89
CONVERGEN	= that the instrument is important and has the potential to be developed										
DIVERGEN	= that the instrument is not important and has no potential to be developed										

From processing data analysis using the Delphi method on the main variables of the Archipelago's Marine Defense Posture and Strategy, 8 (eight) main variables were obtained that were feasible to be developed in the next model analysis, the eight main variables were as follows:

a. Potential Threats
b. Ability
c. Strength
d. Power Projection
e. Political
f. Economy
g. Defense and security
h. Technology

3.2. Causal Interconction Relationship Between Variables

To find out the relationship between variables, the authors use the DEMATEL method of analysis to determine the most dominant variable. The results of the DEMATEL analysis are shown in *Inner Dependent Matrix*and Impact digraph as follows:

First Step is Determind the avg Matrix. The average matrix obtained from the expert questionnaire can be seen in the Table 4 below:

Table 4. Average Matrix

AVERAGE MATRIX			THREAT PERCEPTION	INDONESIAN NAVY POSTURE			STRATEGIC ENVIRONMENTAL DEVELOPMENT				SUM
			Potential Threats	Capability	Strength	Power Projection	Political	Economy	Defense	Technology	
			K2	K3	K4	K5	K6	K7	K9	K10	
THREAT PERCEPTION	**Potential Threats**	K2	0	3,6	3,8	4	3,6	3	4,4	4,4	26,8
INDONESIAN NAVY POSTURE	**Capability**	K3	3,8	0	4,8	4	3,2	3,4	4	3,2	26,4
	Strength	K4	3,8	4,4	0	4	4,4	3,8	4,2	3,8	28,4
	Power Projection	K5	3,8	3,6	4,6	0	3,6	3,6	4,2	3,4	26,8
	Political	K6	3,4	2,8	3,6	3,4	0	4,4	4	3,2	24,8
	Economy	K7	3,4	3,2	3,8	3,4	3,8	0	3,6	3,4	24,6

STRATEGIC ENVIRONMENTAL DEVELOPMENT	**Defense**	K9	3,6	4	3,4	3,6	3,8	3,6	0	3,8	25,8
	Technology	K10	4,4	4,6	4,2	3,8	4	4,4	3,4	0	28,8
SUM			26,2	26,2	28,2	26,2	26,4	26,2	27,8	25,2	0,035

2nd Step: Calculate the initial normalized direct relationship matrix Normalization of the direct relationship matrix is performed by multiplying the direct relationship matrix by the identity matrix. the results of the multiplication can be seen in the Table 5 below:

Table 5. Normalized Direct Relationship Matrix.

NORMALIZED MATRIX			THREAT PERCEPTION	INDONESIAN NAVY POSTURE				STRATEGIC ENVIRONMENTAL DEVELOPMENT		
			Potential Threats	Capability	Strength	Power Projection	Political	Economy	Defense	Technology
			K2	K3	K4	K5	K6	K7	K9	K10
THREAT PERCEPTION	Potential Threats	K2	1,00	-0,13	-0,13	-0,14	-0,13	-0,10	-0,15	-0,15
INDONESIAN NAVY POSTURE	Capability	K3	-0,13	1,00	-0,17	-0,14	-0,11	-0,12	-0,14	-0,11
	Strength	K4	-0,13	-0,15	1,00	-0,14	-0,15	-0,13	-0,15	-0,13
	Power Projection	K5	-0,13	-0,13	-0,16	1,00	-0,13	-0,13	-0,15	-0,12
STRATEGIC ENVIRONMENTAL DEVELOPMENT	Political	K6	-0,12	-0,10	-0,13	-0,12	1,00	-0,15	-0,14	-0,11
	Economy	K7	-0,12	-0,11	-0,13	-0,12	-0,13	1,00	-0,13	-0,12
	Defense	K9	-0,13	-0,14	-0,12	-0,13	-0,13	-0,13	1,00	-0,13
	Technology	K10	-0,15	-0,16	-0,15	-0,13	-0,14	-0,15	-0,12	1,00

Third Step is Determine the total relationship matrixTo calculate the total relationship matrix, which is done by inverting the matrix on the matrix that has been normalized. The results of the inverse matrix can be seen in the Table 6 below:

Table 6. Total Relationship Matrix.

NORMALIZED MATRIX			THREAT PERCEPTION	INDONESIAN NAVY POSTURE				STRATEGIC ENVIRONMENTAL DEVELOPMENT		
			Potential Threats	Capability	Strength	Power Projection	Political	Economy	Defense	Technology
			K2	K3	K4	K5	K6	K7	K9	K10
THREAT PERCEPTION	Potential Threats	K2	1,371	1,485	1,579	1,494	1,494	1,466	1,580	1,460
INDONESIAN NAVY POSTURE	Capability	K3	1,468	1,355	1,586	1,476	1,464	1,457	1,550	1,409
	Strength	K4	1,553	1,572	1,533	1,560	1,582	1,554	1,644	1,507

	Power Projection	K5	1,485	1,482	1,597	1,370	1,492	1,479	1,572	1,430
STRATEGIC ENVIRONMENTAL DEVELOPMENT	Political	K6	1,377	1,363	1,467	1,379	1,284	1,406	1,465	1,331
	Economy	K7	1,372	1,368	1,467	1,373	1,394	1,267	1,448	1,331
	Defense	K9	1,432	1,445	1,515	1,433	1,449	1,433	1,394	1,394
	Technology	K10	1,589	1,597	1,681	1,575	1,591	1,589	1,643	1,409

4th Step: Determine the threshold velue and impact . The threshold value is obtained from the average value in the total relationship matrix. From table 6 the threshold value is obtained by 1,474. While the value in column D is the result of the sum in each row of Total Relationship Matrix, while the value in column R is the result of the sum of each column in the Total Relationship Matrix. The results in step four can be seen in the following Table 7:

Table 7. Results of DEMATEL Data Analysis Method

VARIABLE			D	R	D+R	D - R	CAUSAL
THREAT FORECAST	K2	Potential Threats	12.94	12.71	25.65	0.231	Dispatchers
POSTURE INDONESIA NAVY	K3	Ability	12.88	12.94	25,82	-0.064	Receivers
	K4	Strength	13.74	13.55	27,29	0.190	dispatchers
	K5	Power Projection	13,1	13.06	26,15	0.041	Dispatchers
STRATEGIC ENVIRONMENTAL DEVELOPMENT	K6	Political	12,29	13,26	25.55	-0.965	Receivers
	K7	Economy	12.41	13.03	25,44	-0.617	Receivers
	K9	Defense & security	12.75	13.64	26,39	-0.885	Receivers
	K10	Technology	14,28	12.56	26,84	1,721	Dispatchers

4. CONCLUSION.

Conclusions about the above data processing can be drawn based on the results of data analysis and discussion conducted. The results of the analysis using the DELPHI-DEMATEL method for the main variables show that there are eight main variables that are feasible to continue for further analysis. While the causal interconnection relationship between the main variables is shown in table 8 and Figure 3 *Impact digraphs*as follows:

Table 8. Ranking Analysis of the Dematel Method

CODE	VARIABLE	D	R	D+R	RANK	D - R	INFORMATION
K2	Potential Threats	12.94	12.71	25.65	7	0.23	CAUSE
K3	Ability	12.88	12.94	25,82	6	-0.06	CAUSE
K4	Strength	13.74	13.55	27,29	1	0.19	CAUSE
K5	Power Projection	13,1	13.06	26,15	4	0.04	CAUSE
K6	Political	12,29	13,26	25.55	8	-0.96	EFFECT
K7	Economy	12.41	13.03	25,44	9	-0.62	EFFECT
K9	Defense & security	12.75	13.64	26,39	3	-0.89	EFFECT
K10	Technology	14,28	12.56	26,84	2	1.72	CAUSE

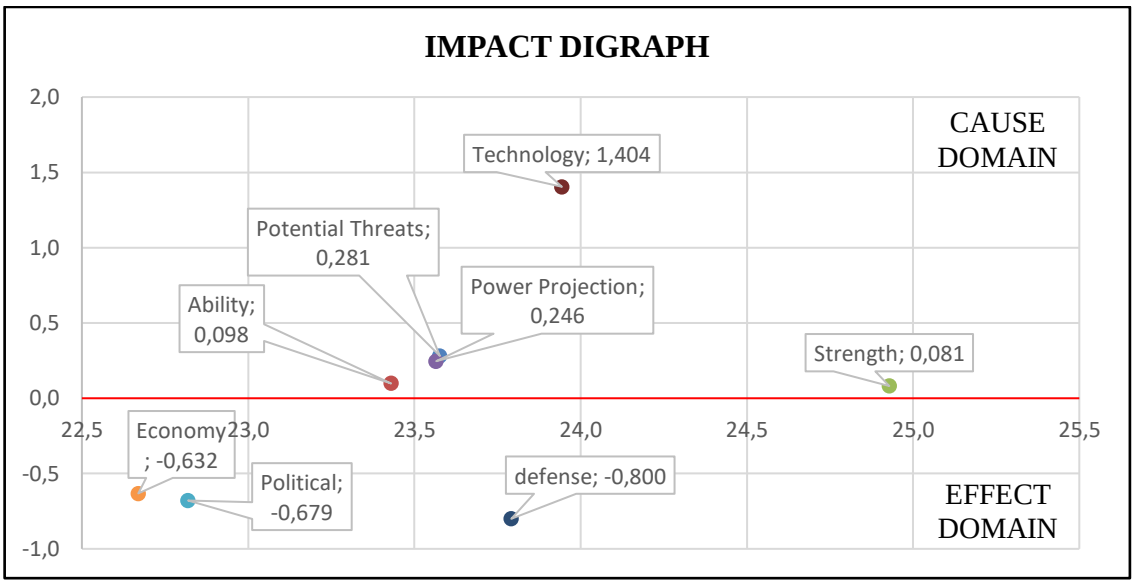

Figure 3. Impact Digraphs

The purpose of this study was to evaluate the relationship of different criteria to an effective and operational marine protection system using the DEMATEL method. Unlike the other MCDM models, this method can show a causal relationship between criteria (Ahmed et al., 2023). The DEMATEL analysis results above show that the strength variable (K4) is the main factor in implementing the Archipelago Marine Defense System, then followed by the Technology variable (K10), this is the most effective and efficient variable to be developed in supporting the Archipelago Sea Defense System (SPLN). The results of this study are in line with Yudi Listiono and Lukman Yudho Prakoso, who concluded that "the Indonesian Navy needs up-to-date technology in building strength in carrying out its duties" (Listiyono et al., 2019). based on the results of analysis between variables using the Delphi-DEMATEL method on the archipelago's marine defense system, it is found that the most variable are the assets used to carry out operations, technology that can support defense and security operations and stability. While the variables that most influence the archipelago's marine defense system are technological factors, potential threats, strength, power projection, and capabilities possessed by the Indonesian Navy.

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EXAMINING THE RELATIONSHIP BETWEEN COMPETENCY, MOTIVATION, WORKABILITY, AND PERFORMANCE IN THE INDONESIAN NAVY: A STRUCTURAL EQUATION MODELING APPROACH

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ABSTRACT

The success of an organization is intricately linked to the caliber of its human resources. The performance of personnel serves as a fundamental gauge of their quality. Consequently, in order to fulfill the vision of the Indonesian Navy, enhancing the quality of its human resources takes precedence. The program implemented to bolster soldier performance involves equipping them with competence through comprehensive education, training, and personnel development initiatives. Motivation plays a pivotal role in this process, and several measures are taken to foster it. These measures include augmenting welfare benefits, providing career coaching, and bestowing rewards upon exceptional personnel. By synergizing the Competency Variables (X1) and Motivation (X2), the aim is to enhance Work Ability (Z), ultimately leading to elevated Performance (Y) levels and attaining optimal outcomes. The present research employs structural equation modeling to examine the influence of these variables, thereby generating valuable insights into which factors exert the greatest impact on soldier performance. By conducting this study, the intent is to offer precise data pertaining to the variables that wield the most influence over soldier performance. Consequently, the findings will enable the provision of more accurate suggestions and recommendations. Armed with this knowledge, the Indonesian Navy can refine its strategies for enhancing human resource quality, thus fostering an environment conducive to superior performance. Moreover, the research outcomes will contribute to the broader understanding of factors that contribute to organizational success, serving as a guide for other institutions seeking to optimize their workforce performance.

Keywords**:** *Structure Equation Modeling (SEM), Influence Test, Soldier Performance, Motivation, Koarmada* 2

1. INTRODUCTION

One of the most important reform agendas is to reorganize the roles, functions and duties of the Indonesian Armed Forces within the Indonesian constitutional system. More specifically, the role, functions and responsibilities of the TNI will be reviewed periodically from the point of view of the essence of the TNI, not only as an instrument of national defense, but also as an important part of the national security system in a democratic political order. The main role of the Indonesian Armed Forces is as an instrument in carrying out national defense which has been carried out well through operations carried out by the TNI, both military operations of war (OMP) and military operations other than war (OMSP) with the scope of Activities that are internal to the country. and abroad (UU, 2004).

Based on Law number 34 of 2004 concerning the TNI, Article 9 states that the Indonesian Navy has the following main tasks (Koarmada, 2006): (1) Fulfill the responsibilities of the TNI in the field of defense; (2) Uphold the law and maintain security in the maritime area under national jurisdiction in accordance with ratified provisions of international law; (3) Fulfill the responsibilities of naval diplomacy in order to support the foreign policy of the government; (4) Fulfill the responsibilities of the TNI in the development and augmentation of maritime forces; and (5) Fulfill the empowerment of the sea defense area. Based on these primary responsibilities, it is clear that the Indonesian Navy performs diplomatic, police, and military duties in order to protect sovereignty, security, and safety at sea.

As a guideline and policy direction for creating a large, strong, professional and solid Indonesian Navy, the Indonesian Navy was built with the vision of creating a professional, modern and resilient Navy force in order to achieve high readiness and alertness in carrying out the tasks of the Navy. entrusted by the state. To realize this vision, it is carried out through four priority programs, namely; (1) development of Professional, Modern and Resilient Indonesian Navy Human Resources; (2) fulfilling the need for defense equipment to achieve strength that is ready to be operationalized in the form of high alertness and readiness; (3) improvement of base facilities and facilities and infrastructure that can support the operations and duties of the Indonesian Navy; (4) operations management and logistics support system (MABESAL, 2023).

In developing organizational quality there are various factors that influence it, including the ability of employees/workers (Suryo and Arfiany 2020). Good competence can help soldiers in dealing with the dynamics of assignments in the current era of globalization and has a positive effect on performance. Improving performance can be done by increasing both academic and vocational competence through education, training, work groups and independent learning (Rivai 2006). This is in line with priority programs in the development of TNI AL human resources which are carried out through the process of recruitment, education, maintenance, assignment and dismissal.

The formation of soldier competence is carried out through education and training patterns. Based on the Kasal Decree Number Kep/451/II/2018 concerning Instructions for Implementing TNI AL Personnel Education, the purpose of education for TNI AL personnel is to form and equip students as professional warriors, capable of carrying out their duties and aware of their responsibilities and obligations. Through education, it is hoped that it will produce soldiers who are qualified in science and technology, have skills appropriate to their profession, and have good attitudes and behavior.

Based on initial information collected from the operations unit in the Koarmada 2 environment, it was found that several soldiers felt less confident and felt they were not able to handle the problems they faced, some soldiers got stressed easily, there was a decrease in discipline which would ultimately reduce performance. This study aims to determine the effect of Soldier Competence and Motivation on Soldier Performance with Work Ability as an Intervening Variable. The relationship between variables is so complex and complicated and there is a reciprocal relationship between the indicators of each variable. Therefore the authors use the Structural Equation Modeling (SEM) method where SEM is a multivariate statistical analysis method that can be used to measure latent/unobserved variables, analyze factors, pathways and regression simultaneously/simultaneously and can measure direct or indirect effects. In addition, the SEM method will present data on which variables are most influential so that they can provide more accurate suggestions and input.

2. MATERIAL.

2.1. *Structural Equation Modelling* (SEM)

Ghozali (2008) explained that the SEM (Structural Equation Modeling) model is a second-generation method for multivariate analysis that enables researchers to look at intricate relationships between variables, both recursive and non-recursive, to get a full view of the entire model (Haryono 2016). The SEM model has been used in various fields of science such as: human resources (HR), education, psychology, economics and other social sciences. SEM was developed as a solution to

solve multivariate analysis problems. Latan (2012), Ghozali (2008), Jogiyanto (2011) and Wijaya (2009) state that SEM provides several advantages, including:

a. Can create models with many variables.

b. Can examine variables that cannot be measured directly (unobserved).

c. Can test the measurement error (measurement error) for the observed variable (observed).

d. Confirming the theory according to research data (Confirmatory Factor Analysis).

e. Can answer various research problems in a set of analysis in a more systematic and comprehensive manner

f. It is more illustrative, robust and reliable than the regression model when it models interactions, non-linearity, measurement errors, correlations of error terms and correlations between multiple independent latent variables.

g. Used as an alternative to path analysis and covariance-based time series data analysis.

h. Perform factor, path and regression analyzes simultaneously.

i. Be able to explain the complex interrelationships of variables and the direct or indirect effects of one or several variables on other variables.

j. Has higher flexibility for researchers to connect between theory and data.

The stages of structural equation modeling and analysis are divided into 7 (seven) steps, namely:

a. The creation of theoretical models.

b. Draw a flowchart.

c. Changing structural equations from path diagrams.

d. Select a data analysis input matrix.

e. Evaluate model recognition

f. Evaluating the goodness-of-fit standards.

g. Model estimate interpretation.

The SEM method has several assumptions that must be met before carrying out further analysis. The assumptions that must be complied with include sample size, measurement scale and data distribution. An explanation of these assumptions will be explained as follows:

a. Sampling Technique

According to Hair (2010) the sample size in research must have a minimum sample size of 100 to 200 or at least 5 to 10 times the number of variables in the model that is structured as a system (Hair, et al. 2010), which can be explained in the following formulation This:

n = 5 × Xvariabel Model s.d. 10 × Xvariabel Model

n = sample size to be observed.

In this study, researchers also used the Slovin method as a comparison to determine the minimum number of samples that should be used. This method is used if the population size is known (Wiyono 2020). Determination of the total number of samples was carried out using the Slovin method which can be seen in the following equation:

$n = \frac{N}{1+Ne^2}$ with:

n = sample size to be observed

N = population number of personnel

E = precision value (eg 95% confidence level, then e = 0.05)

b. Measurement Scale

The parameter estimation method used in this study is the Maximum Likelihood Estimation (MLE). This method has the condition that the data used is continuous interval data. Interval scale data measurements have the same characteristics as Likert scale scores. According to Edward and Kenny in Ghozali (2008) the score produced by the Likert scale was correlated with 0.92 higher than the Thurstone scale which is an interval scale. Thus the use of a Likert scale meets the assumptions for using

the MLE method in SEM analysis (Bahri 2014). In contrast, Hair (2010) asserts that an indicator with an ordinal response and only slightly more than eight categories may be used as an interval scale or, conversely, may not be if the variable is continuously variable. To use the SEM method, all indicators do not need to be on the same scale and do not need to be normalized.

c. Multivariate Normal.

The second assumption that must be met in conducting an analysis using the SEM method is the multivariate normal assumption. One of the normality testing methods that can be used in bivariate or multivariate problems is to use the square distance method.

d. *Outlier*

A data that significantly deviates from other data is called an outlier. There are two types of outliers, namely global outliers and collective outliers. In a data set, a data is categorized as a global outlier if the data significantly deviates from other data. Global outliers are the simplest type of outliers. Most of the outlier detection methods are used to find global outliers. Meanwhile, collective outliers are data that significantly deviate from the entire existing data (Han, Kamber and Pei 2012). One of the methods used to detect outliers multivariately is to use the leverage point 〖(h〗_i). An observation with an extreme value in a predictor variable is called a data that has a high leverage value.

e. *Confirmatory Factor Analysis* (CFA)

The method used to test how well the measured variable can represent the previously formed construct or factor is Confirmatory Factor Analysis. CFA is used to carry out theoretical testing in measurement models with correspondence specifications between indicators and constructs.

2.2 Methodology

To fulfill the stages in the development of the SEM model, a literature study stage was carried out to find relationships and develop a theoretical model, followed by the preparation of a path diagram. The next stage is to apply the path diagram to the structural equation in the SEM application software. To get the input model, it is done by compiling a research questionnaire on each model variable. The resulting data were then analyzed through the identification of model relationships, which were evaluated based on the goodness of fit value to obtain a valid model. After the model is declared valid, it is continued with model interpretation.

3. RESULT AND DISCUSSION.

3.1 Theoretical Model Development.

According to Wibowo (2012), competence is the capacity to carry out or accomplish a task or job based on knowledge and abilities and backed by the work attitude required by the task. Competence is the work ability of each individual, according to Law Number 13 of 2003 Concerning Manpower, which contains elements of knowledge, skills, and attitudes that are in compliance with specified criteria.

Table 1. Indicators in Soldier Competency Variables

Variable	Indikator
Soldiers Competence	Knowledge
	Skills
	Work attitude

Maslow asserts that motivation produces behavior that is focused on achieving goals, and that an organizational leader must be aware of the requirements of his subordinates. Maslow developed a hypothesis that is now known as the Need Hierarchy Model or the hypothesis of the Hierarchy of Needs. According to the priority scale, there are different levels of human needs in Maslow's theory. If the basic requirements are satisfied, then someone

will naturally want to satisfy the following need, says Maslow. (Notoatmodjo, 2009) suggests that motivation is any effort based on influencing one's behavior to increase organizational goals as much as possible. It can be concluded that motivation is a reason that can also be an encouragement for everyone to do, complete, or complete an activity that they started to achieve the goals that have been determined by that motivation.

Table 2. Indicators in Motivational Variables

Variabel	Indikator
Motivation	Physical Requirements
	Needs for safety
	Public Needs
	The requirement for admiration
	Needs for self-actualization

According to (Hasibuan, 2003), work ability is a work result achieved by a person in carrying out the tasks assigned to him based on skills, experience, sincerity, and time. The indicators used include work ability, education, and years of service. (Robbins, 1998).

Table 3. Indicators in Soldier Work Capability Variables

Variabel	Indikator
Work ability	Ability to Work
	Education
	Years of service

According to Mangkunegara (2008), Performance is the outcome of an employee's quality and quantity of work completed while carrying out his obligations in accordance with the duties assigned to him. The indicators used include the quantity of work, quality of work, timeliness, attendance, and cooperation (Bangun, 2012).

Table 4. Indicators in Soldier Performance Variables

Variabel	Indikator
Soldiers Performance	Working Quantity
	Work quality
	Job knowledge
	Soldier's opinion about work
	Soldier's decision over work
	Soldier work planning
	Division of work area according to corps/vocational school

Based on literature studies and theories on research variables, which are then concluded in a definition that becomes the basis and reference in the research data collection process mentioned above, namely: Soldier Competence (X1), Motivation (X2), Work Ability (Z), and Warrior Performance (Y), The independent latent variables are soldier competence and motivation; the dependent variable is soldier performance; and the intervening variable is work ability.

3.2 Preparation of Path Diagrams.

Developing a structural model based on theory, namely analyzing the relationship between exogenous variables and endogenous variables in accordance with the conceptual framework that has been defined previously.

Based on the theoretical approach, the conceptual framework for this research was produced as shown in Figure 1, as follows:

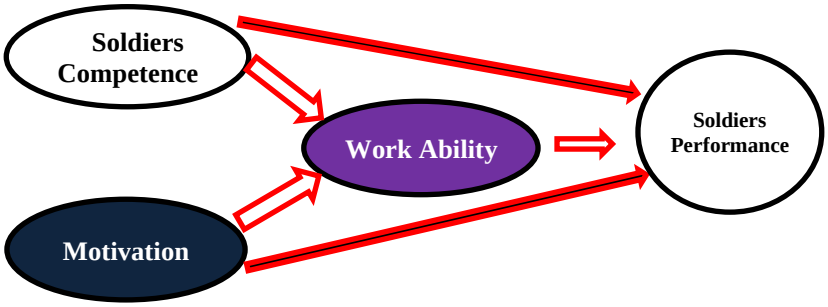

Figure 1. Research Conceptual Model

Hypotheses are conjectures that are tested by collecting facts that lead to a temporary formulation that states the hope that there is a certain relationship between two or more facts (Hair et al. 2010). Based on the conceptual understanding above, the research hypothesis can be arranged in the form of the following statements:

a. Hypothesis H1: Soldier competency characteristics have a substantial impact on job ability.

b. Hypothesis 2, H2: Work ability is significantly impacted by motivation.

c. Hypothesis 3, H3: Soldier performance is significantly affected directly by soldier competency.

d. Hypothesis 4, H4: Soldier performance is significantly affected by motivation.

e. Hypothesis 5, H5: Work ability has a big impact on troop performance.

f. Hypothesis 6, H6: Soldier work abilities has a huge impact on how well they perform as soldiers.

g. Hypothesis 7, H7: The ability to work hard has a big impact on army performance.

3.3 Compilation of Structural Equations

The studied and postulated variables' causal link is represented by the structural equation as a function or model.

$$Z = a_1X_1 + a_2X_2 + e1$$

$$Y = a_2X_1 + a_3X_2 + e2$$

The preparation of structural equations is carried out based on the results of the analysis between variables and the composition of the subvariables. The preparation of structural equations was carried out using the AMOS 25 software application.

3.4 Data Collection and Input.

According to Bernard (2012), data are raw facts about people, places, events, and things that are important to organize. Meanwhile, according to William and Sawyer (2007), data are facts and figures that are processed into information. According to the description given above, data is a set of numbers and facts that can be used to create information. The data used as the input model is primary research data from interviews with the Head of the Pusdikpel Head of Education and Research Center and the KRI Kadepops in the Koarmada 2 and Satlinlamil environments in Surabaya,

as well as questionnaires for non-commissioned officers and enlisted graduates of the Pusdikpel in the KRI Koarmada 2 ranks.This study used samples from the population of non-commissioned officers and privates who graduated from Pusdikpel Batch 1 and 2, 40 batches 1 and 2, and 41 batch 1. These samples were used to obtain primary data by filling out questionnaires. The population is the entire element or elements to be studied. In this study, the population of non-commissioned officers and privates graduated from Pusdikpel. The composition and number of the population in Table 5.

Table 5 Number of Non-commissioned Officers and Privates Graduates of Operational Corp Educational Centre.

RANK STRATA	NUMBER OF GRADUATES
NCO Force 39 batch 1	58
Non-commissioned Officer Batch 39 batch 2	31
NCO Battalion 40 batch 1	34
Non-commissioned Officer Batch 40 batch 2	33
NCO Force 41 batch 1	26
Enlisted Batch 39 batch 1	46
Enlisted Batch 39 batch 2	47
Enlisted Batch 40 batch 1	56
Enlisted Batch 40 batch 2	45
Enlisted Batch 41 Batch 1	49
Total	379

Ghozali (2010) asserts that the sample size for structural equation models is typically at least 200 observations. The sample size must satisfy the minimal sample size for the application of the structural equation modeling (SEM) model because the methodology and data analysis require SEM. The Slovin method was used to determine the sample size for this investigation, which included a total of 379 persons.

The sample employed in this study was composed of 195 persons based on the findings of the sample calculation performed using the Slovin method.Descriptive analysis methods and data analysis using inferential statistics are utilized for processing and data analysis. using quantitative descriptive data analysis methods to create a preliminary description of the study's subject and reveal the characteristics of how each variable's scores are distributed Frequency distribution tables and histograms can be used to display descriptive data analysis. While using SEM (Structural Equation Models), inferential analysis is utilized to test the study hypothesis. Every research hypothesis was tested with a value of = 0.05.

The SEM method is included in the parametric statistical test; therefore, before testing the research hypothesis, a basic assumption test is first carried out as a requirement that the data to be analyzed meet the required criteria.

3.5 SEM Structural Model Identification.

The process of data analysis using the SEM model begins with identifying the model to check whether it is over-identified or not so that further analysis can be carried out. This was done after the SEM model diagram was formed using AMOS 25 software. For parameter estimation in the structural equation model, the maximum likelihood method was used. In statistics, maximum likelihood estimation is known as a parameter estimation method of a statistical model that uses the mean and variance as parameters to find certain parameter values that make the most common results to be used in parameter estimation. This is done because, asymptotically, the observation is the most likely (given the model). The maximum likelihood method is unbiased, the estimator obtained is consistent, and the estimator is close to the normal distribution.

3.6 Goodness of Fit criteria.

The model's goodness of fit index (goodness of fit index) serves as a standard for gauging how well the two models fit together. A change is made to the model if you don't achieve a fit result.

a. Chi Square

The chi-square is said to be good if the calculated chi-square value is less than the table chi-square. The Chi-square table value can be calculated using the function in the Office Excel program, namely through the "CHIINV" function and by entering the input command df 109 with a significance of 5%. In this way, the value of the Chi-square table (2table(df=109)) is 160,372.

b. Significant Probability

The probability of the model is said to be good if it is greater than the significance level of 5% or 0.05.

c. CMIN/df

A measurement derived from the Chi-square value divided by the degree of freedom is the referred Chi-square (CMIN/DF). This indicator, which assesses the model's goodness-of-fit relationship with the anticipated number of estimated coefficients to achieve a suitability level, is known as a sparse suitability index. The threshold value is below 2.00.

d. RMSEA

The approximation error with the Root Mean Square To correct for Chi-square values in large samples, one can utilize the RMSE index. Acceptance level suggested: 0.085.

e. GFI

The Goodness of Fit Index (GFI), which is derived from the squared residual of the predicted model compared to the actual data, measures how well the overall model fits the data. Values that are close to 1 show that the model under test fits the data well. With a suggested acceptance rate of more than 0.9.

f. AGFI

The degree of freedom of the suggested model has been matched with the degree of freedom of the null model to create the adjusted goodness of fit index (AGFI), a development of the GFI index. With an AGFI > 0.90 suggested acceptance value.

g. TLI (Tucker Lewis metric)

An alternate incremental fit metric that contrasts the tested model with the reference model is the TLI. TLI is a measure of model fit that is less sensitive to sample size. Value to be used: > 0.95.

h. CFI

A value that approaches 1 in the Comparative Fit measure (CFI), an incremental fit measure that compares the model under test with its magnitude in the range of 0 to 1, denotes a high level of fit. Given that this index has a highly suggested value of > 0.973 and is largely insensitive to sample size and model complexity, it is highly advised that it be used.

3.7 Data Interpretation

Interpret the model obtained from the analysis results on each indicator obtained from the best SEM model. This stage is carried out after the goodness of fit value on the model is declared good.

4. CONCLUSION.

In this study, identification of variables, preparation of hypotheses, determination of research objects and subjects, identification of population and number of samples, path analysis, and model structure were carried out in the AMOS application. Soldier motivation and competence were independent latent factors employed in this study. Soldier performance was the dependent latent variable. Intervening variables included work ability. The population of the research object was 379, and the sample used was 195 people. The next research steps can be carried out in the process of compiling questionnaires, data collection, data processing, data input and analysis, structure identification, goodness of fit assessment, model modification, and data interpretation of model results. Data analysis uses SPSS to test basic assumptions. Data analysis

uses AMOS to determine the influence between model variables.

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