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System Dynamics for Smart Defense System of the Archipelago Sea Defense in Indonesia

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ABSTRACT

The modeling of Smart Defense for the Indonesian Maritime Defense Strategy is determined by the influence and interconnected interaction among various aspects as a complex system. Hence, a comprehensive analysis is needed to evaluate the Smart Defense for the Indonesian Sea Defense Strategy from the perspectives of Technology, Operational Strategy, Indonesian Navy Posture, and Threat Perception. To assess the value of Smart Defense capabilities, a dynamic model is developed to project the value of the Indonesian Maritime Defense Strategy over a period of five years. In this paper, the researcher constructs a model using a Dynamic Systems approach integrated with the Delphi method to determine the influential criteria for smart defense in the maritime defense strategy, and the Fuzzy Weighting method is employed to obtain the value of smart defense capabilities based on the aspects of Technology, Operational Strategy, Indonesian Navy Posture, and Threat Perception. The formulated model and simulation results using the System Dynamic approach reveal that the value Smart Defense of the Archipelago Sea Defense Strategy is projected to be 86.8% (Capable/Excellent) in the year 2023 and is expected to increase to 88.8% (Capable/Excellent) by the fifth year, entering 2028. Thus, based on these findings, the Indonesian Maritime Defense Strategy's Smart Defense is still classified as Capable/Excellent.

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 and the Indonesian Maritime Defense Strategy (Setiyawan, 2018). Fulfilling the Needs for the Development of the National Defense System for 2020-2044 the required forces of the Indonesian Navy consist of warships, 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 Indonesia while remaining oriented towards synergistic integration of the three dimensions (Susilo et al., 2019).

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 (Prakoso, 2022).

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, the forces of the sea dimension do not stand alone, it is necessary to optimize the Integrated Fleet Weapons System 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

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and deterrence (Batara, 2023; Dipua et al., 2021).

There are several contributions offered in this research. This study fills a gap in the qualitative analysis of smart defense. Second, this study enriches the literature on smart defense strategies. Third, this research can provide a framework for evaluating the smart defense of the archipelago's maritime defense strategy. Fourth, the development of existing research literature, methodologies and theories as well as technical solutions in promoting smart defense strategies is an additional contribution.

This research consists of several parts. Section 2 provides an explanation of the literature review, including the concept of smart defense and Alfred Thayer Mahan's theory. Section 3 describes the methodology consisting of the research design, the conceptual framework, the Delphi method, the fuzzy-weighting method and the dynamic system model. Section 4 describes the results and discussion, including Identifying Main Variable Aspects of Smart Defense The Archipelago's Sea Defense Strategy, Delphi Method Calculations, Fuzzy Weighting Method Calculations, Model System Dynamic Method. Section 5 is the conclusion of the research, implications, limitations of the research and future research. 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 making 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. Literature Review.

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 (Rowe, 1989). 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 (Azhar, 2022; Thompson, 2011). War and technology always have a causal relationship, meaning that war greatly influences the technological advances of war equipment and vice versa (Greiman, 2020). 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. (Mustofa, 2022; Raska, 2021). Artificial intelligence or Artificial Intelligence (AI) is an important element of the fourth industrial revolution era. AI technology and applications have a tremendous impact. Artificial intelligence (AI) is an important element of the fourth industrial revolution era. AI technology and applications have a tremendous impact (Payne, 2018). Artificial intelligence (AI) is an important element of the fourth industrial revolution era. AI technology and applications have a tremendous impact (Truong et al., 2020).

2.2. Alfred Thayer Mahan's theory.

Alfred Thayer Mahan, a United States Navy High Officer, in his book "The Influence of Sea Power upon History" put forward the theory that sea power is the most important element for the progress and glory of a country, which if these sea powers are empowered, it will improve the welfare and security of a country. Conversely, if these sea powers are neglected, it will result in losses for a country or even undermine the country (Lord, 2021).

Mahan in his book says that there are 6 elements of "Sea Power" which can make the prosperity and greatness of a nation or country in the sea (Russell, 2006). The elements in question are: 1) geographical position; 2) physical conformation; 3) extent of territory; 4) population; 5) national character; and finally, 6) the character and policy of the government. [25] These divide naturally into two subfields: territory and people.

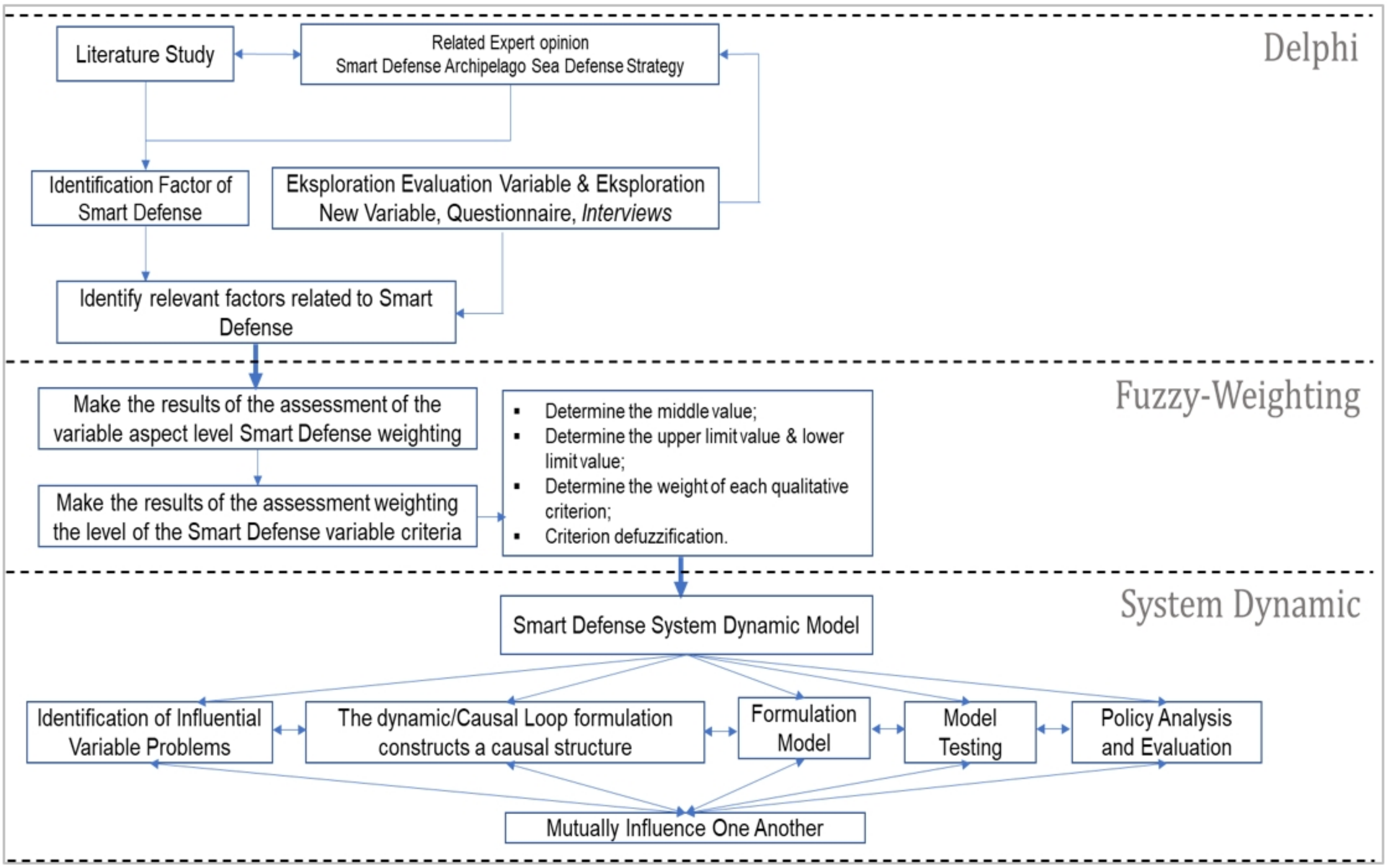
3. Methodology.

The research design in this study is an experimental design, which involves alternative scenarios in the form of changes to the independent variables. The study aims to depict cause and effect within a system and provide a profound understanding of the complex system under investigation. The research design is illustrated as shown in Figure 1 below:

3.1. 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 (Cobben et al., 2023; Flanagan et al., 2016). 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 the 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 (Jeyarajan, 2018). 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 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 Delphi method formula so that they became a presentation of the results of the agreement of the resource persons group.

Figure 1: Conceptual Framework.



Source: Author.

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

Source: Authors.

3.2. *Fuzzy Weighting Method.*

The data processing uses the Fuzzy weighting algorithm up to level 8 (eight) as follows (Dursun, 2018):

1. Make the results of the weighting assessment of the qualitative aspect variable level.
2. Make the results of the weighting of the assessment of the level of qualitative criteria variables.
3. 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 (Zhang & Li, 2011). The mathematical notation is as follows:a_t

$$a_t = \frac{\sum_{i=1}^{k} \sum_j Tij}{\sum_i^k = 1_{n_{ij}}} \tag{1}$$

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

1. 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.
2. 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:

$$c_t = \frac{\sum_j^n = 1c_{tj}}{n}, a_t = \frac{\sum_j^n = 1a_{tj}}{n} b_t = \frac{\sum_j^n = 1b_{tj}}{n} \tag{2}$$

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

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

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

N = number of assessors (decision makers) The aggregate score is N = (where Nt.=aggregation weight value for the t-th qualitative criterionc_j, a_j, b_j)

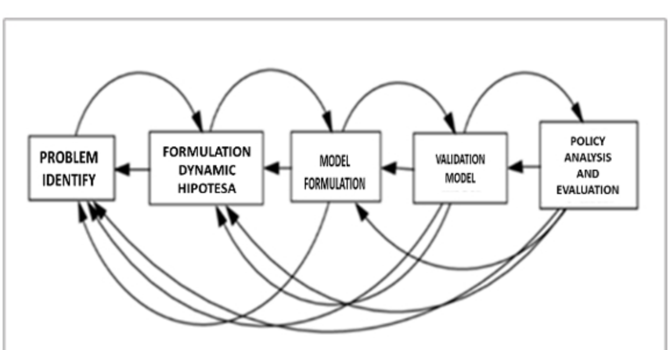
3.3. System Dynamics.

System dynamics (SD) has its origins in the work of engineer Jay W. Forrester. System dynamics modeling can be described primarily as a kind of engineering activity rather than a scientific activity, as it aims at designing deliverables. B. Models, policies, plans, organizational schemes, etc. for concrete situations to be improved under valuable priorities and limited resources. However, philosophy of science is usually used to find the reason for system dynamics (SD) (Olaya, 2019).

It is generally accepted that SD is a powerful tool for analyzing relationships and interactions between variables in a system. This helps in understanding the impact of various factors on the goals defined in the system and provides useful information to decision makers. It is a representative simulation method for evaluating decision-making performance. You can analyze complex interdependencies between variables in your system and improve the accuracy of your evaluation results.Mainly he has three types of variables in the feedback loop (Herrera & Kopainsky, 2020; Tan et al., 2018).This includes equity variables, interest rate variables and auxiliary variables. Inventory variables accumulate flows over a continuous period of time. A velocity variable represents the flow over a period of time. Auxiliary variables identify rate variables. The three types of variables are related by integrals, derivatives, or other types of equations (Tan et al., 2018).

In studying and analyzing the system, we need a method where each component becomes the focus of analysis. One of the superior methods in analyzing systems is system dynamics. In simple terms, the system is defined as a set of components that interact with each other to achieve a certain goal.

Figure 2: Stages in the system dynamic modeling process.



Source: Authors.

4. 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. Modeling (Developing).

4.1. Identifying Main Variable Aspects of Smart Defense The Archipelago's Sea Defense Strategy.

The initial stage in the series of developing a smart defense model for the archipelago's sea defense strategy 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:

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.

4.2. 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.

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), Indonesian Navy Posture (K2) and Threat Perception (K4) which will be used as the final data for further weighting processing using the next method.

4.3. Fuzzy Weighting Method Calculations.

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 (Teniwut et al., 2019), 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 2: Preliminary 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.	Tomaszewski et al., (2016)
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 role of the military, the role of constable and the role of diplomacy. The success of carrying out the tasks of the Indonesian Navy will depend on the posture it has.	Susilo et al. (2019)
3.	Technology	The future battlefield environment is increasingly network-based. Network Centric Warfare (NCW) 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.	Chung et al. (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 fishing, illegal mining, pollution sea and fuel smuggling.	Prakoso (2022)
5.	Political	Politics comes from the Greek "polis". Aristotle called his work on state matters "political", 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.	Huang & Billo (2014)
6.	Social and Culture	In general, 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.	Arif & Kurniawan (2018)
7.	Natural Resources	Natural Resources are the elements of the natural environment, both physical and biological, that are needed by humans to meet their needs and improve their welfare.	Dipua et al. (2020)

Source: Authors.

Table 3: Simulation of 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**

Source: Authors.

The data processing uses the Fuzzy weighting algorithm as follows (Susilo et al., 2020):

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.

d. Determine the value of the upper limit and lower limit of fuzzy numbers.

e. Calculates the aggregate weight of each criterion.

f. Calculating the defuzzy value from the results of the assessment of each qualitative criterion.

g. Calculating the final weight value / level of importance of each aspect variable and criteria.

Table 4: Assessment Aggregate Simulation 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	7	9	8	9	9	8	9

Source: Authors.

Table 5: Assessment Aggregate Simulation on Operational Strategy Aspects.

NO	CRITERIA	E1	E2	E3	E4	E5	E6	E7
1	Command & control / maritime operation center	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	8	9	9	9	9	7	6
6	Anti Submarine Warfare (ASW) defense	8	7	9	8	8	8	7
7	Sea Control	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

Source: Authors.

Table 6: Assessment Aggregate Simulation on Aspects of Indonesian Navy Posture.

NO	CRITERIA	E1	E2	E3	E4	E5	E6	E7
1	Weapons	9	9	9	8	9	9	9
2	Security, Defense, Intelmar, Diplomacy, Support	8	7	7	8	8	9	8
3	Degree of Operation (Degree of Harvesting / Deployment / routine ops & Degree of Enforcement / Employment 3 trouble spot)	9	7	7	8	8	8	9

Source: Authors.

Table 7: Simulation 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

Source: Authors.

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 = levels very low, low, medium, high and very high ratings.

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

Tij= numerical value of the T linguistic scale for the 1^{st} aspect of the j^{th} criterion.Table 8 Aggregate simulation of mid, lower and upper limit values for expert 1 to expert 4.

Table 8: Aggregate simulation of mid, lower and upper limit values for expert 1 to expert 4.

NO	LEVELS LINGUISTIC	E1			E2			E3			E4		
		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

Source: Authors.

Table 9: Aggregate simulation of mid, lower and upper limit values for expert 5 to expert 7.

NO	LEVELS LINGUISTIC	E5			E6			E7		
		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

Source: Authors.

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:

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

with : t = criteria1,2,3............n.

Table 10: Main Aspect Defuzzy Value (simulation).

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

Source: Authors.

Table 11: Technology Aspect Criteria Defuzzy Value (simulation).

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	6,252
		35,982

Source: Authors.

Table 12: Defuzzy Value Criteria Operational Strategy Aspect (simulation).

NO	CRITERIA	DEFUZZY VALUE
1	Command & control / maritime operation center	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	5.185
6	Anti Submarine Warfare (ASW) Defense	6,909
7	Sea Control	6,161
8	Human Resources Development	7,290
9	Risk Management	7,671
10	Logistics	6,877
		62,482

Source: Authors.

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*/ΣNt(1-n)

NB t = The final weight value of each criterion

Nt = Defuzzification criterion weight value

ΣNt(1-n) = Sum of the weight values of all defuzzification criteriaTable 15 Key Aspect Weighting Value (simulation)

Table 13: Defuzzy Value of Indonesian Navy Posture Aspect Criteria (simulation).

NO	CRITERIA	DEFUZZY VALUE
1	Weapons	7,671
2	Security	6,575
3	Defense	7,194
4	Intelmar	6,252
5	Diplomacy	6,194
6	Defense Area	5.185
7	Support	6,909
8	Harvesting/Deployment/routine ops degrees	6,233
9	Degree of Enforcement/Employment 3 trouble spot	7,433
		59,647

Source: Authors.

Table 14: Defuzzy Value of Threat Perception Aspect Criteria (simulation).

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

Source: Authors.

Table 15: Key Aspect Weighting Value (simulation).

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

Source: Authors.

Table 16: Technology Aspect Criteria Weighting Value (simulation).

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

Source: Authors.

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

1. 0.27 = Value of Technology Aspect.
2. 0.23 = Value of Operational Strategy Aspects.
3. 0.26 = Value of Indonesian Navy Posture Aspect.
4. 0.24 = Value of Threat Perception Aspect.

Table 17: Weighting Criteria Aspect Operational Strategy Value (simulation).

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	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

Source: Authors.

Table 18: Indonesian Navy Posture Aspect Criteria Weighting Value (simulation).

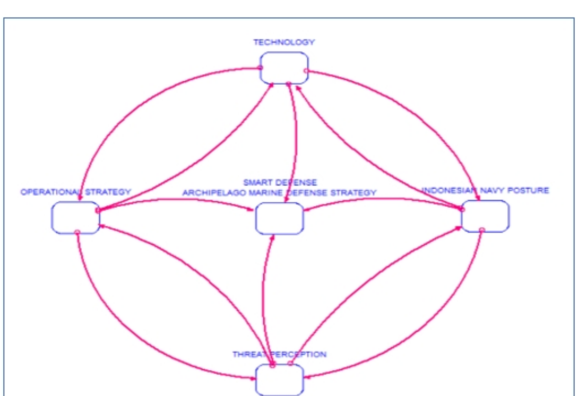
NO	CRITERIA	FINAL WEIGHT
1	Weapons	0.129
2	Security	0.110
3	Defense	0.121
4	Intelmar	0.105
5	Diplomacy	0.1039
6	Dawinhanla	0.0869
7	Support	0.1158
8	Harvesting/Deployment/routine ops degrees	0.104
9	Degree of Enforcement/Employment 3 trouble spot	0.125

Source: Authors.

4.4. Model System Dynamic Method.

Then each of the main aspects as described above has sub-variables and criteria (these variables are explained in the following discussion) so that when a Causal Loop Diagram is compiled it will form a closed system as illustrated in Figure 3 as follows:

Figure 3: Causal loop diagram for all aspects of the smart defense of the archipelago sea defense strategy.



Source: Authors.

In Figure 3 above, the causal diagram explains that the smart defense strategy for the maritime defense of the archipelago is at the midpoint of a system. Where this point is influenced by the main aspect variables and their sub-variables. The sub-variables of each variable interact influence one another, interact and form a dynamic relationship pattern. After obtaining information from experts and other references from various sources as well as previous studies, the next step is to formulate the Smart Defense model for the Nusantara Sea Defense Strategy. This model formulation is structured to be able to see the value of the relationship between variables and their sub-variables that interact and influence one another in a system. Before this model is made in a causal loop diagram, it is necessary to have an explanation of the entity variables from the initial description which can be categorized to make a system model formulation such as stock/level, flow/flow or a converter in a system. For this reason, the researcher then needs to clearly define the description, for naming which parts of the entity are stock/level, flow/flow or a converter so that it is clear what the model maker/researcher wants.

4.5. Model simulation analysis on the Smart Defense of the Archipelago Marine Defense Strategy.

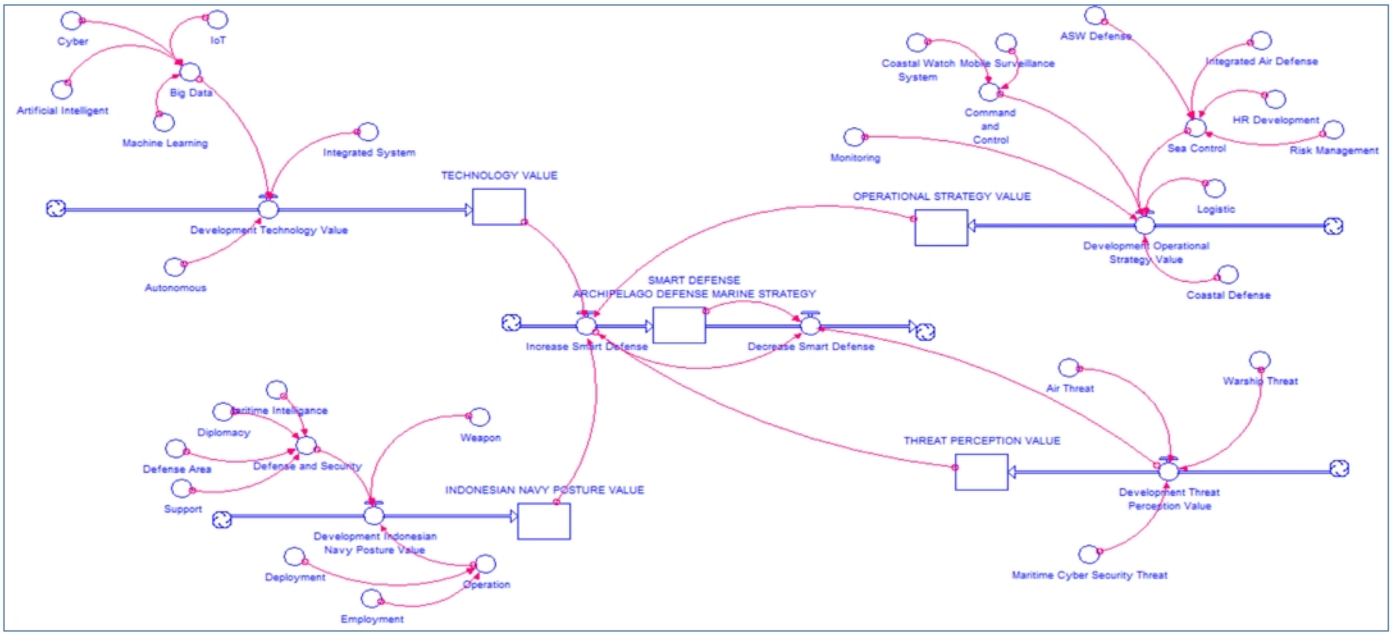
After analyzing the model simulation for each aspect of the Smart Defense Strategy for the Archipelago Sea Defense Strategy which consists of Technology Aspects, Operations Strategy Aspects, Indonesian Navy Posture Aspects and Threat Perception Aspects, then obtaining values from the variables of these four aspects, the next step is to analyze the formulation of the Defense Strategy Smart Defense model. The Archipelago Sea as shown in Figure 4 as follows:

Based on the formulation of this model, the Smart Defense of the Archipelago Sea Defense Strategy is the overall result of the four variable aspects whose values have been obtained and then also integrated with the constant values of the four aspects of the smart defense of the archipelago's maritime defense strategy which are obtained from the weighting results of the influence of the importance level of the four aspects using the Fuzzy Weighting method which has obtained the value from the previous discussion, namely the constant value of the Technology Aspect is worth 0.27, the constant value of the Operations Strategy Aspect is worth 0.23, the constant value of Indonesian Navy Posture is worth 0.26 and the constant value of the Threat Perception Aspect is worth 0.24 which has been measured based on the sub-variables of the four aspects.

4.6. Assessment of Variable Conditions.

In the conceptualization of the model, apart from determining the weight of variable importance, an assessment of the condition of the variables that occurs within a certain period of time is required. Several variables can be assessed according to the parameters used in the model. However, some variables are given assumption values based on linguistic scales that are arranged to equate the parameters used in the conceptualization of the model. The following is a linguistic scale used in the assessment of variable conditions, namely:

Figure 4: Smart Defense Diagram of the Archipelago Sea Defense Strategy All Aspect.



Source: Authors.

Table 19: Linguistic scale of Smart Defense capabilities of the Archipelago Marine Defense Strategy.

Capability	Scale Value	Index value (%)	Strategic Definition
Very low	1.00 – 3.00	0 – 30	Prone to
Low	3.01 – 5.00	30.01 – 50	Alert
Currently	5.01 – 7.00	50.01 – 70	Rational
Tall	7.01 – 9.00	70.01 – 90	Capable (Superior)
Very high	9.01 – 10.00	90.01 – 100	Absolute

Source: Authors.

The table 19 above is the Smart Defense Capability index. The index value in percentage will represent the capability scale value which will be presented in the final score of the Nusantara Sea Defense Strategy's Smart Defense Capability. The following is the value of each aspect based on the smart defense capability index:

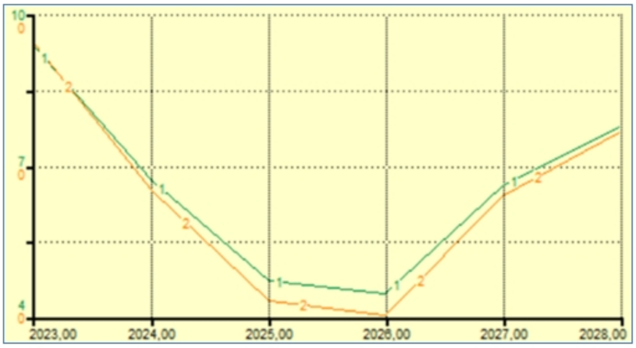
The technology aspect has a significant influence on the value of IoT with a rational strategic definition of 62.4%. The results of this value are the output of system dynamics that occur in the IoT value in the technological aspect which is taken according to the index value of the smart defense of the archipelago's marine defense strategy. The Operations Strategy aspect has a significant influence from the value of logistics with a strategic definition of Capable/Excellent 71.6%. The results of this value are the output of system dynamics that occur in the logistics value of the operational strategy aspect which is taken according to the index value smart defense of the archipelago sea defense strategy. The Indonesian Navy posture aspect has a significant influence from the weapon score with a strategic definition of Capable/Excellent 74.8%. The result of this value is the output of the dynamics of the system that occurs in the weapon value on the aspect of the Indonesian Navy's posture which is taken according to the index value of the smart defense of the archipelago's sea defense strategy. The threat perception aspect has a significant influence from the maritime cyber security threat value with a rational strategic definition of 62.8%. The result of this value is the output of system dynamics that occurs in the maritime cyber security threat value on the threat perception aspect which is taken according to the index value of the smart defense of the archipelago's defense strategy.

4.7. Preparation of Policy Scenarios.

The policy scenario is taken based on conditions that allow it to be controlled by Stakeholders / policy makers in this case the Indonesian Navy. In addition, the scenario can be determined based on the variables that affect the main aspect system variables by using a sensitivity test that has been done previously on the sensitivity analysis of system model variables. Sensitivity analysis basically assumes what will happen in real conditions and possible policy choicescarried out by policy makers (Wijaya et al, 2011). Then every parameter change if it is increased or decreased from the basic scenario parameter values, if it is proven that these changes result in real and significant changes to the main parameters, then these parameters will be considered as key parameters (Sterman, 2000).

a. Scenario 1 Technology Aspect with scenario: Integrated system improvement. Where the condition of the integrated system is assumed to be increased by 30%, the following is a graph of the scenario of the relationship between the integrated system and big data variables:

Figure 5: Test Scenario 1 30% increase in the integrated system variable.

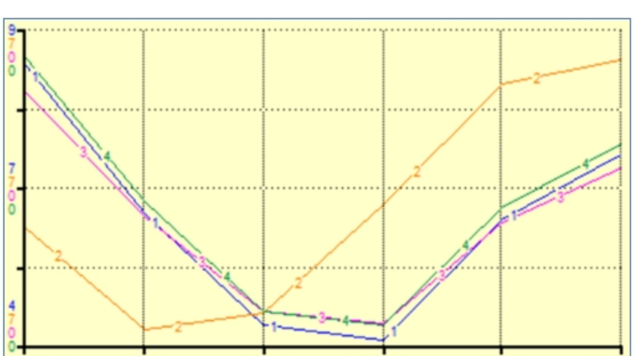


Source: Authors.

From the picture above green line is intregated system and orange line is big data variable, after conducting simulations for the period 2023 to 2028. The simulation results show that at the beginning of 2023 to 2026 there is a decrease in the integrated system variable and is followed by the same trend pattern of decline in big data variables, in this condition policy scenarios are planned before late. On the basis of this vigilance, an increase in the integrated system of 30% will only have an impact after 3 years, namely in 2026 and in line with big data variables until 2028 there will be a significant increase, after the policy scenario is implemented. This is none other than due to efforts to increase the variables that affect these technological aspects which will also have an automatic impact on increasing the value of the smart defense of the archipelago's maritime defense strategy going forward.

b. Scenario 2 Aspects of Operations Strategy: increasing logistical variables is a scenario taken in this aspect to be able to find out how it affects the smart defense of the archipelago's maritime defense strategy, so that its sustainability value can later be evaluated. Where the condition of the logistics variable is assumed to have increased by 30%, the following is a graph of the scenario of the relationship between the Smart Defense Value of the Nusantara Sea Defense Strategy and the Aspects of Operations Strategy.

Figure 6: Test Scenario 2 with a 30% increase in logistic variables.

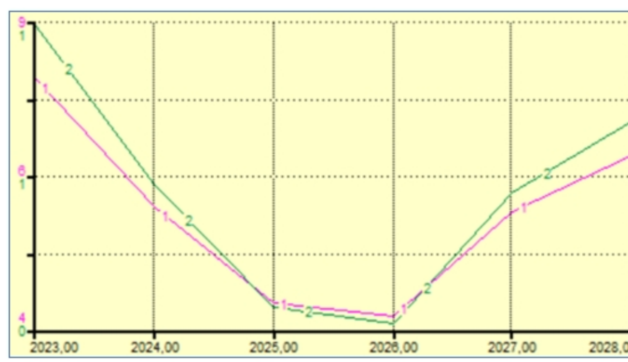


Source: Authors.

From Figure 5 above, blue line is logistic, orange line is smart defense value, pink is command control and the green line is sea control, it can be seen that in the next 5 years it is assumed that the logistic variable has increased by 30%, as can be seen in Figure 5, each variable has experienced a decrease in the first three years, namely 2023 to 2026, then an increase occurred in from 2026 to 2028 due to the 30% increase in logistics policy scenario the impact is starting to be felt so that in the period of 2026 with an increase in logistics or in this case increasing the additional spending budget of the Indonesian Navy, it will also have an impact on increasing command and control variables and sea control variables and giving effect also on the smart defense value of the archipelago's maritime defense strategy.From the scenario engineering results of the developed model, it is concluded that a significant addition to the logistics budget will have implications for increasing the aspects of the operational strategy and the smart defense value of the archipelago's maritime defense strategy.

c. Scenario 3 Aspects of Indonesian Navy Posture: increasing weapon variable is 30% to be able to find out how it affects the security variable.

Figure 7: Scenario 3 test assumes a 30% increase in the weapon variable.



Source: Authors.

Starting from the simulation results from 2023 to 2028 in Figure 6. The simulation results show that at the beginning of 2023 to 2026 there is a decrease in the weapon pink line and green line is security variable and at that time it is also followed by a concurrent decrease in the security variable, responding to these conditions the policy scenario start planning before it's too late. On the basis of vigilance against the decrease in weapon and security variables in the aspect of Indonesian Navy posture, a 30% increase in weapons is carried out, but this will have an effect after the third year, namely in 2026 after the policy scenario is implemented. Therefore weapons consisting of warships, aircraft, Marines, Bases, Marine Special Forces and Personnel can safeguard the interests of the Indonesian nation at sea and guarantee security for sea users.

d. Scenario 4 Aspects of Threat Perception: increase the Maritime Cyber Security variable by 30% to be able to find out how it affects the Smart Defense Value of the Nusantara Sea Defense Strategy.

Figure 8: Test Scenario 4 assuming a 30% increase in Maritime Cyber Security Threat.

Source: Authors.

Observing Figure 7 above in understanding the dynamics of the maritime cyber security variable from 2023 to 2028, blue line is threat perception value, red line is smart defense value and pink line is maritime cyber security threat, where it is assumed that the condition of the maritime cyber security threat variable has increased by 30% actually gives a trend pattern of increasing threat perception values from year to year (2023 to 2028). According to the time movement of the simulation, it appears that there is a close relationship between threat perception and the smart defense of the archipelago's sea defense strategy, namely a negative relationship, when the threat perception increases, the value of the smart defense strategy for the archipelago's sea defense strategy will decrease, and vice versa. The increase in threat perception cannot be separated from the decline in the smart defense of the archipelago's maritime defense strategy.

5. Implication.

The expected theoretical benefits, each stage of the results of this research can produce Smart Defense modeling of the Nusantara Sea Defense Strategy in supporting the tasks of the Indonesian Navy.

The practical benefit is being able to apply dynamic model problem solving with the Delphi, Fuzzy and System Dynamic approaches to modeling smart defense of the archipelago's sea defense strategy in supporting the duties of the Indonesian Navy.

Conclusions

From the simulation and analysis that has been carried out in the previous chapter, the following conclusions can be drawn:

Variables in the main aspects that play an important role in the Smart Defense model of the Archipelago Sea Defense Strategy are as follows 1) On Technology Aspects with integrated system key variables; 2) On Aspects of Operations Strategy where the key variable is Logistics; 3) On Indonesian Navy Posture Aspect where the key variable is Weapon; 4) On Aspect of Threat Perception where the key variable is Maritime Cyber Security.

In this study, Fuzzy Weighting method is used to determine priorities in the development of Smart Defense for the Archipelago's Sea Defense Strategy. After performing calculations using the Fuzzy Weighting method for each criterion, the final weighting results for the main aspects are obtained as follows a) Technological Aspect: 0.27; b) Operational Strategy Aspect: 0.23; c) Indonesian Navy Posture Aspect: 0.26; d) Threat Perceived Aspect: 0.24

The values of these constants will be used in integration with the dynamic system model to produce the final value of the Smart Defense of the Nusantara Sea Defense Strategy.

From The results of the formulation and simulation of the model with a dynamic system approach through several policy scenarios that were developed covering four aspects, namely aspects of technology, aspects of operational strategy, aspects of Indonesian Navy posture and aspects of threat perception, the best scenario analysis results obtained were scenario 3.

Table 20: Scenarios for each aspect and the results of the percentage of smart defense scores.

NO	SCENARIO	SCENARIO RESULTS	PROCENTAGE SMART DEFENSE
1	**Scenario 1:** Aspect Technology	**The Smart Defense score for the Archipelago Sea Defense Strategy increased from 8.16 to 8.33** and the value of the Big Data variable also increased from 0.05 to 0.09 and the integrated system variable from 6.33 to 7.76.	**UP 2.08 %**
2	**Scenario 2:** Aspect Operations Strategy	**Smart Defense score of the Nusantara Sea Defense Strategy from 7.44 to 7.46**, the logistic variable has increased in value from 6.77 to 7.01, command and control from 0.03 to 0.05 then the sea control value from 0.04 to 0.06.	**UP 0.27 %**
3	**Scenario 3:** Aspect TNI AL posture	**The value of the Smart Defense Strategy for the Archipelago's Sea Defense Strategy is 7.42 to 7.73**, Indonesian Navy Posture value from 7.31 to 7.36, Weapon variable from 6.07 to 6.31 and on security variable 0.68 to 0.79.	**UP 4.17 %**
4	**Scenario 4:** Aspect Threat Perception	**The value of Smart Defense for the Nusantara Sea Defense Strategy is 7.18 to 7.06**, The Threat Perception score increased from 8.47 to 8.59, the cyber security variable from 5.63 to 8.06.	**UP 1.67 %**

Source: Authors.

From table 20 above it can be observed that there is a causal relationship that influences each other between the variables in the sub-model from scenario 1 (one) to scenario 4 (four), the value obtained from the smart defense strategy of the archipelago's sea defense with scenario 1 is the value of smart defense increased by 2.08%, scenario 2 increased by 0.27%, scenario 3 increased by 4.17% but in scenario 4 it decreased by 1.67%. In accordance with what was conveyed by experts that organizational capability is the ability of an organization to use its resources (Grant, 2010; Gerry Scholes, and Whittington, 2008). Based on the results of the discussion above, the modeling of the strengths and capabilities of smart defense is basically an effort to build the resources and capabilities of the Indonesian Navy in terms of technology, operational strategy, posture of the Indonesian Navy and considering aspects of current threat perception. In Scenario 1 of the Technology Aspect, by increasing the integrated system variable in the Technology Aspect, it will provide an influential interaction with Big Data variables (IoT, Artificial Intelligence and Machine Learning) and provide value reinforcement for the smart defense of the archipelago's maritime defense strategy. Scenario 2 Aspects of Operations Strategy, by increasing the logistics variable in the Strategic Operations Aspect, in this case, the addition of the Indonesian Navy expenditure budget will have an impact on increasing the Command & control / maritime operation center variable and the value of the sea control variable / sea task force at The marine route of the Indonesian archipelago and followed by increase in the value of the smart defense of the archipelago's maritime defense strategy. Scenario 3 Aspects of Indonesian Navy Posture, increasing the value of the Weapon/Integrated Fleet Weapons System variable by 30% has an impact on the security of a country and automatically increases the value of Indonesian Navy posture which will also have an impact on decreasing the threat perception value. This is not followed by Scenario 4 Aspects of Threat Perception. Maritime security threats, including cyber threats, need to be watched out for, as seen in the decrease in value in scenario 4 (four).

There are some limitations in this research. First, this research is devoted to evaluating the value of each main aspect in smart defense according to experts, the next step is to calculate the weighting value of each main aspect in the smart defense of the archipelago's maritime defense strategy and then proceed to modeling the smart defense to support Indonesian Navy tasks, but not discuss existing threat perception mitigation strategies. Future research can discuss this risk analysis using the same method but with different criteria and alternatives in the future. Second, cyber security and cyber defense where many criteria can be considered which can be discussed in detail in subsequent studies. Third, This study does not discuss threat mitigation strategies as a response to reduce the risk of maritime cyber security threats. Future research can continue this research.

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