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PROCEEDINGS

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INTERNATIONAL CONFERENCE ON MARITIME SCIENCE AND TECHNOLOGY

INDONESIA NAVAL TECHNOLOGY COLLEGE

FIELD :

1. OPERATIONS RESEARCH
2. LOGISTICS MANAGEMENT
3. POLICY STRATEGY

SURABAYA, NOVEMBER 16th 2017

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INDONESIA NAVAL TECHNOLOGY COLLEGE
POSTGRADUATE INTERNATIONAL CONFERENCE

“RESEARCH STRATEGY FOR SUPPORTING MARITIME SCIENCE”

Field :

1. **Operation Research.**
2. **Logistics Management.**
3. **Policy and Strategy.**

SURABAYA, NOVEMBER 16th 2017

POSTGRADUATE STUDIES PROGRAM
INDONESIA NAVAL TECHNOLOGY COLLEGE

Proceedings

Indonesia Naval Technology College
Postgraduate International Conference

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PREFACE

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

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

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

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

Surabaya, 13 November 2017
Chairman of Committee,

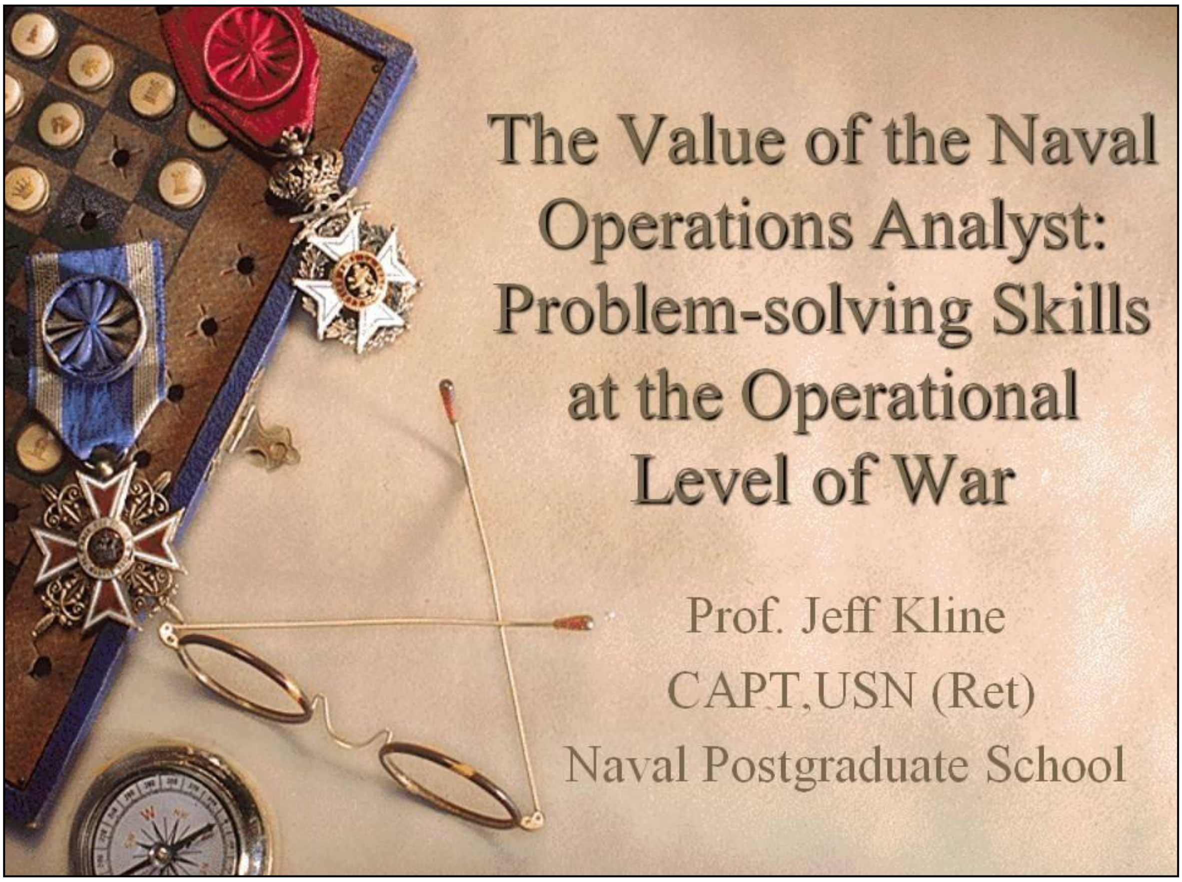
Dr. Ahmadi
Captain Navy

TABLE OF CONTENTS

Captain Jeffrey E. Kline,
United States Navy (Retired) Professor of Practice,
Operations Research Naval Postgraduate School,
Monterey

Jeff Kline attended the University of Missouri, School of Engineering, graduating with honors in Industrial Engineering, and received his Navy commission through the Naval Reserve Officers Training Corps program in 1979.

Jeff is currently a Professor of Practice in Operations Research and holds the OPNAV N91 Chair of Systems Engineering Analysis. He teaches Joint Campaign Analysis, executive risk assessment, systems analysis and coordinates maritime security education programs offered at NPS. Jeff supports applied analytical research in maritime operations and security, theater ballistic missile defense, and future force composition studies. He has served on the Chief of Naval Operations Fleet Design Advisory Board and on several Naval Study Board Committees



Definitions

Naval Combat: *adjective* 1: relating to combat on the sea (~missions) 2: designed or destined for combat (~troops and sailors)

Analyst: *noun* 1: a person who analyzes or who is skilled in analysis[i]

Naval Combat Analyst: Pro-active crisis-planning operator capable of applying critical thinking and problem solving techniques to war fighting and operational environments at the Task Force level. **Not to be confused with an Analyst of Combat.**

[i] Webster's New Collegiate Dictionary, G.&C. Merriam Co, Springfield, MA 1979

Theme:

A community of operationally-experienced officers knowledgeable in Operations Analysis methods is valuable for their unique combined talents at the operational-level of command.

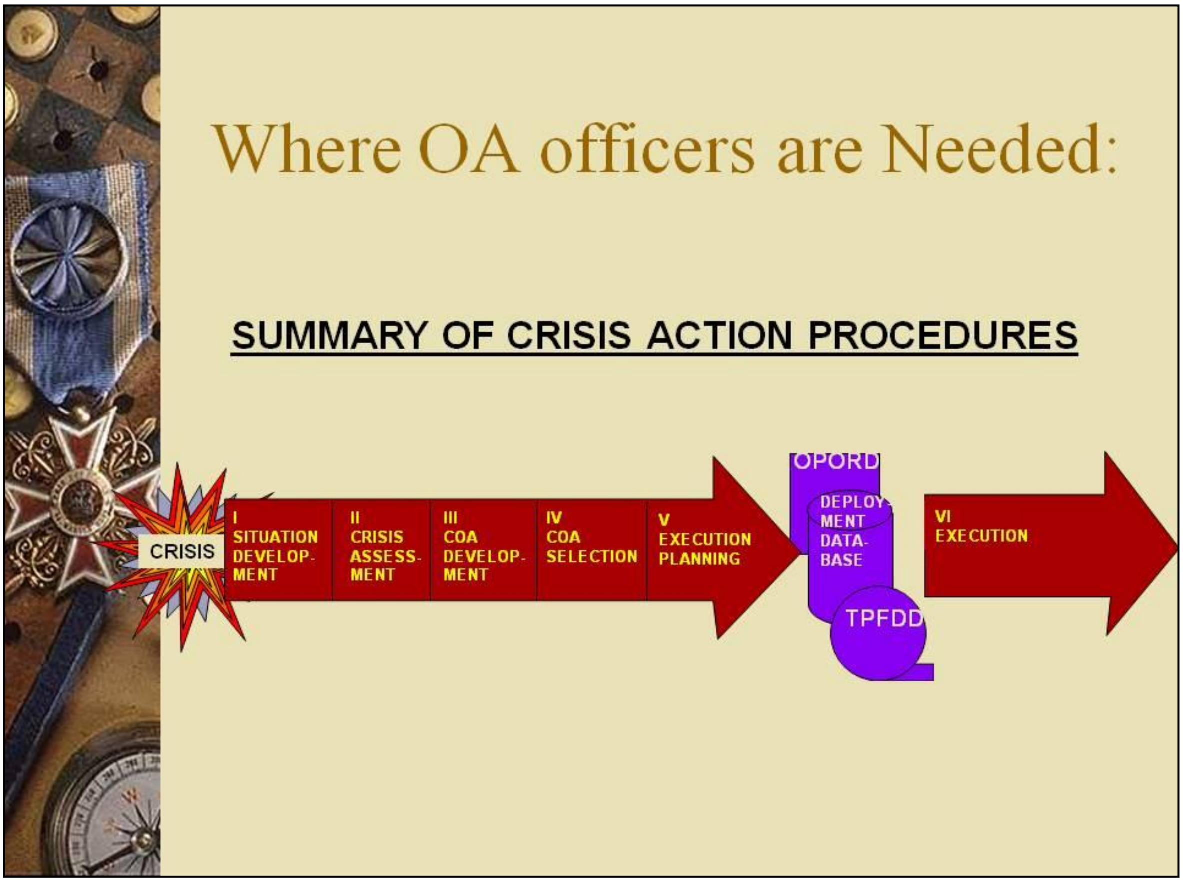
….or: get 'em out of Headquarters and into the field !

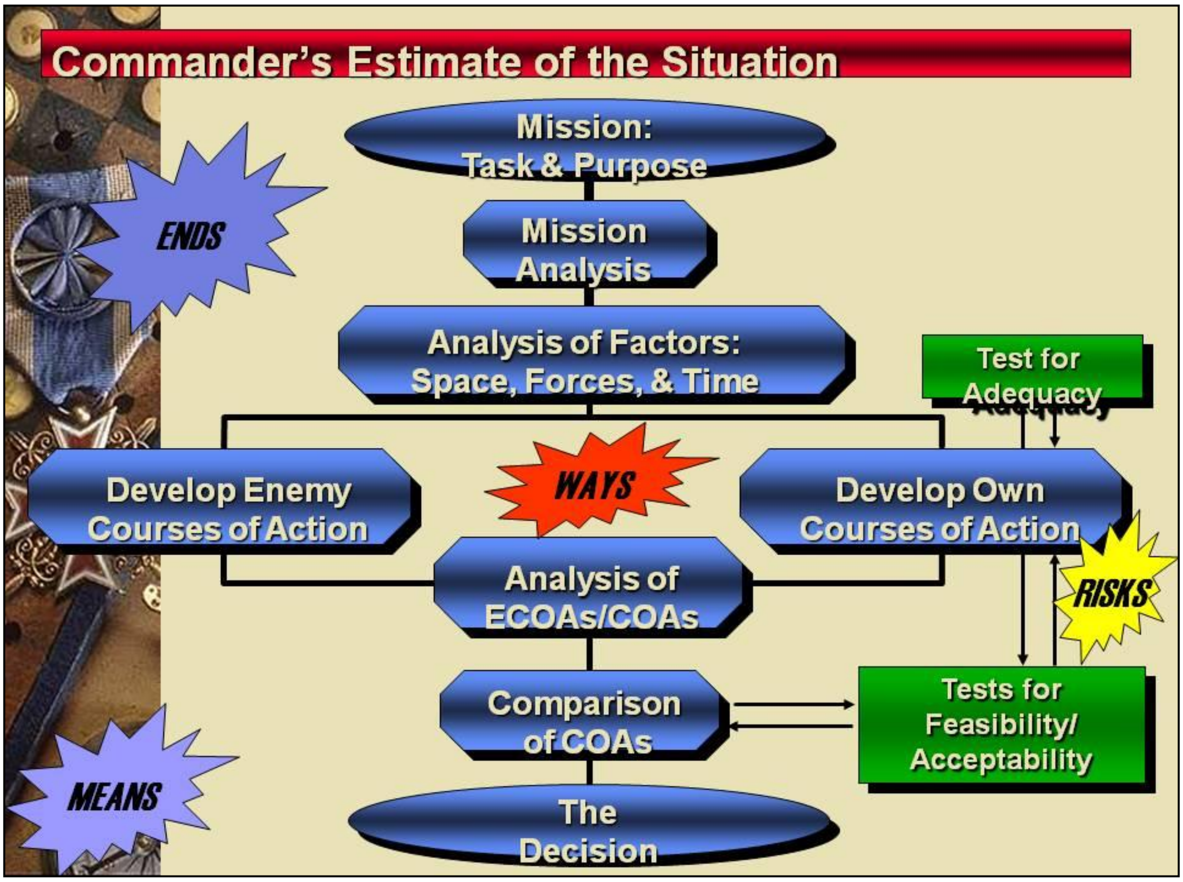
Traditional Uses of Officers educated in Operations Analysis

- Great for Force Structure Planning!
- Weapon/System Acquisition and Testing
- Manpower analysis
- Logistics Planning
- Modeling and Simulation development
- Post-conflict evaluation (Analysis of Combat)

Renewed Emphases Needed:

- Send OA naval officers to current operations planning staffs – they alone hold the unique experience and talents to fill this niche.
- Not to "advise", but actively plan for the Commander in the operations or plans branch—particularly in crisis action planning.
- Team with civilian analysts


Where OA officers are Needed:
SUMMARY OF CRISIS ACTION PROCEDURES
CRISIS
I SITUATION DEVELOP-MENT
II CRISIS ASSESS-MENT
III COA DEVELOP-MENT
IV COA SELECTION
V EXECUTION PLANNING
OPORD
DEPLOY-MENT DATA-BASE
TPFDD
VI EXECUTION


Commander's Estimate of the Situation
ENDS
Mission: Task & Purpose
Mission Analysis
Analysis of Factors: Space, Forces, & Time
Test for Adequacy
Develop Enemy Courses of Action
WAYS
Develop Own Courses of Action
RISKS
Analysis of ECOAs/COAs
Comparison of COAs
Tests for Feasibility/ Acceptability
MEANS
The Decision

Examples from the OA tool set for *planning* in a crisis

- Problem formulation: objective identification and metric selection
- Decision Analysis
- Game Theory
- Network Analysis
- Search Theory
- Basic Risk analyses (Probs and Stats)
- Simple Modeling and Simulation
- Optimization: Resource assignment

After the Planning is done: **EXECUTE!**

Optimized scheduling of ISR assets

Real-time operations evaluation using planning metrics

Pattern of life analysis

Network analysis for target selection

Strike scheduling

Search planning and execution

An Example: Decrease Risk for General Officers being targeted in Operations

A Case Study in Hypothesis Testing

12.08.12 11

Overview

Situation: Iraq 2008, perceived high number of insurgent attacks against Forward Operating Bases (FOB) within 30 minutes after arrival of a particular U.S. Army General. **General believed he was being targeted.**

Decision: Identify if General was being selected for insurgent attack and if so, discover means, which identified that he was visiting the FOB.

Objective: Decrease risk of General officer movements.

OA Contribution: Confirmed evidence of General officer targeting by Hypothesis Testing (Statistics) and made recommendations on changing the movement procedures decreasing the risk for the General officer.

Result or outcome: Reduction of insurgent attacks against Generals

12.08.12 12

Situation

- Iraq Forward Operating Bases (FOB) received indirect fire frequently, General officer visit or not.
- A particular U.S. Army General had made twenty helo trips and in ten of these, the FOB being visited received indirect fire within thirty minutes of his helo landing.

Approach

- **Experience of the General:** his visits triggered the attacks on FOBs
- **Hypothesis**: it is "deliberate" and not "random" that there are more attacks on FOBs after helo landing with Generals sitting in the helo!
- **Testing by the OA**: seeking evidence by collecting and analyzing data –> providing evidence for hypothesis

OA Contribution

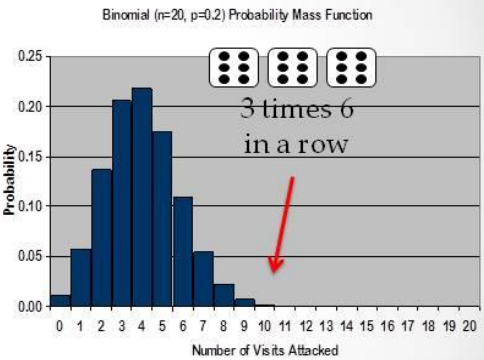
- **Collecting the Data**
  - During the time period of interest, how many indirect attacks occurred on FOBs? Of these, how many attacks were there within thirty minutes of a helo landing?
  - Result: Based on the data, any "random" Helo landing triggering attack on a FOB was 20%.
- **"Generals Experience" (Data)**
  - Based on the data, the General's Helo landing triggered a FOB attack 10 out of 20 times (i.e. 50%)

15

OA Contribution Providing Evidence

- **Hypothesis Testing**

  Chance for 50% of FOB attacks after a helo landing (General officer movements) is only 0.3%



CONCLUSION: Data analysis supports the Generals hypothesis

16

Follow-on actions supported by OA

- Several indicators were discovered which could have indicated General officer movements:
  - Clear communication references
  - General officer helo markings
- Once these indicators were removed, the risk of insurgent attacks for the General officer movements decreased from 50% to 20%.

A short Sea Story…

USS AQUILA (PHM-4)

Two ways to transit:

LM2500 Gas Turbine
"Fast with lots of Gas"

Two Mercedes Diesels
"Slow fuel sipper mode"

L.P. provides transit planning options. Minimize fuel for a particular transit time, or minimize transit time for a particular fuel allowance.

How to educate the Combat Analyst…

- Theory of War
- Operations Planning Process
- *Tools and techniques grounded in* ***Scenario****-based instruction*
- Understanding of basic analytic methods (quick turn around analysis)

Unsolicited Philosophy for Officer-Analysts

- **A little understandable analysis will carry your message further than the most complex mathematical models**
- **You are an officer and decision maker first – analyst second.**
- **See point one—communicate to the senior officer.**

International Conference on MST STTAL PG

Family-based Self Organized Learning Environment to Support SISHANTA as a Cybernetics Defense Network

Daniel Mohammad Rosyid -DOE ITS
Masroro Lilik Ekowanti -DPA UHT
16/11/2017, STTAL Surabaya

1

The threats to Indonesia in the 21st century landscape is more of **neocortical warfare** in which territorial occupation is considered tobe increasingly risky, costly and unnecessary
(Sayidiman Surjohadiprodjo 2015)

Daniel M. Rosyid ITS - Masroro L. Ekowanti UHT

Asymmetrical investment and trade agreement is combined with **war of the mind** to instill a sense of inferiority complex, promote unhealthy and consumptive life style of the community, espescially the young

Natural resource acquisition can be carried out through asymmetrical long-term foreign investment and trade agreement on the basis of free marketism

Daniel M. Rosyid ITS - Masroro L. Ekowanti UHT

Daniel M. Rosyid ITS - Masroro L. Ekowanti UHT

Daniel M. Rosyid ITS - Masroro L. Ekowanti UHT

Research Problem :

How can we develop an operation strategy to provide a sustainable defense response to neocortical threats in a democratic society ?

Daniel M. Rosyid ITS - Masroro L. Ekowanti UHT

2

The most subtle form of the neocortical warfare is through

education

twisted into

the school system

Daniel M. Rosyid ITS - Masroro L. Ekowanti UHT

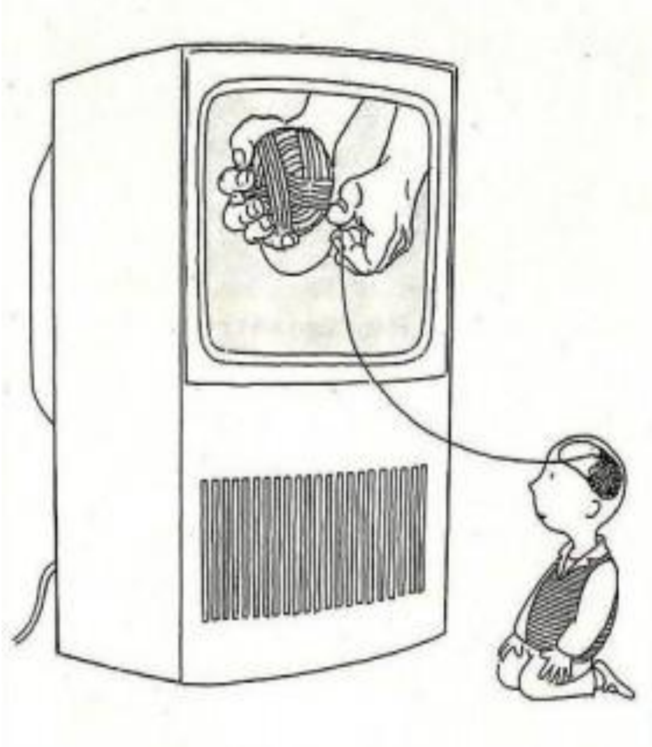
Mass, forced school systems deteriorates the independent learning capacity of a society by taking over the educative tasks of **the family as the most formative base of any society**

Daniel M. Rosyid ITS - Masroro L. Ekowanti UHT

Independence of the mind is NOT the objective of any (mass, forced) school system which is basically a **miseducation of the mass**

The school system and TV are the **institutional duo** as the misiles of the neocortical warfare

Daniel M. Rosyid ITS - Masroro L. Ekowanti UHT



Daniel M. Rosyid ITS - Masroro L. Ekowanti UHT

The school system and TV are the instruments neccessary to support **a growth-obsessed industrial society**
-the most destructive form in damaging our planet

Daniel M. Rosyid ITS - Masroro L. Ekowanti UHT

3

The independent learning capacity of a family provides the basis for a **universal defense system** against neocortical warfare

The Sistem Pertahanan Semesta (SISHANTA UU34/2004) against neocortical threat can be formulated as a **Cybernetics Defense Network (CDN)**

Cybernetics is preoccupied with **operation models** distinguished by being hierarchical, adaptive and making permanent use of feedback loops, i.e. **organizational dynamics**

A Cybernetics Defense Network is an **operational strategy** to provide timely and effective, yet efficient universal defense responses to any neocortical threat

The Markas Besar TNI as the core of SISHANTA plays as a defense **syndicator** by which **Self Organized Learning Environment** (SOLE) **nodes** are orchestrated in a networking, flexible fashion

Family-based SOLEs are then orchestrated as a cybernetics defense network to smartly response to imminent neocortical threats

A family is a typical SOLE
in which independent learning and smart decision making is nurtured and continuously exercised leading to a sustainable, healthy and productive community

Daniel M. Rosyid ITS - Masroro L. Ekowanti UHT

4

Healthy and productive families will improve the social capital of a community leading to more cohesive and egalitarian nation

Daniel M. Rosyid ITS - Masroro L. Ekowanti UHT

Decision making processes at different levels will be much more efficient and smarter leading to lower political and social costs

Family SOLE-based Cybernetics Defense Network is key to a sustainable universal defense system in a truely democratic society

Daniel M. Rosyid ITS - Masroro L. Ekowanti UHT

References

Ekowanti, M. L."Perencanaan, Pelaksanaan, Evaluasi Kebijakan/Program" UHT Press 2014;
Illich, I "Deschooling Society", 1970;
Mitra, S. "Hole in the Wall" TED Talk 2010;
Rosyid, D.M."Belajar, bukan Bersekolah", QBaca Telkom, 2015;
Rosyid, D.M. "Paradigma Kepulauan Pembangunan Nasional" ITS Press, 2010;
Rosyid, DM and Ekowanti, ML "Growth Obsession and World Class Navy Vision". Jurnal Pertahanan. 2013;
Rosyid, D.M."Paradigma Maritim dan Energi dalam Ekonomi Baru". Intrans Pub. 2017

Implementation of Maritime Defense Pillar in Support of Global Maritime Fulcrum: Challenges and Solutions

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Indonesia Defense University
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Abstract: Global Maritime Fulcrum's fifth pillar of maritime defense is crucial in supporting and protecting the achievement of the other four pillars. This government policy is a strategic move in facing and anticipating dynamics of national, regional, and global strategic environment. As population grow in less-prosperous areas in the world, conflict and radicalization tend to grow and become today's and future's phenomena. Depleting land resources is met with higher demand of food and energy. Resources at sea has become the ideal alternative to sustain the world's need of food and energy, along with the need to push economic growth. This implies increased activities at sea should be anticipated along with the implications of more conflicts at sea than on land. It is therefore paramount to discuss further how the fifth pillar could protect and support the other four pillars to achieve current and future national interest. Maritime defense has a strong influence on the development of Indonesia's maritime culture. It is also needed to support maritime resources development, protect maritime infrastructure and connectivity development, and strengthen maritime diplomacy.
Keywords: Global Maritime Fulcrum • Maritime Defense • Maritime Resources • Maritime Infrastructure • Defense Apparatus.

1. Introduction

Global Maritime Fulcrum (GMF) policy consists of five pillars, which are; 1) maritime culture development; 2) maritime resources management; 3) maritime infrastructure and connectivity development; 4) maritime diplomacy; and 5) maritime defense, where all of these pillars are connected as a unity and influence one another.[1] Maritime defense may be the last pillar, but in fact it is the most crucial one in order to protect the sustainability of the other four pillars. Its influence is very-well dominated by global security realities, which have become unstable due to many factors. Climate change has caused drought and food scarcity. Global population has increased significantly, yet again in less prosperous regions such as the Middle

[1] http://www.presidenri.go.id/berita-aktual/indonesia-sebagai-poros-maritim-dunia.html, accessed on 13 October 2017 at 10.47 Jakarta time.

East, South Asia, Southeast Asia, and Africa, conflict and radicalism continue to rise with the promise of escalated violence in the future. Global economy has yet to show significant development ever since the 2008 financial crisis, which would mean more countries would fall into bankruptcy and triggering further social unrest. The latter would entail the rise of radicalism, terrorism, civil war, and even, interstate wars. Land resources for energy and food are depleting, resulting in resource competition and more will go to the seas for these resources as well as to push economic growth.

These are the realities of our time. In the past decade we see more competition on maritime resources, which has also triggered more conflicts. Such a reality is evident in Indonesia. For example is the IUU fishing practice by fishermen of neighboring countries in Indonesia's seas. In response, Indonesia implements the "ship-sinking" policy to ships used for IUU fishing, although the policy is met by various responses. Another good example is Indonesia-Malaysia dispute in Ambalat. A similar dispute is evident in the South China Sea, where China claims almost all of the body of water and is met by protests from countries in the region and beyond. Not only are conflicts causing tension among countries, along with civil wars, we are looking at more radicalization and terrorism in the Middle East and Southeast Asia, in which all could very well influence Indonesia's security. Terrorist groups conduct criminal acts at sea, from smuggling, drug cartel, and kidnapping as their fund raising methods.[2] They also conduct maritime terrorism as evident in the Superferry incident in the Philippines in 2004.[3] There are concerns such activities could be practiced in Indonesia. Hence, there is a growing need to increase the role of maritime defense apparatus in securing Indonesian waters from threats on security, sovereignty, and violation of law at sea. It is evident, therefore, the fifth pillar of GMF truly influence and support the development of maritime culture and the implementation of maritime diplomacy in order to protect Indonesia's national interest in the future.

2. The Influence of Maritime Defense upon the Development of Maritime Culture

Indonesia is currently experiencing sea blindness, a condition where the sea is not considered as a strategic aspect.[4] Some experts believe the condition comes from colonialism and its success in erasing the true identity of people as a maritime nation. Sea blindness has caused the people and the government to turn their backs from the sea, as can be seen in policies and the characteristics of the people. The characteristics of Indonesia's geography, which is an archipelago with semi-enclosed waters, indicate our threats and opportunities mostly come from the sea. Alfred T. Mahan underlined the importance of people and government characters in the development of a country's seapower.[5] Without these two characters, the ability and sustainability of a nation to "rule the seas" will hardly be realized.

In order to eliminate its sea blindness, the Indonesian government has put in place its maritime-oriented policy, starting with the first GMF pillar of developing people and government characters based on the development of maritime culture. The culture, in this

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[2] Williams, Phil, *Terrorist Financing*, in Shmella, Paul et.al, *Fighting Back: What Governments Can Do About Terrorism*, Stanford: Stanford University Press, 2011, p. 51.

[3] BBC, Bomb Caused Philippine Ferry Fire, http://news.bbc.co.uk/2/hi/asia-pacific/3732356.stm, accessed on 23 October 2017 at 01.32 Jakarta time.

[4] Till, Geoffrey, *Indonesia as a Growing Maritime Power: Possible Implications for Australia*, Sea Power Centre Australia, 2015, p. 4.

[5] WestCott, Allan (Eds), *Mahan on Naval Warfare: Selections from the Writings of Rear Admiral Alfred T. Mahan*, 1918, p. 43--48.

context, goes beyond the understanding of the sea as a tradition and spiritual bond; the sea is an arena for life and work, it is an identity and a part of the country's strategic development policy. The goal is simple; to develop a consensus between the people and the government to never again turn their backs from the sea. This policy also aims to educate high-quality, skilled human resources to take on important posts in the maritime world. These human resources are crucial to manage Indonesia's maritime resources, to protect activities at sea from threats of crime, and to uphold sovereignty at sea. The challenge, nevertheless, is structural since the culture of land and agrarian is rooted deep within the psyche of the country, and therefore requires re-internalization of maritime culture in a step-by-step manner.

The first step is to educate the people on maritime affairs through formal education (schools and universities), non-formal education (courses), and informal education (fishermen groups, for example). The goal is to develop human resources with skills in the maritime domain and to develop the people's awareness on the importance of maritime security. This step necessitates an increase in number and capacity of formal education institutions on maritime science (seafaring, port management, maritime logistics, marine science, marine biology, to name a few). It should be followed by increasing the interest to join these institution by providing information, counseling and employment and attractive salary package. Changes should be made to school curriculum to include local content. For instance, schools located near coastal areas should include maritime security and marine conservation into their curriculum. Schools should also focus on providing lessons on Indonesia's maritime history in order to increase maritime awareness since early stage, enhance the interest of students to contribute in the field of maritime security in their adulthood, and to increase students' sense of pride as a nation of strong maritime roots and culture;

Second, the government needs to increase the proportion of higher education and researches on maritime defense and strategic management in order to have high quality analysts and decision makers in the maritime area who are visionary and scholarly;

Third, to maintain the preservation of the people's maritime culture. Rituals, norms and values related to the seas should be preserved to maintain the bond between those living along the coastal areas with the sea. Through such preservation, the people could develop their own awareness on the social-cultural aspects of the sea in their lives, pushing them to protect and respect the sea even more. Efforts can be seen in the preservation of the culture of Bakaro Village, West Papua with its tradition of giving food to fishes in at sea as well as the *Larung* and *Sedekah Laut* tradition, where locals show their respect and gratitude by providing offerings to the sea. These traditions also valuable tourist attraction; more the reason to preserve such ways. The private sector can also play a part in this third step by promoting maritime traditions to tourists and mass media;

Fourth, to increase awareness on the importance of maritime security and sustainability through counseling, public service announcement, and social service activities. It is important to ensure that the message on the role of maritime sustainability as the key to balance culture, social life, economy and public safety, especially in coastal areas, is understood clearly by the people. A polluted sea or the extinction of a certain species would have devastated consequence to the coastal people, including the loss of their culture and rituals, such as fish harvesting or sea turtle hunting (Tabob ritual in Maluku) or whale hunting (Lamalera, East Nusa Tenggara). Other examples are the increased activities of IUU fishing (using trawls and bombs) and kidnapping and piracy activities at sea. All would only do harm to the coastal people, taking away their livelihood. Counseling should come not only from the government, but also from academics and defense and security apparatus, including the Polair (Water/Maritime Police), Bakamla (Coast Guard), and TNI AL (the Indonesian Navy);

Fifth, developing a positive image on the good relations among maritime defense apparatus to people living in coastal areas to promote an awareness and culture of reporting suspicious activities on and off shore as well as cooperating with the authorities. This will allow not only the development of people-based Maritime Domain Awareness (MDA), but also a sense of pride and sympathy among the people, which would then encourage some to be a part of the apparatus.

It is hoped through these five steps, Indonesia could once again develop its maritime culture as well as ensure it is sustainable. Culture and mindset are abstract and structural, and therefore the dominant changer would rely on education apparatus. Maritime defense apparatus can play an important part by providing counseling and implement best practices.

3. Maritime Defense in Support of Maritime Resources Development

The future holds many challenges for Indonesia. Food and energy scarcity, global economic crisis due to climate change and low global economic growth are just some of these challenges that may occur in coming decades. By 2030, Indonesia will have a population of 300 million people. At the same time, Indonesia "may" become a net importer of food and energy. This means Indonesia requires a stable flow of food and energy, followed by positive economic growth in order to maintain its political, economy, social, and defense-security stability. One way is to develop maritime resources. The seas are abundant with food and energy, from fish stocks, oil and gas reserves deep within the seabed to blue energy resources of tidal waves, solar and wind power, underwater geothermal, and Ocean Thermal Energy Conversion (OTEC). Sea-borne trade, marine resource exploitation and maritime industry will also push economic growth, allowing sea management to assist Indonesia to break free from economic crisis. In short, Indonesia's ticket out of food, energy and economic crises is the development of its maritime resources and potentials. This, however, implies more activities will happen at sea, which will require more protection from maritime defense apparatus along with protection of maritime resources from criminal activities, pollution and claims from other countries.

In order to protect the second GMF pillar, maritime defense apparatus should conduct activities to safeguard national maritime resources in Indonesian waters until some areas of high seas that are linked directly with the country's resources. Thus, a number of efforts should be taken into consideration.

First, the government should establish basing infrastructure on the locations of national maritime resources, such as the western coast of Sumatera, Natuna Sea, Karimata Strait, southern coast of Java, Timor Sea, Arafura and Banda Seas, northern coast of Sulawesi, Halmahera Sea, and the Pacific Ocean in the north of Papua. These basings will maximize the response time and support effective fleet deployment in facing illegal activities at sea, including IUU fishing and illegal oceanography surveys and waste disposal. In return, they provide sense of security against threat at sea. Basings will also allow more effective deployment of defense apparatus in dealing with provocation, threats against sovereignty and annexation of Indonesia's maritime area from other countries;

Second, providing effective detection and communication facilities as well as weaponries to optimize law enforcement and uphold sovereignty at sea. These facilities include radar, sonar, acoustic transmitter, communication towers, listening posts, targeting system, CCTVs, Automatic Identification System (AIS), Vessel Monitoring System (VMS), and navigational assistance;

Third, procuring special weapon systems for maritime security in the Exclusive Economic Zone (EEZ), high seas, and deep sea. They include corvettes and frigates, patrol vessels, aircraft and helicopters for intelligence, surveillance, reconnaissance (ISR) and communications, UAVs and Unmanned Sub-Surface Vessels (USSVs), navigation satellites, and weapons for deterrence;

Fourth, strengthening Bakamla as Indonesia's coast guard with the capacity as a single agency-multi tasks in order to eliminate current confusion in decision making process on law enforcement a sea (multi agency). Having Bakamla as the national coast guard allows the international community to better comply with Indonesia's rules and regulations as they sail and conduct activities in our seas. Allocating particular zones in maritime defense is also an important step strengthening the role of Bakamla as a single agency-multi tasks, especially for TNI AL, Polair, Ministry of Fishery Affairs, and Customs. This should be followed by development of an integrated communication and information and intelligence sharing system among maritime defense and law enforcement apparatus to attain effective and efficient response and asset deployment at sea;

Fifth, develop synergy of TNI AL-Bakamla maritime defense system to safeguard EEZ and the high seas to have a dynamic and flexible system, able to face various types of threat from both state and non-state actors. Bakamla would be responsible for pollution at sea, IUU Fishing, and sea pillage, while TNI AL will uphold sovereignty at sea through the deployment of its assets for better and more effective deterrence. Nevertheless, both agencies could also uphold the law in regards to certain criminal acts at sea, such as smuggling, piracy, hijacking, kidnapping and maritime terrorism. It is crucial to strengthen Bakamla so that the agency can avert provocation and uphold sovereignty upon foreign warships in Indonesian waters as well as the high seas. Japan's practice of deploying its coast guard vessels to face warship and paramilitary intrusion into its waters is an important lesson, where upholding sovereignty does not always require warships. This practice has even maintain stability in regards to the tensions between Japan and China, allowing both countries to avoid conventional war;

Sixth, conduct combine exercises between TNI AL and civilian maritime law enforcement agencies in order to develop interoperability and sharing of best practices on effective maritime defense. The exercise will not only enhance the skills of their personnel, but also to eliminate ambiguity when tow or more agencies are conducting law enforcement operation in the same area. Members of maritime society should take part in such exercises to develop a bond between law enforcement agencies and the people. It will also increase civilian ability in facing certain threats at sea;

Seventh, by conducting cooperation with other countries, in particular those along areas prone to maritime security threats or where agreement on maritime boundaries has yet to be achieved. Cooperation may include coordinated and joint patrols. This is especially important to ensure no parties could take advantage of "unguarded" areas at sea.

4. Maritime Defense to Protect Maritime Infrastructure Development

As a developing country, infrastructure development is one of Indonesia's national priorities. The country is still experiencing local economic fragmentation, one of the consequences of its lack of infrastructure and efficient connectivity system.[6] The lack of

[6] Harvard Kennedy School, *The Sum is Greater than the Parts: Melipatgandakan Kemakmuran di Indonesia Melalui Integrasi Lokal dan Global*, Jakarta: PT. Gramedia Pustaka Utama, 2014, p. xiv-xix.

infrastructure has put a huge burden on logistics. In 2012, Indonesia has the most expensive logistical cost in shipping among ASEAN countries, with a proportion of 15 percent from the value of goods.[7] Around 70 percent of Indonesia's trade are concentrated in Tanjung Priok Port, a signal of uneven distribution of maritime infrastructure and the vulnerability of its national logistical system if Tanjung Priok Port faces problems.[8] Indonesia's Logistic Performance Index (LPI) decreased from rank 59 in 2012 to 63 in 2016.[9] In the face of such issues, GMF included the development of maritime infrastructure as its third pillar, and it has become the current administration's main priorities on national infrastructure development. In the near future, the country will see an increase in the number of maritime infrastructure all around the world.

The role of maritime infrastructure is essential in breaking economic fragmentation since sea transportation is more efficient and cheaper compared to land and air transportation. Indonesia's geography is dominated by islands and waters, which should provide competitive advantage in regards to logistics. Maritime infrastructure development will require safeguarding from threats of smuggling, piracy, sabotage, terrorism and hacking, to allow safe and smooth operation. Next are efforts to ensure such safety and security.

First, maritime infrastructure, especially ports, should have 20 percent of their land to develop defense-security facilities. The planning should involve TNI AL, Bakamla, National Intelligence Agency (BIN), Polair, and other related stakeholders. An effective deployment of defense-security assets is the main goal here, by assuring security clearance, mapping of existing underwater cables, decreasing the size of shadow areas, and lower the possibility of ports becoming the gateway of criminal activities. The facilities should accommodate personnel from maritime defense agencies in order to provide cross-agency security system. other infrastructure, such as the weather station, could be integrated with other detection equipment in order to detect anomalies and signs of natural disasters at sea that may very well have grave impact on land, allowing early detection of such disasters;

Second, maritime infrastructure, especially ports, should be designed and built in adherence to international security indicators, from CSI, ISPS Code and SOLAS. This will allow more effective prevention of criminal acts as well as nurturing international trust and confidence on Indonesian ports, inviting more ships to anchor at Indonesian ports. Integrating national security clearance systems for ports with international security system will decrease dwelling time and expedite Indonesia's trade process in the international level;

Third, maritime infrastructure must be able to withstand cyber threats and attacks. Modern ports operate by computer and are linked to the internet through effective and efficient port service system. The system relies heavily on computers and the internet in controlling the container terminal and monitoring ship movement from VMS and AIS controls. Malware attacks such as ransomware and hackers who could change the course of a vessel should become the reasons for any maritime infrastructure to develop its cyber defense system.[10] A cyber attack on Tanjung Priok Port would be a major disaster for Indonesia's national logistic system. The same system should also be equipped in oil off-shore platforms,

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[7] *Ibid*.

[8] *Ibid*.

[9] World Bank, *International LPI Global Ranking*, https://lpi.worldbank.org/international/global, accessed on 25 September 2017 at 23.43 Jakarta time.

[10] Jonathan, Saul, *Global Shipping Feels Fallout From Maersk Cyber Attack*, https://www.reuters.com/article/us-cyber-attack-maersk/global-shipping-feels-fallout-from-maersk-cyber-attack-idUSKBN19K2LE, accessed on 21 October 2017 at 20.34 Jakarta time.

communication system, and satellites. A hacked system may happen just for a few days, however, the consequences are immense in terms of financial lost, damaged equipment and infrastructure, and even the lost of lives. In short, cyber security should be a top priority in ports. Hence, the role of National Cryptographic Agency (in short LAN, soon to become National Cyber and Cryptographic Agency), BIN, Polri, and TNI is important in managing cyber threats in ports. Indonesia should also conduct cyber cooperation to ensure an integrated security system;

Fourth, in order to safeguards national maritime infrastructure, patrols and protection should be implemented in the coastline, EEZ and high seas by maritime law enforcement and maritime defense agencies. Maritime infrastructures – ports, offshore oil platforms, buoys, lighthouse, to name a few -- are prone to various threats, from ship colliding, robbery, to becoming a target of a terrorist attack. The value of these infrastructure are crucial to national economy and security as well as the sake of people's lives. The challenge in securing these infrastructures is in their different locations, far from one another. Maritime defense agencies must have the ability to cover a large area of operations along with quick time of response. Aircraft is a valuable asset in this matter, able to reach a location faster than ships and has better range of vision. Therefore, the Indonesian Air Force (TNI AU) should be involved in protecting maritime infrastructures.

5. Maritime Defense for Maritime Connectivity

Protection of maritime infrastructure is correlated with protection of maritime connectivity. A logistic system requires not only infrastructure but also a good connectivity system. Although infrastructure and connectivity are both parts of the third GMF pillar, they do not share a common security system. The prior is stationary while the latter is mobile. Protection of maritime connectivity should be able to face dynamics at sea, and therefore necessitates a different set of assets and methods. This paper will not only discuss ways to better protect Indonesia's maritime connectivity, but also how a connectivity network may cover the archipelago better and link the system with foreign logistics network.

First, the Sea Toll Road (Tol Laut) program should be developed not only for shipping along National Inner Circle or Lingkar Dalam Nasional (includes Malacca Strait, Karimata Strait, and northern part of Java Sea, to name a few), but also National Outer Ring or Lingkar Luar Nasional, including the waters in the western part of Sumatera, southern part of Java Sea, Sulawesi Sea, northern part of Papua, and deepwater areas (Arafuru and Banda Seas);

Second, the program should connect national ports with international ports; Singapore, Port Klang, Hong Kong, Macau, Shanghai, Mumbai, Rotterdam, Dubai, Sevastopol, Vladivostok, Tokyo, Quebec, Lagos, Hawai, Darwin, Canberra, Brussels, Istanbul, Wellington, New York, Caracas, Narvik, Stockholm, Helsinki, Busan, and other strategic port cities. Such international connectivity will push exports and imports to and from these countries. In order to support this idea, Indonesia needs to develop main ports in each of its big islands as the main export ports to particular countries. For example, main ports in Sumatera would be located in Aceh, Padang, and Bangka/Belitung, for Kalimantan in Pontianak and Balikpapan, for Sulawersi in Makassar, Plau and Bitung, for Nusa Tenggara in Lombok and Kupang, for Maluku in Ambon and Morotai, and Papua will be in Sorong, Biak, Jayapura, and Merauke. Such planning will ensure efficiency and better management of shipping connectivity to other countries, as well as supporting security (through the implementation of ISPS Code and CSI);

Third, protection of both National Inner and Outer Circles by maritime defense agencies. The protection should be reviewed from two aspects, accidents at sea and crimes at sea. Both routes have different characteristics. The former consists of relatively shallow waters with big and small islands, and so deployed platforms should consist of small and medium forces (patrol ships of 23-60 meters and corvettes) along with medium aircraft (two engines). The latter is dominated by semi-enclosed waters, where bigger ships, corvettes and frigates, would be able to handle big waves and bad weather. Aircraft should be large (four engines) with longer coverage distance, higher endurance, and able to withstand bad weather. Some waters in the National Inner Circle are famous for their big waves, including Flores Sea, Makassar Strait, Maluku Sea and Seram Sea, and therefore require bigger ships to patrol the area. Medium-sized surveillance aircraft would be sufficient. It is important to involve TNI AU in order to better detecting and tracking ships and security threats. Along with TNI AL, Bakamla and Polair, these agencies should have an integrated information and intelligence sharing system, including land detection infrastructures: radars, listening posts, and weather stations;

Fourth, maritime defense forces should be able to have forward presence until EEZ and the high seas, especially in certain coordinates of ships coming towards and outwards. Such presence is crucial in order to tackle hijacking, kidnapping, ship collision, illegal waste dumping, and capture of suspicious vessels of possible sabotage or maritime terrorism;

Fifth, regulate all ships beyond 300 GT to use AIS (in line with SOLAS regulations) for monitoring and tracking ships, either to respond to accidents at sea or to track down suspicious vessels. It is hard to track and warn ships without AIS in case of danger, which would also endanger other ships at sea. All ports should have VMS and hotline for assistance request in case of accident or natural disaster at sea. This mechanism could increase crew safety and allow better management of shipping routes and logistics;

Sixth, every ship with AIS should also equipped itself with cyber defense system, including VMS equipment on land to prevent hacking efforts that could disrupt shipping routes, allow sabotage activities or even terrorism. Ships are now sailing by using automatic navigation by GPS. The system is prone to hacking or malware attack, and so cyber defense system is paramount. Worst case scenarios include ships navigating outside their course and colliding with other ships, such container, LNG and supertanker vessels, or even with a port, a sea traffic jam due to a sinking ship in a narrow strait. Hackers and malware attacks could also sink ships on the location of international underwater cables that could have catastrophic consequences on national and global stability.

6. Maritime Defense to strengthen Maritime Diplomacy

Diplomacy plays an important role in maintaining security stability. Achieving national interests through diplomacy and negotiation should be an expertise mastered by Indonesia in regional and global arena. Maritime defense could strengthen such craftsmanship in order to realize Indonesia's GMF policy through the following efforts.

First, Indonesia should ensure the Sea Toll Road program is connected to international connectivity network. The negotiation is crucial to allow Indonesian-flagged vessels to anchor at international ports and take part in global logistics system. In order to attain international confidence in this matter, all of Indonesia's ports should comply with ISPS Code and CSI, especially the ones connecting directly with global maritime connectivity network. Adequate maritime defense will strengthen clearance process and increase efficiency of national-regional-global logistics systems;

Second, Indonesia should conduct MoU and cooperation with other countries on safety of navigation in order to have their maritime authorities to monitor Indonesian-flagged vessels in their waters from criminal acts at sea as well as accidents at sea;

Third, China's Belt and Road Initiative (BRI) should be negotiated to align the project with Indonesia's national interest. It should be mandatory for maritime infrastructures built based on BRI program to allocate 20 percent of their land for security facilities. Raw materials and workers should come from Indonesia in order to boost local economic growth. Profit sharing system should also be negotiated in order to ensure Indonesia's benefits from the arrangement. Another important factor is the prohibition of any deployment of Chinese military force in order to uphold sovereignty;

Fourth, Indonesia should anticipate the development of Kra Canal by developing maritime infrastructure in Aceh (Sabang) and Natuna (Ranai) as well as other commercial infrastructures, including industrial complexes, warehouses, oil distillery and bunker, and factories of cement, steel and fish processing. Indonesia should also start to negotiate on how its ships could pass Kra Canal safely and economically for a better and effective national, regional, and global connectivity. If Indonesia could utilize Kra Canal, it will ensure a better connectivity from norther Sumatera to Natuna, Anambas, West Kalimantan, and also to countries in East Asia;

Fifth, through naval diplomacy, Indonesia should strengthen its sovereignty and national interest at sea from threats of state and non-state actors through discussion, agreement, and deterrence. The latter is done by modernizing its maritime defense fleet and increasing its presence at sea. Such deterrence will make countries thin twice before conducting any kind of provocation, since Indonesia's maritime defense forces could tackle such intent as soon as possible with modern and reliable assets and platforms. The modernization process must follow the principles of reasonable navy and reasonable naval security forces to avoid unwanted tensions and regional arms race;

Sixth, conduct coordinated and joint patrol in certain hot spots, which should be agreed first through MoUs. Sea monitoring is not only challenging but also expensive. Hence, cooperation with neighboring countries provides solution to the issue. Joint and coordinated patrols could also be done in disputed waters (where boundaries are yet to be clear) in order to prevent security and defense gaps, which then will allow criminals to take advantage and hamper national security;

Seventh, conclude maritime boundary negotiations with neighboring states. Agreement on existing maritime dispute should be achieved as soon as possible in order to conduct more effective maritime security efforts and avoid escalating tension that may erupt at any given time. Designation of maritime boundary coordinates will also assist in marine resources exploitation;

Eighth, conduct negotiation for cooperation on maritime cyber security. It is a fact that Indonesia's cyber security abilities are still in premature, including in the maritime domain. As a country with a strategic location on map, a transit of ships sailing from all over the world, the vulnerability of Indonesia's cyber space upon its maritime infrastructures and assets could bring about unpredicted lost. If such thing occurred, Indonesia will lose not only its face but also its place in the international community.

7. Conclusion

In an unstable and uncertain world, maritime security challenges and threats could easily hamper the realization of GMF policy. This condition necessitates a priority on the fifth pillar of GMF; maritime defense. Weak apparatus could not protect Indonesia's interest, and therefore requires strengthening of both agencies and capacities as the policy's primary objectives. New ideas and initiatives are important in order to accelerate the realization of GMF. The programs discussed in the paper are for long-term, which requires consistency in terms of maritime policy. The absence of commitment and consensus among policy makers, operators and evaluators will only make GMF a mere dream or hope that could never be realized. Thus, ensuring the people and government awareness to look at the sea should be done vigorously and structured in order to eliminate sea blindness, which has separated Indonesia from its true identity; a nation strong and triumphant at sea.

References

Harvard Kennedy School, *The Sum is Greater than the Parts: Melipatgandakan Kemakmuran di Indonesia Melalui Integrasi Lokal dan Global*, Jakarta: PT. Gramedia Pustaka Utama, 2014.

Malik, Mohan (ed.), *Maritime Security in the Indo-Pacific: Perspective from China, India and the United States*, London: Rowman and Littlefield, 2014.

Marsetio, *Sea Power Indonesia*, Jakarta: Universitas Pertahanan Press, 2014.

Octavian, Amarulla, *Budaya, Identitas dan Masalah Keamanan Maritim*, Jakarta: Universitas Pertahanan Press, 2014.

Octavian, Amarulla, *Pirates: Between Aden and Malacca*, Jakarta: Indonesia Defense University Press, 2016.

Westcott, Allan (Eds), *Mahan on Naval Warfare: Selections from the Writings of Rear Admiral Alfred T. Mahan*, 1918.

Williams, Phil, *Terrorist Financing*, in Shmella, Paul et.al, *Fighting Back: What Governments Can Do About Terrorism*, Stanford: Stanford University Press, 2011.

Sakhuja, Vijay, and Jane Chan (ed.), *China's Maritime Silk Road and Asia*, New Delhi: Vij Books India Pvt Ltd, 2016.

Sakhuja, Vijay, and Kapil Narula (ed.), *The Blue Economy: Concept, Constiuents and Development*, New Delhi: Pentagon Press, 2017.

Slanchev, Branislav L., *Military Threats: The Costs of Coercion and the Price of Prace*, Cambridge: Cambridge University Press, 2011.

Supriyanto, Makmur, *Tentang Ilmu Pertahanan*, Jakarta: Yayasan Pustaka Obor Indonesia, 2014.

Till, Geofrey, *Indonesia as a Growing Maritime Power: Possible Implications for Australia*, Sea Power Centre Australia, 2015.

Tippe, Syarifudin, *Ilmu Pertahanan: Sejarah, Konsep, Teori dan Implementasi*, Jakarta: Salemba Humanika, 2016.

__________, *Buku Putih Pertahanan Indonesia 2015*, Jakarta: Kementerian Pertahanan RI, 2015.

__________, *Asia-Pacific Regional Security Assesment 2017*, London: The International Institute for Strategic Studies, 2017.

BBC, *Bomb Caused Phillipine Ferry Fire*, http://news.bbc.co.uk/2/hi/asia-pacific/3732356.stm.

Jonathan, Saul, *Global Shipping Feels Fallout From Maersk Cyber Attack*,

World Bank, *International LPI Global Ranking*, https://lpi.worldbank.org/international/global.

https://www.reuters.com/article/us-cyber-attack-maersk/global-shipping-feels-fallout-from-maersk-cyber-attack-idUSKBN19K2LE.

FIELD I
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KNOWLEDGE TRANSFER STRATEGIES SELECTION IN ERP SYSTEM IMPLEMENTATION WITHIN INDONESIAN SMALL AND MEDIUM ENTERPRISES

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ABSTRACT

Indonesian Small and Medium Enterprises (SMEs) have attempted to implement Enterprise Resource Planning (ERP) System to enhance their business sustainability and become more competitive in the global market, albeit with some problems. Drawing from the relevant literature of information system success models, knowledge management and user behaviour, this study has developed a research model to examine various factors of knowledge transfer process in ERP implementation within Indonesian SMEs. The research model includes specific constructs and paths which affect the evaluation of a successful knowledge transfer strategy. Multiple Criteria Decision Making and Goal Programming were used to select the most appropriate knowledge transfer strategy in an adopting company. The study found that consulting companies and management supports have significant roles to the factors that lead to good knowledge transfer. The proposed model, with minor modifications, can asssit Indonesian SMEs in deciding and selecting their knowledge transfer strategy.

KEYWORDS : ERP system, Goal Programming , Knowledge Transfer, Multiple Criteria Decision Making, Small and Medium Enterprises.

1. INTRODUCTION.

Nowadays, modern companies utilise computerised process and automation in various operational fields ranging from accounting, supply chain management to production supervision. The adoption and use of Information Technology (IT), particularly complex software such as Enterprise Resource Planning (ERP) system, have mostly been initiated by large companies. With the growing trend toward computerisation in the business world and availability of more affordable options of ERP system, in the form of open source software or modular version, Small and Medium Enterprises (SMEs) have also begun to invest in ERP implementation projects.

ERP system is developed as a group of computer applications that integrates and coordinates various business processes both across and within a company (Davenport, 1998). In recent years, ERP vendors have expanded their market segment to SMEs since almost all of the large enterprises have already implemented ERP systems and the market has become close-to-saturation (Stein and Hawking, 2003). As a result, there are now a wide range of ERP products for business owners to choose from including products dedicated to the SMEs market.

The SMEs sector in Indonesia is regarded as one of the main drivers of the Indonesian economy. Saksono (2014) underlined the significant role of SMEs that form the backbone of world economies to ensure growth with equity among countries. In this regard, data from BPS survey in 2013 shows that the SME sector in Indonesia constitutes more than 99.98 per cent of all Indonesian enterprises and employs 97.2 per cent of the total workforce

(Yudhoyono, 2014). Ministry of Cooperatives and SMEs recorded that with respect to the GDP contribution, Indonesian SMEs have recently contributed around 57 per cent to Indonesian GDP in 2016.

While the SME sector in Indonesia is recognised for its contribution to the economy, there are considerable obstacles faced by these companies, especially from the lack of technological infrastructure and business expertise. Globalization, intense competition from similar companies in Asian regions along with increasing demand for better quality products has prompted Indonesian SMEs to improve their competitiveness to stake a larger share in the world markets.

For many SMEs, demand for better service by business partners or customers often provide the impetus for IT implementation. In many SMEs, their supply chain partners have often pushed their decision to adopt IT. Studies about IT adoption in SMEs reveal that the small firms often decide to implement IT in order to deliver quality service and effective communication to their suppliers and customers (Caldeira and Ward, 2002). The efficiency of ERP system-based communication in supply chains at large enterprises has motivated SMEs to implement ERP application to develop supply networks with their business partners (Argyropoulou, Loannou and Prastacos, 2007).

While Indonesian SMEs have also begun to implement ERP in their operations, the systems remain under-utilised in these firms and many are yet to fully experience the benefits of ERP systems. The studies of ERP adoption in Indonesian SMEs reveal that the problems in under-utilisation of ERP stem from a considerable knowledge gap between ERP vendors, consultants and recipient companies (Sarosa, 2007; Handayani, 2008). The critical role of knowledge for ERP success is also reflected in the broader literature on ERP implementation, where authors generally agree that an effective knowledge transfer facilitates corporate investment to adopt ERP system, in particular, to capture, elevate and retain ERP system knowledge among their employees (Soja, 2008; Abdallah and Albadri, 2010; Heinze and Hake , 2010).

Interest has then grown in examining how knowledge is acquired and maintained during ERP system implementation projects but this has not been investigated in depth in the ERP projects of smaller firms. Furthermore, research that focus on the adoption of ERP systems in Indonesian SMEs do not explain how small and medium firms actually manage the knowledge transfer process in the ERP system projects. There appears to be little research emphasizing on knowledge transfer process in Indonesian SMEs' ERP system implementation projects, challenges that their managers face in managing the process, and how to address those challenges. To that end, this paper reports on a quantitative research to examine the contribution of factors that influence the selection of knowledge transfer strategies in Indonesian SMEs' ERP projects.

The question of what causes the success or failure of adoption of IS in an organisation has become an interesting topic for researchers. Research in end user's training for IT implementation projects support the notion that knowledge transfer plays an essential role for successful IT system implementation (Haines and Goodhue, 2003; Karlsen and Gottschalk, 2004). This case applies to the implementation of the ERP system as a complex IT product that can be distinguished from other software solutions due to its explicit and inherent business rules which could impose different ways of doing business and bring about culture change in adopting organisations. In the process of ERP implementation, the transfer of knowledge during the projects is considered as one of the significant support factors for ensuring a successful and beneficial ERP project (Skok and

Legge, 2002). These scholars argue that the better knowledge of the ERP projects will allow for better training of staff on wider level as a result of being exposed to new knowledge.

Since ERP systems are expensive, complex, time consuming and difficult to implement, competent external experts are important to increase the likelihood of ERP implementation success. Many organisations lack the personnel with IT expertise to carry out ERP system implementation, and often those organisations acquire the required expertise by hiring consulting companies to guide them through the whole implementation process (Li, Liao and Lei, 2006).

The process of knowledge transfer involves exchange of knowledge and its application between the knowledge source and its recipient. According to Argote and Ingram (2006), knowledge transfer is “a process through which an individual or an organisational unit (e.g., a group, department, and division) is influenced by the experience of another individual or unit which becomes apparent by changes that are produced in the knowledge base or results of the individual or recipient unit”. When the implementation partners fail to capture the adopting organisation's business process and requirements for the system, the ERP system implementation may be deemed as unsuccessful in fulfilling the needs of the adopting organisation. Conversely, even a perfectly-installed ERP system can turn out to be a wasteful investment when the end-users do not understand how to operate the ERP system in their daily activities.

Therefore, knowledge is not merely a component of the training given to users while adopting ERP systems, but the ability of trainers to disseminate the knowledge and the users to absorb that knowledge can be a significant factor of ERP success. ERP success is not merely a matter of logistical success in implementation of the technology, but is determined by the way the organisation is able to disseminate knowledge about the usage and benefits of IS among its employees. Timbrell, Andrews and Gable (2001) argue that knowledge management plays a significant role in evaluating the sources of knowledge transfer problems and solving the most important barriers in ERP system projects. The proposed model in this paper describes the problem related to the selection of knowledge transfer strategies in a hierarchical form and integrates the criteria of knowledge transfer with various knowledge transfer strategy options. It also explicitly evaluate the tangible and intangible constraints regarding the strategy alternatives and formulate a multiple criteria goal programming model to identify the best knowledge transfer strategy.

2. LITERATURE REVIEW

2.1 Knowledge Transfer Strategies

A vast literature of knowledge management research has examined many range of knowledge transfer strategies, and attempted to classify them. One strategy classification is system-based strategy which emphasizes on the capability to make, save, share, and utilize an organization’s documented knowledge through advanced ITs (Davenport et al., 1998). Another classification focuses on the belief that tacit knowledge which existing in peoples’ heads is the most valuable knowledge and should be transferred through direct contacts and social relationships (Choi et al., 2008). This strategy is classified as human-oriented strategy. Knowledge transfer process using human-oriented strategy is considered time consuming, expensive and slow. Therefore, tacit knowledge transfer process requires an efficient codification into explicit medias (Schulz and Jobe, 2001).

An organization needs to understand which knowledge transfer strategies better suited to their circumstances. Some authorts suggest a combination of knowledge transfer strategies while others argue that knowledge transfer strategies should be implemented solely (Choi et al., 2008) However, other researchers argued that organizations should pursue a balanced approach which calls for the combination of knowledge transfer strategies appropriately (Choi et al. 2008). Choi and Lee (2003) showed that combination set of system-based and human-oriented strategies resulted in better knowledge transfer performance. Wu and Lee (2007) suggested a dynamic strategy as a combination of both knowledge management strategies. The dynamic strategy combines the concept of human-oriented and system-based knowledge transfer strategies and emphasizes on both tacit and explicit (Wu and Lee, 2007). Organizations should consider their decision criteria when selecting their strategies.Therefore, it is necessary to evaluate different criteria in the practice of choosing the appropriate knowledge transfer strategy.

2.1 Knowledge Transfer Criteria

After reviewing the literature on the dynamic relationships between ERP Systems, knowledge management and organisational characteristics, many of criteria in DeLone and McLean IS Success Model (DeLone and McLean, 2003) and Knowledge Management System Success (KMS) framework (Kulkarni, Ravindran and Freeze, 2007) found to be the most relevant for this study. The DeLone and McLean IS success model (DeLone and McLean, 2003) established a sufficient foundation for predicting the relationship between user's intentions and IS usage, but it does not include the perception of the user's confidence in the external partner chosen by the organisation to implement the system. KMS model (Kulkarni et.al., 2007) follows the path of DeLone and McLean IS success model but excludes consultant involvement in their model. Wong and Lu (2005) modified DeLone and McLean IS success model by adding the factor of external IT experts to measure the success of computerisation in Taiwan's SMEs. They suggested that confidence towards external experts as the partner in the development of IT may affect the success rate of IS implementation. Many studies have underlined consultant involvement as one of the key determinants of successful implementation of ERP systems (Willcocks and Sykes, 2000; Loh and Koh, 2004; Ifinedo, 2008). Therefore, this study needs to examine how SMEs' employees tend to use their knowledge to rate the credibility of their ERP consultants. In accordance with Ko, Kirsch and King (2005), the present study contends that consultant or external source credibility relates to the extent to which their knowledge source is perceived to be reliable and knowledgeable. To examine the SMEs' management perception towards consultants' capability in delivering ERP system projects, a construct of ERP Vendor Credibility is added to the original KMS model.

Knowledge management practice will contribute anything to the organizations' goals only if it receives support from their own employees. Kulkarni et. al. (2007) asserts that the commitment of the management to provide both monetary and non-monetary rewards can improve employee efforts to share and reuse knowledge. Motivation factors or rewards are required to motivate employees to generate and contribute their knowledge to knowledge repositories in the organisation rather than hoard it for their individual benefit. In the context of ERP systems, many studies of ERP projects have proved that rewards and incentives have a significant relation with employee participation to support the new system and reduce any resistance to the ERP project (Calvert and Seddon, 2006; Da Silveira, Snider and Balakrishnan, 2012). To investigate how SMEs motivate employees to contribute to knowledge repositories and participate to support ERP projects, this study adds Incentives as a construct to the KMS model.

An organisation with good leadership stands out from its competition because it provides a rewarding work environment where the employees at all levels are encouraged to create business value work with others who have same state of mind and experience accomplishment in their work. Sarosa (2007) recognised that Indonesian SMEs are likely to have a owner manager and immediate family member influence which designates the final decision in every organisational aspects. This situation, where the enterpreneur or owner manager acts as dominant decision maker and facilitates innovative business process, is reflected in this study as SME's Owner Leadership construct.

The effectiveness of knowledge transfer process is dependent on whether the firm has sufficient absorptive capacity before that ERP project is implemented. Therefore, it is necessary to define the term absorptive capacity to understand organisational innovation and best practices from a knowledge management perspective. Ko et al. (2005) studied knowledge transfer from ERP consultants to an organisation and found that the organisations' absorptive capacity and prior knowledge about ERP systems influence the knowledge transfer between their employees and consultants. Absorptive Capacity is regarded as the recipients' ability to value, assimilate and apply knowledge of ERP system in their business activities, which is then hypothesised to influence their perception towards knowledge transfer process in ERP system project. It is necessary for the adopting company to put their best employees on the ERP project team (Vandaie 2008). By doing this, the adopting company selects employees with adequate prior knowledge and learning capacity to absorb the new knowledge which can ensure transfer of knowledge between ERP project team members to contribute to successful ERP system implementation.

Encouraging processes of knowledge sharing where people share and discuss their ideas, opinions and insights can enable them to develop new innovations in operations of their company. The culture of an organisation has an important role in shaping this condition. Karlsen and Gottschalk (2004) posit that organisational culture influences knowledge transfer as it shapes assumptions held by the employees in an organisation about knowledge worth exchanging. They further argue that organisational culture defines the relationship between knowledge source and recipients, develops social interaction where knowledge sharing can happen and shapes the process of knowledge creation and distribution in organisations. A knowledge sharing culture is an environment where there is a willingness from each individual to disseminate information across the organisation, regardless of its size. In the case of ERP system implementation, the team members must know what the others do, gather information from end-users about their business processes and, in return, inform the end-users and their managers about the new process being implemented. With the aim of fostering this culture, individuals must comply with the norms, values and beliefs that employees shaped and honed in the organisation. A defiance of these rules will cause bottlenecks in the knowledge-transfer and important information will not reach the intended audience.

By adopting an ensemble view of IS and KMS models, this study investigates knowledge transfer strategy in ERP system implementation in Indonesian SMEs. The abovementioned literature review has established a foundation for developing a conceptual model that can be employed to analyse the effectiveness of knowledge transfer in ERP system implementation. The DeLone and McLean IS success model and the KMS model provide a framework that explains the criteria in ERP implementation that not only focus on the perceptions of users or user satisfaction but organisational culture and external factors. Since most of the issues in this research are covered by both models, they are adopted in integration with several adjustments. This study poposed a model based on the results of group decision-making and this literature review that there are five criteria, including SME owner leadership (OL), Incentives (I), absorptive capability (AC), knowledge sharing culture (KC), and ERP vendor capability (VC), as knowledge transfer strategy evaluation criteria.

3. METHODOLOGY

A survey questionnaire, developed from the research model was distributed to a sample frame drawn from State Ministry of Cooperative and SMEs database and mailing list of Indonesian small and medium firms and ERP user members' directories. The questionnaire was send by using e-mail; the criteria evaluation and selection of launch strategy were defined; the final criteria was extracted in whish a score of four on the Likert 5-point scale must be achieve. A total of 56 responses were received, producing more than the minimum threshold of 50. In terms of the proportion of the receive responses against the overall targeted sample, the response rate of 56 completed responses from 355 invitations made a response rate of 16%. Since the response rate for survey research in industrial studies typically fall between 15-30% (Vlosky, Westbrook and Poku, 2002), the response rate of this study is acceptable by those general norms.

3.1 Analytic Network Process

Analytic Network Process or ANP is a general theory of relative measurement based on a methodology that deals with effects of interacting elements within control criteria (Saaty, 1999). ANP uses mathematical theory to derive a composite priority ratio from an individual ratio scale and measure influences that deals with dependencies and feedback. ANP is one of the major approaches in the multiple decision making process that provides a common framework for treating decisions without making assumptions about the independence of criteria at many different levels. ANP uses a network map to describe the priorities in a system based on interdependency and feedback. The ANP network map also produces a structured influence network of criteria among clusters and nodes. Clusters are groups of indicators for criteria classification while nodes are criteria or indicators for the model construction. In order to develop the framework of the problem, pair-wise comparisons matrix would be constructed to evaluate all the interactions among the elements. Moreover, priority vectors would be calculated to obtain a supermatrix of the influences among the elements. This supermatrix is derived from the inclusion of priority vectors to obtain overall priorities in a system involving interdependent influences of elements on each other. When the criteria are interrelated, the entry of supermatrix of a hierarchy of n given would indicate the interdependency, and the supermatrix is as follows

$$
W = \begin{array}{cc} & \begin{array}{ccc} C_1 & C_2 & C_N \\ e_{11}\; e_{12} \cdots e_{1n1} & e_{21}\; e_{22} \cdots e_{2n2} & e_{m1}\; e_{m2} \cdots e_{mnm} \end{array} \\ \begin{array}{cc} C_1 & \begin{array}{c} e_{11} \\ e_{12} \\ \vdots \\ e_{1n1} \end{array} \\ \vdots \\ C_2 & \begin{array}{c} e_{21} \\ e_{22} \\ \vdots \\ e_{2n2} \end{array} \\ \vdots \\ C_m & \begin{array}{c} e_{m1} \\ e_{m2} \\ \vdots \\ e_{mnm} \end{array} \end{array} & \begin{bmatrix} W_{11} & W_{12} & W_{1m} \\ W_{21} & W_{22} & W_{2m} \\ \vdots & \vdots & \vdots \\ W_{m1} & W_{m2} & W_{mm} \end{bmatrix} \end{array}
$$

Fig.1 Supermatrix of ANP (Source: Saaty, 2005)

Since W entries are composed of the vectors entered from the pair-wise comparisons, W is a partitioned matrix with the columns of a supermatrix usually total more than one. Therefore, each column of the matrix needs to sum to unity and the supermatrix must be transformed to form a column stochastic matrix. In order to obtain the global priority vectors, the limiting value is calculated by raising W to powers (Saaty and Vargas, 1998).

Once, the supermatrix is transformed into a column stochastic matrix, it is raised to a achieve convergence of the importance weights (Saaty, 1996). The supermatrix is raised to the power of 2k+1, where k is an arbitrarily large number. In other words, the supermatrix limiting powers now becomes $\mathbf{W}^{2k+1}$. Normalizing each block of this supermatrix can capture all the interactions and obtain the final priorities of all elements in the matrix.

3.2 The technique for order preference by similarity to an ideal solution (TOPSIS)

Chen and Hwang (1992), with reference to Hwang and Yoon (1981) proposed the technique for order preference by similarity to an ideal solution (TOPSIS) method to obtain the performance ratings of the available alternatives. TOPSIS is a distance-based MCDM that calculate the distance of each option from the best and worst performing alternatives to determine the positive-ideal and negative-ideal solutions. Positive-ideal solutions are alternatives that maximize the benefits and minimize the cost, while negative-ideal solution are alternatives that minimizes the benefits and maximizes the total cost. TOPSIS method should pick alternatives which have the farthest distance from the negative-ideal solution and the shortest distance from the positive-ideal solution. The process TOPSIS method comprises of these following steps:

Step 1: Calculate the normalized decision matrix. This step allows comparisons across criteria by transforming attribute dimensions into non-dimensional attributes. The normalized value r_{ij} is calculated as follows:

$$r_{ij} = x_{ij}\sqrt{\sum_{i-1}^{m} x_{ij}^2} \quad \text{i =1, 2, ..., m and j = 1, 2, ..., n.} \tag{1}$$

Step 2: Calculate the weighted normalized decision matrix. Multiply each column of the normalized decision matrix by its associated weight. The weighted normalized value v_{ij} is calculated as follows:

$$v_{ij} = r_{ij} \times w_j \quad \text{i =1, 2,..., m and j = 1, 2, ..., n.} \tag{2}$$

where: w_j is the weight of the j^{th} criterion or attribute and $\sum_{j=1}^{n} w_j = 1$.

Step 3: Determine the positive-ideal (A^*) and negative-ideal (A^-) solutions.

$$A^* = \{(\max_i v_{ij} \mid j \in C_b), (\min_i v_{ij} \mid j \in C_c)\} = \{v_j^* \mid j = 1,2,...,m\} \tag{3}$$

$$A^- = \{(\min_i v_{ij} \mid j \in C_b), (\max_i v_{ij} \mid j \in C_c)\} = \{v_j^- \mid j = 1,2,...,m\} \tag{4}$$

Step 4: Calculate the separation measures, using the m-dimensional Euclidean distance. The separation measures of each alternative from the positive ideal solution and the negative ideal solution, respectively, are given as:

$$S_i^* = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^*)^2}, \; j = 1,2,...,m \tag{5}$$

$$S_i^- = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^-)^2}, \; j = 1,2,...,m \tag{6}$$

Step 5: Calculate the relative closeness to the ideal solution. Choose the option with RCi* value closest to 1. The relative closeness of the alternative A_i with respect to A^* is defined as follows:

$$CC_i^* = \frac{S_i^-}{S_i^* + S_i^-}, i = 1,2,...,m$$

(7)

Step 6: Rank the preference order. The index value of *CCi lies between 0 and 1. A larger index value is closer to the ideal solution for alternatives.

3.3. Multiple Criteria Goal Programming

Multiple Criteria Goal Programming (MCGP) allows the decision-maker to set multi-choice aspiration levels for each goal to avoid underestimation of the decision. The rapid development of MCGP has led to significant diversity in models and methods. However, few studies have explored using MCGP to address real-world Multiple Criteria Decision Making (MCDM) problems, such as a product launch strategy selection, which involve the conflict of criteria. In fact, the conflicts between criteria and the incompleteness of information make it very difficult for decision-makers to build a reliable mathematical model for the representation of their preference. In this study, a MCGP problem is stated in the following model (Chang et al. 2014):

$$\text{Min } Z = p_k\,(CC_j d_i^+ , CC_j d_i^+) + (e_i^+ , e_i^-) \quad (8)$$

subject to

$$a_{ij} x_j - d_i^+ + d_i^- = y_i; \quad (9)$$

$$y_i - e_i^+ + e_i^- = g_{i\,\min} \text{ or } g_{i,\max}; \quad (10)$$

$$g_{i,\min} \leq y_i \leq g_{i,\max}; \quad (11)$$

$$x\,j + d_i; \quad (12)$$

d_i^+, d_i^-, e_i^+, e_i^- ≥ 0, i = 1, 2, ..., n, j = 1, 2, ..., m,

where x_j is the knowledge transfer strategy; a_{ij} is the j^{-th} knowledge transfer strategy using the closeness coefficient of the i^{th} SMEs resources; and y_i is the i^{th} available resource or limitation factor that must be considered in the selection decision; p_k denotes some k priority preemptive priority ($p_1 > p_2 >,..., p_k$), for the strategy goals, and other variables are defined as in MCGP. The proposal model bases the selection of the knowledge transfer strategy x_j on the TOPSIS determined closeness coefficient (CC_j) for corresponding d_i^+, and d_i^-. The larger CC_j is, the more likely the corresponding strategy will be selected.

4. RESULT AND DISCUSSION.

This study proposes an application of knowledge transfer strategy selection for SMEs to succesfully implement their ERP system. To illustrate the application and the effectiveness of the proposed ANP, TOPSIS and MCGP models for knowledge transfer strategy selection knowledge transfer strategy selection, the model was introduced to a medium manufacturer in Indonesia as a case study. First, a sample of SMEs was invited to participate in a survey to provide their opinions about the evaluation criteria for knowledge transfer strategy. The survey including experts who have rich experience in new product launches strategy was used to propose the criteria. The knowledge transfer strategy evaluation process in ERP system implementation of Indonesian SMEs is demonstrated as follows:

Step 1. After reviewing the literature and interviewing various practitioners, three knowledge transfer strategies remained for further evaluation. It was determined that there is an interdependence relationship among criteria; the attribute of criterion OL are concerned with criteria KC and I, and the attribute of criterion VC are concerned with criteria I and AC. In addition, the attribute of criterion KC influences criteria I and VC; the attribute of criterion VC influences criterion OL. In order to check net work structure or relationship in the considered criteria or candidate strategy, a group discussion was formed because the type of network or relationship depends on the users' judgement. Figure 2 presents the interdependence relationship among the evaluation criteria, which was determined by the discussion group in a thorough manner.

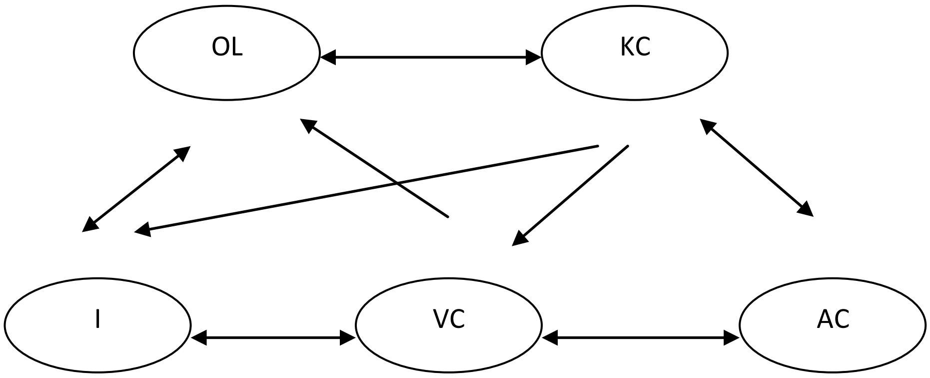

Fig. 2 The interdependence relationship among evaluation criteria: SME owner leadership (OL), Incentives (I), absorptive capability (AC), knowledge sharing culture (KC), and ERP vendor capability (VC)

Step 2. The team members were asked to evaluate all proposed criteria pairwise without assuming interdependence among them. Generating a geometric mean of the evaluators' pairwise comparison values, the result is presented in Table 1. The normalized weights matrix (***w1***) of criteria is as follows:

$$w_1 = \begin{pmatrix} KC \\ I \\ VC \\ AC \\ OL \end{pmatrix} = \begin{pmatrix} 0.245 \\ 0.198 \\ 0.181 \\ 0.136 \\ 0.240 \end{pmatrix}$$

which represents the related local priority of these criteria.

Table 1. Criteria pairwise comparison matrix

	KC	I	VC	AC	OL	W_1
KC	1	2.728	1.213	4.369	0.428	0.244
I	0.367	1	1.853	2.358	0.739	0.199
VC	0.824	0.540	1	2.115	0.572	0.182
AC	0.229	0.424	0.473	1	0.249	0.135
OL	2.336	1.353	1.748	4.016	1	0.241

Note: SME owner leadership (OL), Incentives (I), absorptive capability (AC), knowledge sharing culture (KC), and ERP vendor capability (VC)

Step 3. Next, the interdependence among the evaluation criteria was considered. The team members examined the impact of all criteria by using pairwise comparison. The normalized eigenvectors for these matrices are calculated and shown as five columns in Table 2, where zero was assigned to the eigenvector weights of the evaluation criteria that are independent. The value presented in Table 2 indicates the degree of the relative impact for each evaluation criterion. KCMC, SCI. MMVC. NOAC, TCOL

Table 2. The interdependence matrix of the evaluation criteria

w_3	KC	I	VC	AC	OL
KC	0.471	0.241	0.249	0.154	0.241
I	0	0.197	0.245	0.201	0.203
VC	0.274	0.183	0.343	0.233	0.214
AC	0.255	0.134	0.164	0.197	0.189
OL	0	0.244	0	0.215	0.153

Note: SME owner leadership (OL), Incentives (I), absorptive capability (AC), knowledge sharing culture (KC), and ERP vendor capability (VC)

Step 4. The relative importance of the criteria considering interdependence can be calculated. $\mathbf{w_c}$ can be obtained by synthesizing the results from Steps 2 to 3: $\mathbf{w_c} = \mathbf{w_3} \times \mathbf{w_1}$; obtained knowledge sharing culture (KC) = 0.288; Incentives (I) = 0.161; ERP vendor capability (VC) = 0.246; absorptive capability (AC) = 0.190 and SMEs owner leadership (OL) = 0.115, shown as follows:

$$\mathbf{w_c} = \mathbf{w_3} \times \mathbf{w_1} = \begin{pmatrix} 0.288 \\ 0.161 \\ 0.246 \\ 0.190 \\ 0.115 \end{pmatrix}$$

.

Step 5. In this step of the decision procedure, evaluators were asked to establish the decision matrix by comparing the alternatives under each of the individual criteria. Moreover, all evaluators were asked to give a set of crisp value within the range from 1 to 10 to represent the performance of each alternative with respect to each criterion. After determining the decision matrix by using Eqs. (1) and (2), the normalized decision matrix of the new product launch strategy alternatives can be obtained as shown in Table 3.

Table 3. The weighted normalized decision matrix

w_p	KC	I	VC	AC	OL
HOS	0.448	0.507	0.346	0.552	0.620
SBS	0.333	0.314	0.193	0.201	0.192
DKS	0.218	0.179	0.640	0.247	0.187

Note: * The knowledge transfer strategies such as HOS = Human-oriented strategy, SBS = System-based strategy, and DKS = Dynamic strategy.

In the meanwhile, the overall priorities for the candidate launch strategies $\mathbf{w_{ANP}}$ are calculated by multiplying $\mathbf{w_P}$ by $\mathbf{w_c}$.

$$w_{ANP} = w_p \times w_c = \begin{pmatrix} 0.472 \\ 0.254 \\ 0.319 \end{pmatrix}$$

It is demonstrated in Step 5 that the results of the ANP method are (HOS, SBS, DKS) = $(0.472, 0.254, 0.319)^T$. Therefore, the human-oriented strategy will have the highest weights value (0.472). Consideration to ANP method this strategy will be selected.

Step 6. By using Eqs (3) and (4), the final ranking procedure should determine the ideal and negative-ideal solutions. Therefore, the positive-ideal and negative-ideal solutions are determined as follows:

$A^* = (0.448, 0.507, 0.640, 0.552, 0.620)$,

$A^- = (0.218, 0.179, 0.193, 0.201, 0.187)$.

By using Eqs (5), (6) and (7), the computed distances of each launch strategy to the ideal solution (d_i^+) and the negative-ideal solution (d_i^-), and the closeness coefficient (CC_j^*) are presented in Table 4. In Table 4 the human-oriented strategy will have the highest CC_j^* value (0.434), therefore, when consideration to TOPSIS method the HOS will be chosen.

Table 4. Computations of d_i^+, d_i^- and CC_j^*

w_p	d_i^+	d_i^-	CC_j^*
HOS	1.275	0.979	0.434
SBS	1.017	0.419	0.292
DKS	0.951	0.585	0.381

Note: * The knowledge transfer strategies such as HOS = Human-oriented strategy, SBS = System-based strategy, and DKS = Dynamic strategy.

Step 7. The closeness coefficients (CC_j^*, i = 1, 2, 3) are obtained from Step 6 for each strategy. To formulate the MCGP model, the specific criteria constraints and range of the strategy was taken from one of medium-sized manufacturer company in Indonesia, as shown in Table 5. Knowledge transfer strategy weights are used as CC_j^* (e.g., HOS = 0.434, SBS = 0.292, DKS = 0.381) in an objective function (e.g., p_2 $(0.434d_4^- + 0.292\, d_5^- + 0.381\, d_6^-$ in Table 5)) to allocate resources among the strategies.

Table 5. Specific criteria of new launch strategies and value ranges

Strategies	Cost	Hours	Employees
HOS	3000	1056	22
SBS	8000	864	18
DKS	6500	960	20
Range	8000	1200	25

The MCGP model formulation to select a knowledge transfer strategy is shown below

$$\text{Min } Z = (d_1^+) + (d_2^+) + (d_3^+) + 0.434\, d_4^- + 0.292\, d_5^- + 0.381 d_6^- \quad (13)$$

Subject to :

$$3000X_1 + 8000X_2 + 6500X_3 + d_1^- - d_1^+ = 8000 \quad (14)$$

$$1056X_1 + 864X_2 + 960X_3 + d_2^- - d_2^+ = 1200 \quad (15)$$

$$22X_1 + 18X_2 + 20X_3 + d_3^- - d_3^+ = 25 \quad (16)$$

$$X_1 + d_4^- = 1 \quad (17)$$

$$X_2 + d_5^- = 1 \quad (18)$$

$$X_3 + d_6^- = 1 \quad (19)$$

$X_1 + X_2 + X_3 = 1$

(20)

$Xj = 0$ or 1, $j = 1,2,3$

Based on the MCGP model formulation, the knowledge transfer strategy selection problem was solved using LINGO (Schrage 2002) on a AMD Athlon II-X4 CPU 3.00 GHz-based microcomputer in a few seconds of computer time. The optimal solutions are as follows:

$x1 = 1, x2 = x3 = 0,$

That is, the goals are fully satisfied, and x1 = 1 denoted that the HOS strategy will be selected.

5. CONCLUSION.

Collaborative evaluation technology is a popular method used in finding a solution to the problem of MCDM. One of the reasons for the popularity of ANP, TOPSIS and MCGP as an applicable method is the fact that it considers not only tangible and intangible criteria but also multi-choice aspiration levels. Given that many multiple-choice aspiration levels may exist in the real world, a multiple-choice method is most appropriate for a decision problem, which involves the evaluation of different criteria or attributes such as knowledge transfer strategy selection in ERP system implementation in SMEs.

When a firm is going to implement an ERP system, managers are always challenged with finding the proper strategy to support the implementation. The knowledge transfer strategy adopted also determines whether an ERP system implementation would succeed or fail. To achieve this goal, decision makers should apply the best method and accurate criteria to analyze and solve the knowledge transfer strategy selection problems. This paper illustrates how the ANP, TOPSIS and MCGP model would be implemented to help SMEs manufacturers in implementing their ERP system. Using this model, a selected company was able to determine the best knowledge transfer strategy for their ERP system project. Results show that the human oriented strategy is the best choice for the company. This finding also suggests that human-oriented strategy is more appropriate for improving knowledge sharing culture, absorptive capacity, SMEs owner leadership and vendor involvement within the company. This finding also confirms that the manufacturing companies can achieve strategic benefits in ERP system implemetation through focusing on effective knowledge transfer strategy. Although the above mentioned approaches can deal with multiple criteria, they have not taken into consideration the impact of knowledge content quality and business requirements of company stakeholders on the evaluating criteria. In reality, the weightings of knowledge transfer evaluating criteria depend a lot on business strategies and priorities. In cases where the weightings are assigned subjectively and arbitrarily without considering the majority of company stakeholders, the strategies selected may not provide what a company exactly wants.

6. REFERENCES

Abdallah, S., and Albadri, F. (2010) "A Perspective on ICT Diffusion in the Arab Region", *ICT Acceptance, Investment and Organisation: Cultural Practices and Values in the Arab World*, vol. 1.

Argote, L., and Ingram, P.(2006)"Knowledge transfer: A basis for competitive advantage in firms", *Organisational behavior and human decision processes*, Vol. 82, no. 1, pp. 150-169.

Argyropoulou, M., Loannou, G. and Prastacos, G.P. (2007) "Enterprise Resource Planning implementation at Small and Medium sized Enterprises: an initial study of the Greek market", *International Journal of Integrated Supply Management*, vol. 3, no. 4, pp. 406-25.

Caldeira, M.M. and Ward, J.M. (2002) "Understanding the Successful Adoption and Use of IS/IT in SMEs: An Explanation from Manufacturing Industries", *Information Systems Journal*, vol. 12, pp. 121-152.

Calvert, C. and Seddon, P. (2006), "The importance of ongoing ERP training and support", *Proceedings of the 17th Australasian Conference on Information Systems* (ACIS 2006), Adelaide, Australia.

Chang, C. T., Chen, H. M., Zhuang, Z. Y. (2014), "Integrated multi-choice goal programming and multi-segment goal programming for supplier selection considering imperfect-quality and price-quantity discounts in a multiple sourcing environment", *International Journal of Systems Science*, vol. 45(5), pp. 1101–1111.

Chen S.J., Hwang C.L. (1992), *Fuzzy Multiple Attribute Decision Making: Methods and Applications,* Springer-Verlang, Berlin.

Da Silveira, G.J., Snider, B., and Balakrishnan, J. (2012), "Compensation-based incentives, ERP, and delivery performance in manufacturing: Analysis from production and improvement perspectives", *International Journal of Operations and Production Management*, vol. 33, no. 4, pp. 3-53.

Davenport, T.H. (1998), "Putting the Enterprise into the Enterprise System", *Harvard Business Review*, vol. 76, no. 4, pp. 121-31.

Davenport, T. H. and Pruzak, L.(2000), *Working Knowledge: How Organisations Manage What They Know*, Harvard Business Press.

DeLone, W.H. and McLean, E.R. (2003), "The DeLone and McLean model of information systems success: A ten-year update", *Journal of Management Information Systems*, vol. 19, no. 4, pp. 9-30.

Dierickx, I., and Cool, K. (1989), "Asset stock accumulation and the sustainability of competitive advantage", *Management Science*, vol. 35, no. 12, pp. 1504-1513.

Dunford R. (2000) ,"'Key challenges in the search of effective management of knowledge in management consulting firms", *Journal of Knowledge Management*, vol. 4, no. 4, pp. 295-302.

Gargeya, V.B. and Brady, C. (2005), "Success and failure factors of adopting SAP in ERP system implementation", *Business Process Management Journal*, vol. 11, no. 5, pp. 501-516.

Haines, M.N. and Goodhue, D.L. (2003) "Implementation Partner Involvement and Knowledge Transfer in the Context of ERP Implementations", *International Journal of Human Computer Interaction*, vol. 16, no. 1, pp. 23-38.

Handayani, E. (2008) "ERP Openbravo implementation on Small Furniture Manufacturing Company", Bachelor thesis, Muhammadiyah University, Surakarta.

Heavey, C., Simsek, Z., and Fox, B. C. (2015), "Managerial social networks and ambidexterity of SMEs: The moderating role of a proactive commitment to innovation", *Human Resource Management*, http:onlinelibrary.wiley.com/doi/10.1002/hrm.21703/full.

Heinze, P. and Hake, M. (2010) "Knowledge Oriented Implementation of Collaborative Supply Chain Management, Advanced Manufacturing and Sustainable Logistics", Vol. 46, pp 222-233.

Hwang C.L., Yoon K. (1981) *Multiple Attibute Decision Methods and Applications*, Springer, Berlin, Heidelberg.

Ifinedo, P. (2008) "Impacts of business vision, top management support, and external expertise on ERP success", *Business Process Management Journal*, vol. 14, issue 4, pp. 551 - 568, 2008.

Jones, M.C., and Price, R.L. (2004), "Organisational Knowledge Sharing in ERP Implementation: Lessons from Industry", *Journal of Organisational and End User Computing*, vol. 16, no. 1, pp.21-40.

Karlsen, J. and Gottschalk, P. (2004)"Factors Affecting Knowledge Transfer in IT Projects’, *Engineering Management Journal*, vol. 16, no. 1, pp. 3-10.

Ko, D.G., Kirsch, L.J. and King, W.R.(2005), "Antecedents of Knowledge Transfer From Consultants to Clients in Enterprise System Implementations", *MIS Quarterly*, vol. 29, no. 1, pp. 59-85.

Kulkarni, U.R., Ravindran, S. and Freeze, R.(2007), "A Knowledge Management Success Model: Theoretical Development and Empirical Validation", *Journal of Management Information Systems*, vol. 23, no. 3, pp. 309-347.

Li, Y., Liao, X.W. and Lei, H.Z.(2006) "A Knowledge Management System for ERP Implementation’, *Systems Research and Behavioral Science*, vol. 23, pp. 157-168.

Loh, T.C. and Koh, S.C.L. (2004), "Critical Elements for a Successful Enterprise Resource Planning Implementation in Small-and Medium-sized Enterprises", *International Journal of Production Research*, vol. 42, no. 17, pp. 3433-55.

Metaxiotis, K., (2009), "Exploring the Rationales for ERP and Knowledge Management Integration in SMEs", *Journal of Enterprise Information Management*, vol. 22, no. 1/2, pp. 51-62.

Ministry of Cooperatives and SMEs, (2013) "Perkembangan Data Usaha Mikro, Kecil, Menengah (UMKM) dan Usaha Besar (UB) Tahun 2011-2012", http://www.depkop.go.id/berita-informasi/data-informasi/data-umkm.

Nonaka, I., (1994), "A dynamic theory of organizational knowledge creation", *Organization Science*, vol. 5 no. 1, pp. 14-37.

Saaty, T. L. (1996), *Decision making with dependence and feedback: the analytic network process*, Pittsbugrh, RWS Publications.

Saaty, T. L.; Vargas, L. G. (1998), "Diagnosis with dependent symptoms: Bayes theorem and the analytic hierarchy process", *Operational Research*, vol. 46(4), pp. 491–502.

Saksono, B. (2014) "Koperasi dan UMKM dalam Angka", http://www.neraca.co.id/article/39432/koperasi-dan-umkm-dalam-angka.

Sarosa, S. (2007), "The Information Technology Adoption Process within Indonesian Small and Medium Enterprises", Doctor of Philosophy thesis, University of Technology Sydney.

Schrage, L. 2002. LINGO Release 8.0. LINDO System, Inc.

Skok, W. and M. Legge.(2002) "Evaluating enterprise resource planning (ERP) systems using an interpretive approach", *Proceedings of the 2001 ACM SIGCPR conference*, vol. 9, no. 2, pp. 72-82.

Soja P. (2008) "Difficulties in enterprise system implementation in emerging economies: insights from an exploratory study in Poland", *Information Technology Development*, vol. 14, no. 1, pp. 31–51.

Stein, A., and Hawking, P. (2003) "The second wave ERP market: An Australian viewpoint", *ERP and Data Warehousing in Organisations: Issues and Challenges,* IGI Global, pp. 72-88.

Thompson, R.L., Higgins, C.A. and Howell J.M. (1995), "Influence of Experience on Personal Computer Utilization: Testing a Conceptual Model", *Journal of Management Information Systems*, vol. 11, no. 1, pp. 167-187.

Timbrell, G.T, Andrews, N.M., and Gable, G.G. (2001), "Impediments to Inter-firm Transfer of Best Practices in an enterprise systems context", *Proceedings of 7th Americas Conference on Information Systems*, pp. 1084-1090, Boston.

Tsai, C.M., (2008),"Integrating intra-firm and inter-firm knowledge diffusion into the knowledge diffusion model", *Expert Systems with Applications*, vol. 34, pp. 1423–1433.

Van Gils, A., & Zwart, P.(2004), "Knowledge Acquisition and Learning in Dutch and Belgian SMEs: The Role of Strategic Alliances", *European Management Journal*, vol. 22 no. 6, pp. 685-692.

Vlosky, R.P., Westbrook, T., and Poku, K. (2002), "An exploratory study of internet adoption by primary wood products manufacturers in the western United States", *Forest Products Journal*, vol. 52, no. 6, pp. 35-42.

Willcocks, L. and Sykes R. (2000), "The role of the CIO and IT function in ERP", *Communications of the ACM*, vol. 43, no.4, pp. 32-38, 2000.

Wong, T. T., and Lu, Y. T. (2005)"Key factors for small and medium enterprises in Taiwan to successfully implement information systems", *International Journal of Management and Enterprise Development*, vol. 2, no. 1, pp.106-121.

Yudhoyono, S.B. (2013) "Promoting Economic Growth", *Speech at the APEC CEO Summit 2013, Bali, Indonesia*, http://www.oxfordbusinessgroup.com/viewpoint/president-susilo-bambang-yudhoyono-promoting-economic-growth.

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AN APPROACH TO USING THE GREY- ANALYTIC HIERARCHY PROCESS (G-AHP) FOR SUPPLIER PERFORMANCE MEASUREMENT

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ABSTRACT

In this paper, we present a procedure for assessing supplier's performance, which is an extension of the Analytic Hierarchy Process, which its integrated to Grey Theory methods. Reseachers use different methodologies of MCDM to solve supplier evaluation and selection problems. Integrated AHP, which it is implemented in the software package Expert Choice. The rangking of supplier's perfomance is calculated with grey theory methods after its calculated by AHP procedure. Some specific criteria for measure the performance of the chemical suppliers, among others: guarantee product quality, the accuracy of product delivery to the laboratory suppliers, communication between laboratories and suppliers, after sales service, handling of complaints by suppliers and prices of products. The data obtained are primary data obtained from questionnaires and performance measurement Chemical Supplier Paiton Unit 9 at the laboratory of water later on though the method of Grey- Analytic Hierarchy Process (G-AHP). We present a procedure for supplier performance measurement using G-AHP.Value weighting of votes chemicals supplier performance in PT. PJB UBJ O & M by the method of Grey- Analytic Hierarchy Process (G-AHP) is the weight values for Supplier "A" against the criteria of 0,498, weight values for Supplier "B" against the criteria of 0,942, weight values for Supplier "C" against the criteria of 0,908, and weight values for Supplier "D" against the criteria of 0,711. So, the best chemical supplier, which its calculated by G-AHP is Supplier A. Copyright © 2017 STTAL. - All rights reserved.

KEYWORDS : Supplier performance, Analytic Hierarchy Process, Grey Theory, Expert Choice

1. INTRODUCTION.

Supplier selection is an issue of strategic importance for any company. Since by deciding the best supplier, companies can save material cost and increase competitive advantage. Supplier evaluation is necessary to know what the supplier is doing well in each area of action. There are several evaluation models for supplier selection and evaluation in the literature (Chaharsooghi and Ashrafi, 2014; N. Aissaoul, et al., 2007; I. de Boer et al., 2001). Measuring supplier performance, which includes multi criteria and multiple conflicting objectives, can be defined as the process of finding the right suppliers. Since this selection process mainly involves the evaluation of different criteria and various supplier attributes, it can be considered as a multiple criteria decision making (MCDM).

The Analytic Hierarchy Process (AHP) has been used in various setting to make decisions and solving multiple criteria decision making problems. Several papers have compiled the AHP succes in very different fields (Ishizaka Alessio and Labib ashraf, 2009; Ayhan M.B., 2013). Multiple criteria has led to AHP applications in conjunction with many other decision support tools and methodologies, recent years, many researchers using fuzzy AHP applications for supplier selection problem, but some negative comment or criticism on Fuzzy theory have been subject too for some researchers (Abdullah Lazim, 2013). Although many authors have expressed critisms of AHP, but the popularity of AHP for solving problem MCDM is a fact (Whitaker, 2007). The Grey Theory method is a method for decision making characterized by incompplete information under the multi-dimensional decision circumstance, providing a flexible approach using different weighting coefficients. Since the AHP have some criticism because of weaknesses and have been subject of substantial debate among specialis in MCDM metods, we interest to integreted AHP and Grey theory for supplier performance evaluation. The Grey-AHP is expected to fit the best supplier performance evaluation, providing a simple and straightforward method. The purpose of this paper is to present a procedure for assessing supplier's performance, which is an extension of the Analytic Hierarchy Process, which its integrated to Grey Theory methods.

2. METHODOLOGY

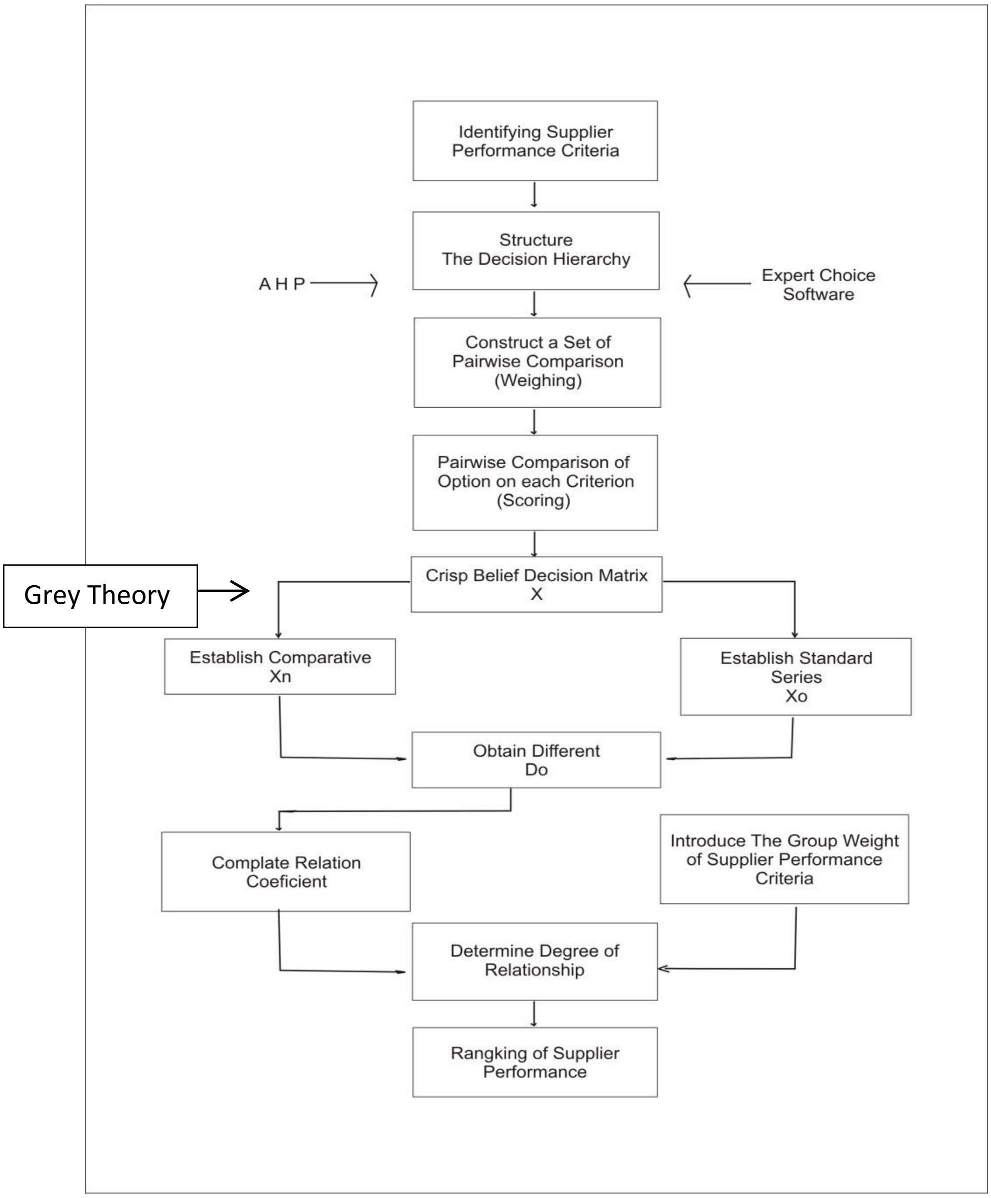

Fig. 1 The G-AHP for Supplier Performance Measurement

2.1 Supplier Performance Evaluation

Supplier Performance Evaluation has been studied extensively in the literature. The majority of supplier evaluations consist of only three factors : price, quality and delivery (Hirakubo and Kublin,1998) and early researches showed special emphasis mainly on cost and then on reliability, responsiveness, safety, and environtmental (Huang and Keskar, 2007). In this paper, we used six criteria for supplier performance evaluation for measure the performance of suppliers, among others: guarantee product quality, the accuracy of product delivery to the laboratory suppliers, communication between laboratories and suppliers, after sales service, handling of complaints by suppliers and prices of products.

2.2 The Analytic Hierarchy Process

The Analytic Hierarchy Processs (AHP) is a theory of measurement through pairwise comparisons and relies on the judgements of experts to derive priority scales. (Saaty, T.L.,2008). To make a decision in an organised way to generate priorities we need to decompose the decision into the following steps.

a. Define the problem and determine the kind of knowledge sought.

b. Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).

c. Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.

d. Use the priorities obtained from the comparisons to weight the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority.

e. Continue this process of weighing and adding until the final priorities of the alternatives in the bottom most level are obtained.

2.3 Expert Choice

In 1983, Dr. Saaty joined Dr. Ernest Forman, a professor of management science at George Washington University, to co-found Expert Choice. The AHP and Expert Choice software engage decision makers in structuring a decision into smaller parts, proceeding from the goal to objectives to sub-objectives down to the alternative courses of action. Decision makers then make simple pairwise comparison judgments throughout the hierarchy to arrive at overall priorities for the alternatives. Expert Choice is intuitive, graphically based and structured in a user-friendly fashion so as to be valuable for conceptual and analytical thinkers, novices and category experts. Because the criteria are presented in a hierarchical structure, decision makers are able to drill down to their level of expertise, and apply judgments to the objectives deemed important to achieving their goals. At the end of the process, decision makers are fully cognizant of how and why the decision was made, with results that are meaningful, easy to communicate, and actionable. The expert choice steps will explored in the next section in case study.

2.4 Grey Theory

Grey theory, proposed by Julong Deng (1989), deals with decisions characterized by incomplete information, and explores system behavior using relational analysis and model construction (Shih et al., 1996; Wu et al., 1984; Chang et al., 2001; Liu et al., 2011; Geum et al., 2011). Grey theory provides a measure to analyze relathionship between discrete quantitative and qualitative series, and all components in the series shall conform to the following characteristics :

existent, countable, extensible and independend. The construction of grey model is describe as below: (Chang et al., 2001; Liu et al.,2011)

(1) Establish comparative series

An information series with n components or decision factors, such as some specific criteria for measure factors of the supplier's performance can be expressed as, $X'_i = \left(X'_i(1), X'_i(2), \ldots, X'_i(K)\right) \in X,$, where $x'_i(k)$ denotes the the kth factors of x_i. If all information series are comparable, the n information series can be described as the following matrix :

$$X = \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{bmatrix} = \begin{bmatrix} X_1(1) & X_1(2) & \cdots & X_1(k) \\ X_2(1) & X_2(2) & \cdots & X_2(k) \\ \vdots & \vdots & & \vdots \\ X_n(1) & X_n(2) & \cdots & X_n(k) \end{bmatrix} \quad (1)$$

(2) Establish the standard series

Degree of relation can describe the relationship of two series, thus, an objetive series called the standard series shall be established, and expressed as $X_0 = X_0(1), X_0(2), \ldots, X_0(k))$. When conducting the performance of the supplier, the smaller the score, therefore the standard series can be the lowest level of all the performance of the supplier.(Pillay & Wang, 2003)

$$X_0 = X_0(1),\ X_0(2), \ldots, X_0(k)) = (0,0,\ldots,0) \quad (2)$$

(3) Obtain the difference between comparative series and standard series

To discover the degree of grey relationship, the difference between the comparative and standard series, D_0, is calculated and reflected in a form of a matrix as seen below :

$$D_0 = \begin{bmatrix} \Delta_{01}(1) & \Delta_{01}(2) & \Delta_{01}(3) & \ldots & \Delta_{01}(k) \\ \Delta_{02}(1) & \Delta_{02}(2) & \Delta_{02}(3) & \ldots & \Delta_{02}(k) \\ \vdots & \vdots & \vdots & \cdot & \vdots \\ \vdots & \vdots & \vdots & \cdot & \vdots \\ \Delta_{0m}(1) & \Delta_{0m}(2) & \Delta_{0m}(3) & \cdots & \Delta_{0m}(k) \end{bmatrix} \quad (3)$$

Where $\Delta_{0j}(k) = \left\|X_0(k) - X_j(k)\right\|$, $X_0(k)$ is the standard series and $X_j(k)$ is the comparative series.

(4) Compute the grey relational coefficient

To compute the relational coefficient, the decision factors of the supplier's performance model are compared with the standard series. The grey relation coefficient, $\gamma(X_0(k), X_i(k)$, is expressed as :

$$\gamma(X_0(k), X_i(k)) = \frac{\Delta_{min} + \varsigma\Delta_{max}}{\Delta_{0j}(k) + \varsigma\Delta_{max}} \quad (4)$$

Where

J = 1,……., m k = 1, ………, n

$X_0(k)$ is the standard series and $X_j(k)$ is the comparative series.

$\Delta_{0j} = \left\|X_0 - X_j(k)\right\|$

$\Delta_{min} = \min_{\forall j \in} \min_{i \forall k} \left\|X_0(k) - X_j(k)\right\|$

$\Delta_{max} = \max_{\forall j \in} \max_{i \forall k} \left\|X_0(k) - X_j(k)\right\|$

ς is an identifier, $\varsigma \in (0,1)$, only affecting the relative value of risk without changing the priority. Generally, ς can be 0,5.

(5) Determine the degree of relation

Before finding the degree of relation, the relative weight of the decision factors shall be first decided in order to be used in the following formulation,

$$\Gamma\left(X_i, X_j\right) = \sum_{k=1}^{n} \beta_k \gamma(X_i(k), X_j(k) \quad (5)$$

where β_k is the weighting coefficient of factors, and $\sum_{k=1}^{n} \beta_k = 1$

if all factors are equally important, the above formulation can be modified as:

$$\Gamma\left(X_i, X_j\right) = \frac{1}{n} \sum_{k=1}^{n} \gamma(X_i(k), X_j(k)) \quad (6)$$

(6) Rank the factors of the supplier's performance

Based on the degree of relation between comparative series and standard series, a relational series can be constructed. If $\gamma(X_0,X_i) \geq \gamma(X_0,X_j)$, which indicates the degree of relation between X_i dan X_0 is greater than that between X_j dan X_0.

3. AN ILLUSTRATIVE CASE STUDY.

One of the existing power plants in Indonesia, Paiton Unit 9 is a capacity of 660 MW. Viewing of how important this power plant in Indonesia it can be said that the power plant is a vital tool of the state, then there is need for maintenance, protection and reliable operation. The main ingredient is water for generating steam, the water used must meet the parameters have been specified by the manufacturer listed in the manual book. To support this required technical chemicals and chemical analyst who used to perform water quality analysis process. Chemicals used by the laboratory of water contained in the Paiton power plant also has a standard 9-standard, therefore the supplier selection must be precise so that the chemicals that come in accordance with the specifications desired by the laboratory.

3.1 By using expert choice, The AHP consists of follows steps : (Ishizaka and Ashraf Labib, 2009)

3.1.1 Problem modelling

Breaking dawn the problem in hierarchy, which can be devided into three parts : goal (The best supplier performance), criteria (1. Guarantee product quality, 2. The accuracy of product delivery to the laboratory suppliers, 3. Communication between laboratories and suppliers, 4. After sales service, 5 . Handling of complaints by suppliers; and 6. Prices of products) and alternatives (Supplier A, Supplier B, Supplier C, and Supplier D).

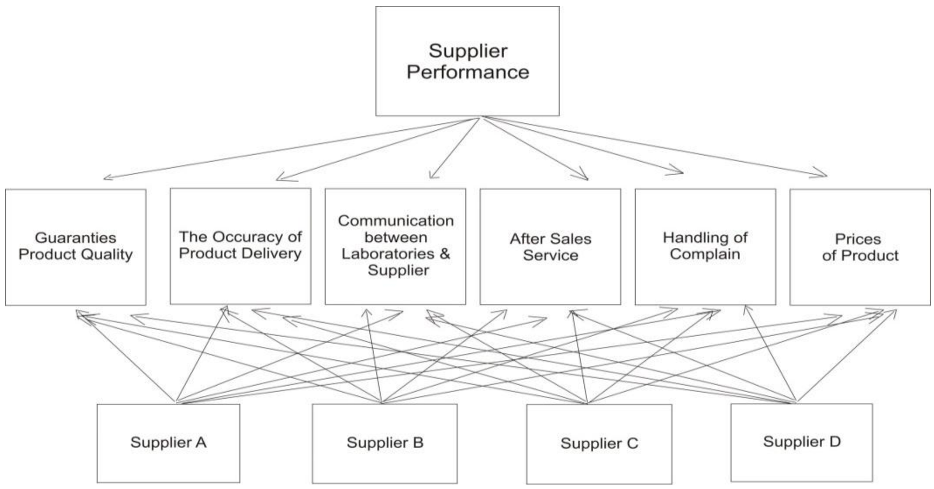

Fig. 2. Hierarchy of supplier performance evaluation

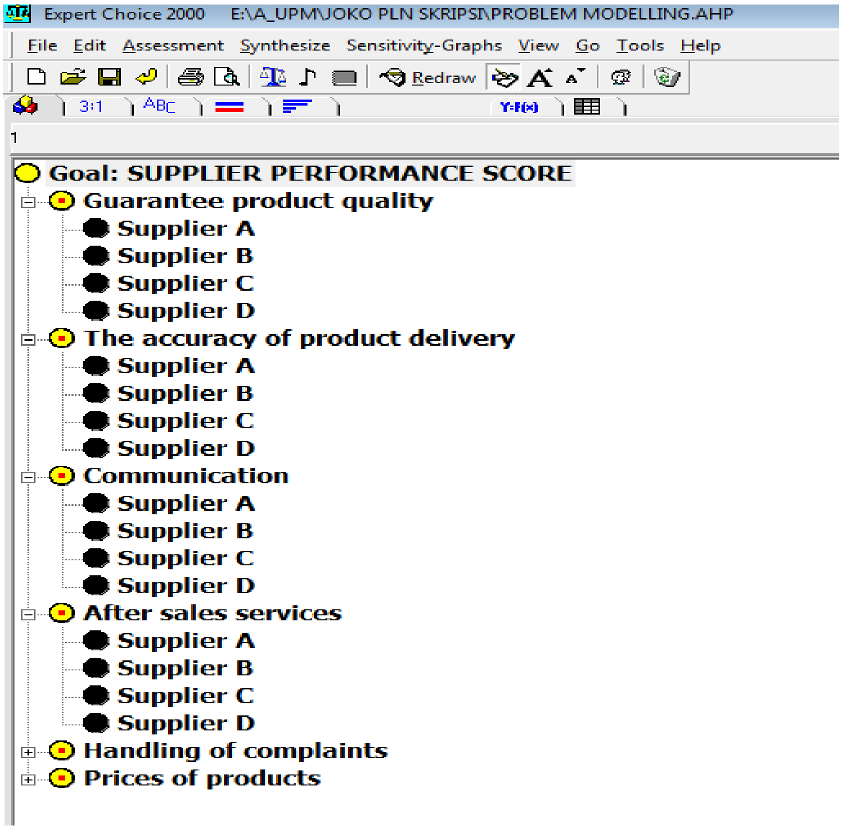

Fig 3 . Hierarchy of supplier performance evaluation, **** which Expert Choice soft ware

3.1.2 Pairwise comparisons

At each node of the hierarchy, a matrix will collect the pairwise comparisons of the decision-maker (e.g. figure 3)

Compare the relative importance with respect to: SUPPLIER PERFORMANCE SCORE

	Guarantee	The accura	Communic	After sales	Handling o	Prices of p
Guarantee product quality		2.0	3.0	3.0	3.0	2.0
The accuracy of product delivery			2.0	2.0	2.0	3.0
Communication				2.0	2.0	3.0
After sales services					1.0	2.0
Handling of complaints						2.0
Prices of products	Incon: 0.05					

Fig. 4 . Comparison matrix of supplier performance criteria

3.1.3 Judgement scales

One of AHP's strengths is the possibility to evaluate quantitative as well as qualitative criteria and alternative on the same preference scale of nine levels. These can be numerical, verbal or graphical.

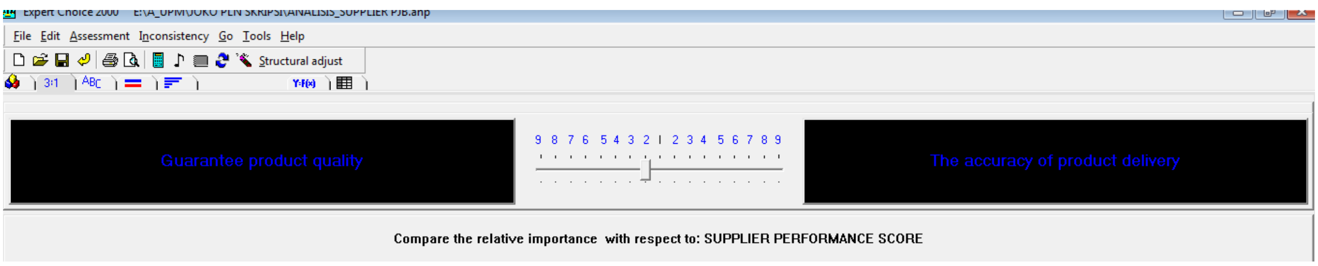

Fig. 5 . Numerical scale

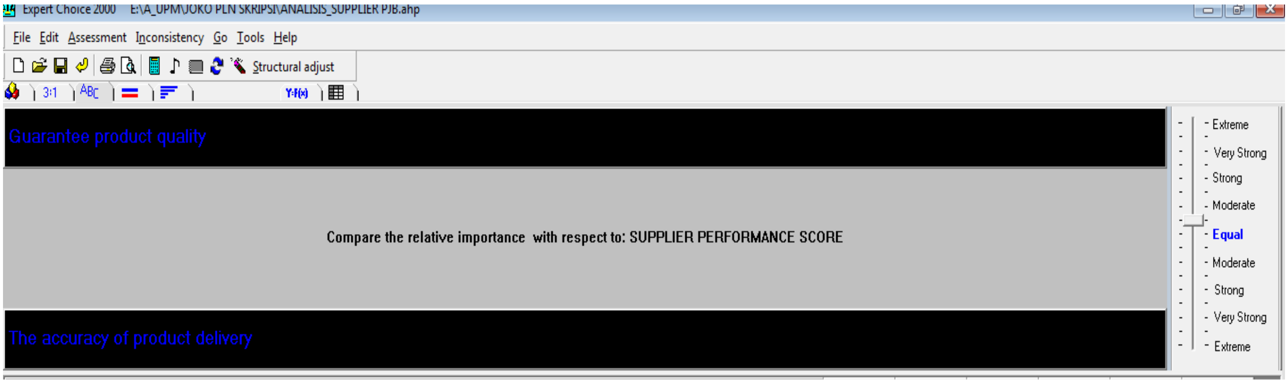

Fig. 6 . Verbal scale

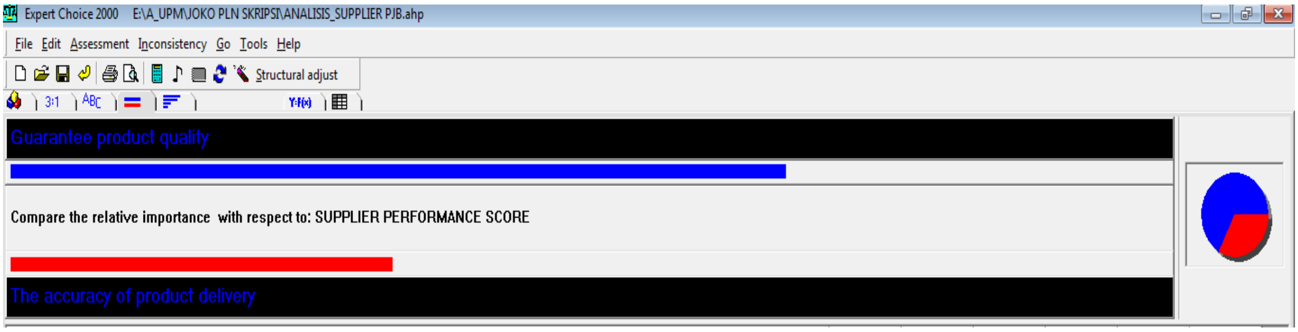

Fig. 7 . Graphical scale

3.1.4 Priorities derivation

Once the comparisons matrices are filled, can be calculated. The traditional AHP uses the eigenvalue method. We start from the case of a consistent matrix with known priorities w_i. In the chase, comparison of alternatives i and j is given by $\frac{w_i}{w_j}$, which multiplied by the priority vector w results in:

$$A = \begin{bmatrix} \frac{w_i}{w_j} & \frac{w_i}{w_j} & \frac{w_i}{w_j} & \cdots & \frac{w_i}{w_n} \\ \frac{w_i}{w_j} & \frac{w_i}{w_j} & \frac{w_i}{w_j} & \cdots & \frac{w_i}{w_n} \\ \frac{w_i}{w_j} & \frac{w_i}{w_j} & \frac{w_i}{w_j} & \cdots & \frac{w_i}{w_n} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ \frac{w_n}{w_j} & \frac{w_n}{w_j} & \frac{w_n}{w_j} & \cdots & \frac{w_n}{w_n} \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ \vdots \\ w_n \end{bmatrix} = n \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ \vdots \\ w_n \end{bmatrix} \qquad (7)$$

Or grouped : $\boldsymbol{A}\,\overline{w} = n\,\overline{w}$ (8)

Where w : vector of priorities

n : dimension of the matrix

$\boldsymbol{A}$: comparison matrix

Equation (8) is the formulation an eigenvector problem. The calculated priorities are exact for a consistent matrix. When slight inconsistencies are introduced, priorities should vary only slightly according to the perturbation theory (Saaty, 2003).

3.1.5 Consistensy

As priorities make sense only if derived from consistent or near consistent matrices, a consistency check must be applied. Saaty (1997) has proposed a consistency index (CI), which is related to the eigentvalue method:

$$CI = \frac{\lambda\,max - n}{n-1} \qquad (9)$$

$where\ \lambda\ max$ = maximal eigenvalue

The consistensi ratio, the ratio CI and RI,is given by :

$$CI = \frac{\mathrm{CI}}{\mathrm{RI}} \qquad (10)$$

Where RI is the random index (the average CI of 500 randomly filled matrices.

If CR is les than 10%, then the matrix can be considered as having an acceptable consistensy.

The ideal mode uses a normalisation by deviding the score of each alternative only by the score of the best alternative under each criterion.

3.1.6 Aggregation

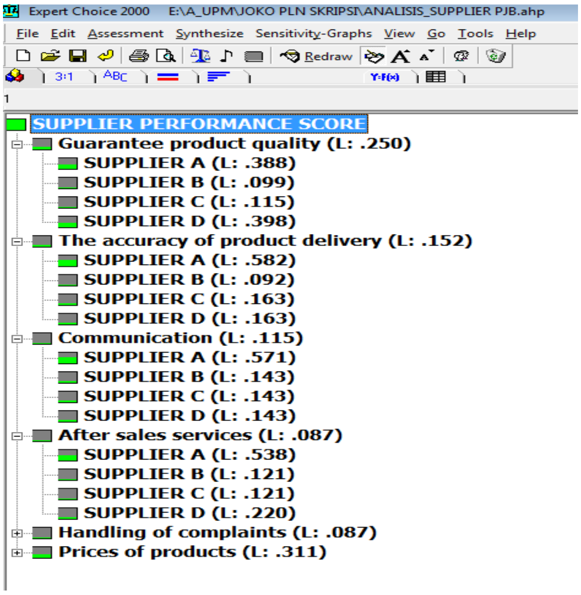

Fig. 8 Priorities with the distribitive mode of supplier performance

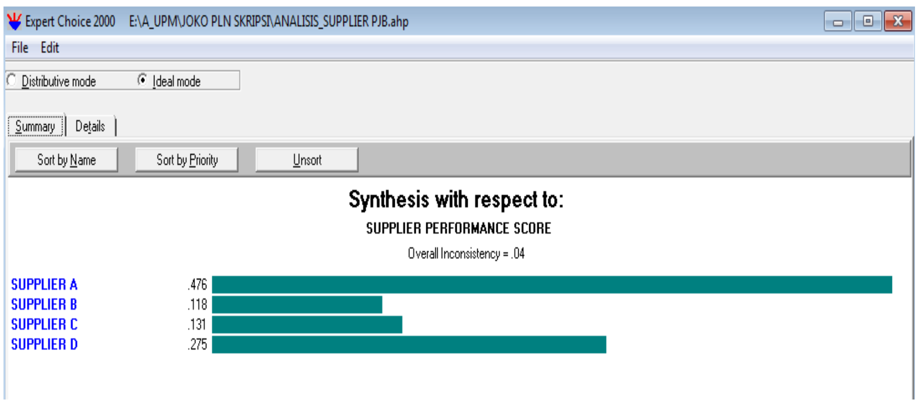

Fig. 9 Synthesis of Supplier performance evaluation

3.1.7 Sensitivity analysis

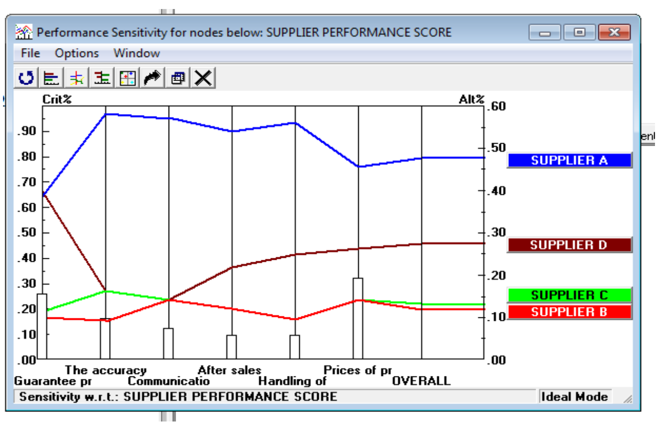

Fig. 10 Graphical sensitivity analyses of Supplier Performance

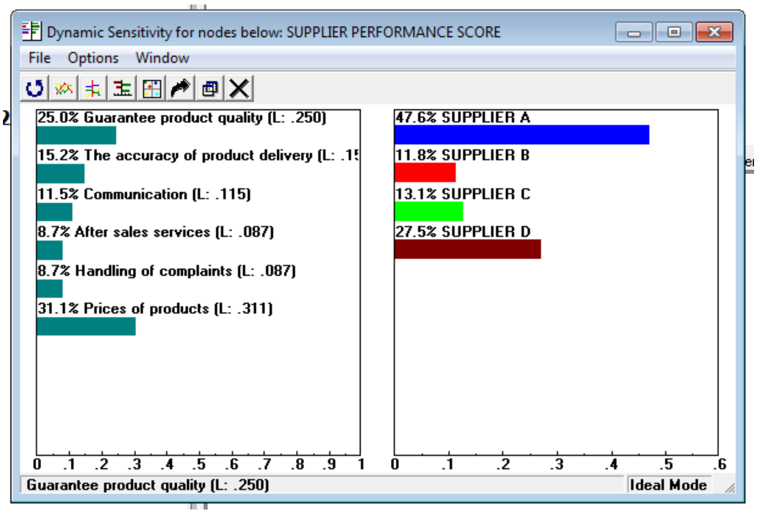

Fig. 11 Dynamic Sensitivity analyses of Supplier performance

3.2 Grey Theory

In order to determine better solution for the alternatives for supplier evaluation proses, the data from AHP analysis is calculated with Grey Theory procedure as follow :

3.2.1 Establish comparative series

An information series with criteria for measure factors of the supplier's performance can be expressed as the following matrix :

$$X = \begin{bmatrix} 0{,}388 & 0{,}582 & 0{,}571 & 0{,}538 & 0{,}560 & 0{,}455 \\ 0{,}099 & 0{,}092 & 0{,}143 & 0{,}121 & 0{,}095 & 0{,}141 \\ 0{,}115 & 0{,}163 & 0{,}143 & 0{,}121 & 0{,}095 & 0{,}141 \\ 0{,}398 & 0{,}163 & 0{,}143 & 0{,}220 & 0{,}249 & 0{,}263 \end{bmatrix}$$

3.2.2 Establish the standard series

The standard series is taken to be lowest possible value, as such the value 0 .(Pillay & Wang, 2003)

$X_0 = (X_0(1),\ X_0(2),$
$X_0(3), X_0(4), X_0(5), X_0(6)) =$
$(0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0)$

3.2.3 Obtain the difference between comparative series and standard series.

The difference between the comparative and standard series, D_0, is calculated and reflected in a matrix as seen below :

$$D_0 = \begin{bmatrix} \Delta_{01}(1) = 0{,}388 & \Delta_{01}(2) = 0{,}582 & \Delta_{01}(3) = 0{,}571 & \Delta_{01}(4) = 0{,}538 & \Delta_{01}(5) = 0{,}560 & \Delta_{01}(6) = 0{,}455 \\ \Delta_{02}(1) = 0{,}099 & \Delta_{02}(2) = 0{,}092 & \Delta_{01}(3) = 0{,}143 & \Delta_{02}(4) = 0{,}121 & \Delta_{01}(5) = 0{,}095 & \Delta_{01}(6) = 0{,}141 \\ \Delta_{03}(1) = 0{,}115 & \Delta_{03}(2) = 0{,}163 & \Delta_{01}(3) = 0{,}143 & \Delta_{03}(4) = 0{,}121 & \Delta_{01}(5) = 0{,}095 & \Delta_{01}(6) = 0{,}141 \\ \Delta_{04}(1) = 0{,}398 & \Delta_{04}(2) = 0{,}163 & \Delta_{01}(4) = 0{,}143 & \Delta_{04}(4) = 0{,}220 & \Delta_{01}(5) = 0{,}249 & \Delta_{01}(6) = 0{,}263 \end{bmatrix}$$

3.2.4 Compute the grey relational coefficient

The grey relation coefficient is calculated as shown here :

$\Delta_{min} = 0{,}092 \qquad \Delta_{max=}\ 0{,}582$

$$\gamma(X_0(k), X_i(k)) = \frac{\Delta_{min} + \varsigma\Delta_{max}}{\Delta_{0j}(k) + \varsigma\Delta_{max}}$$

$$\gamma(X_0(1), X_1 1) = \frac{0{,}092 + 0{,}5\ x\ 0{,}582}{0{,}388 + 0{,}5\ x\ 0{,}582} = 0{,}564$$

$$\gamma(X_0(1), X_1 1) = \frac{0{,}092 + 0{,}5\ x\ 0{,}582}{0{,}099 + 0{,}5\ x\ 0{,}582} = 0{,}982$$

Similarly, the grey relation coefficient for all supplier performance criteria can be calculated in the same way as shown in the matrix below :

$$\gamma(X_0(k), X_i(k)) = \begin{bmatrix} 0,564 & 0,439 & 0,444 & 0,462 & 0,450 & 0,513 \\ 0,982 & 1,000 & 0,882 & 0,930 & 0,992 & 0,887 \\ 0,943 & 0,844 & 0,882 & 0,930 & 0,992 & 0,887 \\ 0,556 & 0,844 & 0,882 & 0,750 & 0,709 & 0,691 \end{bmatrix}$$

3.2.5 Determine the degree of relation

The relative weight of the decision factors as shown here:

Guarantee product quality	:	0,250
The accuracy of product delivery	:	0,152
Communication	:	0,115
After salesservices	:	0,086
Handling of complaints	:	0,086
Prices of products	:	0,311
Total	:	1,000

Substituting the grey relation coefficient and group weights of supplier performance criteria will give the degree of relation for the first supplier performance score as seen here :

$\Gamma(X_0, X_1) =$ (0,564 x 0,250) + (0,439x0,152)+(0,444x0,115)+(0,462x0,086)+

(0,450x0,086)+(0,513x0,311)

= 0,498

In the same way, the degree of relation is calculated for all the supplier performance evaluation and the results are shown as bellow :

	Grey Relation	Rangking
SUPPLIER A	0,498	1
SUPPLIER B	0,942	3
SUPPLIER C	0,908	4
SUPPLIER D	0,711	2

The degree of relation of the five supplier performance give the rangking of the five suppliers as supplier 1>supplier 4 > supplier 2> supplier 3. So, the final conclusion for the supplier performance measurement is that supplier 1 is given the best supplier , following by supplier 4, 2 and 3.

Results should be clear and concise.

Discussion must explore the significance of the results of the work, often in the concluding paragraph, not repeat them. Avoid extensive citations and discussion of published literature. A combined Results and Discussion section is often appropriate.

4. CONCLUSION.

Thera are many different methods to problem solving of supplier performance measurement, the proposed model was used to evaluation of supplier performance in PT PJB UBJ O & M, Probolinggo, Indonesia. After analysing all alternative, which G-AHP as problem solving method, The best supplier with total score 0,498 had been chosen, its Supplier A.

5. REFERENCES

Abdullah Lazim, (2013), "Fuzzy multi criteria decision making and its applications : a brief review of category ", *Procedia - Social and behavioral Sciences* Vol. 97 , pp. 131 - 136.

Ayhan Mustafa Batuhan. (2013), "A Fuzzy AHP approch for Supplier Selection Problem : A Case Study in a Gearmotor Company", *International Journal of Managing Value and Supply Chain (IJMVSC),* vol. 4 no. 3 pp. 11-23.

Chaharsooghi S.K., Ashrafi Mehdi. (2014), "Sustainable Supplier Performance Evaluation and Selection with neofuzzy TOPSIS Method", Hindawi Publishing Corporation *International Scholarly Research Notices* vol. 2014, Article ID 434168, 10 pages.

Chang, C.L., Liu, P.H., & Wei, C.C. (2001), "Failure mode and effects analysis using grey theory", *Integrated Manufacturing Systems, 12(3), 211 - 216*.

Deng, J. (1989) Introduction to grey system theory, *Journal of Grey Systems*, *1* (1), 1 - 24.

Geum, Y., Cho Y., Park Y. (2011) " A systematic approach for diagnosing service failure : Service-specific FMEA and grey ralationalanalysis approach", *Mathematical and Computer Modelling 54,* 3126-3142.

Hirakubo, N. & Kublin, M. 1998, "The Relative Importance of Supplier selection : The case of electronic components procurement in Japan" *International Journal of Purchasing and Materials Management* 34 (2), 19-24.

Ishizaka Alessio, Labib Ashraf. (2009), "Analytic Hierarchy Process and Expert Choice: Benefits and Limitations", *ORinsight,* vol. 22(4): 201-220 Liu, H.C.,

Liu, L., Bian, Q.H., Lin, Q.L., Dong, N., Xu, P.C. (2011), "Failure mode and effects analysis using fuzzy evidential reasoning approach and grey theory", *Expert Systems with applications ,* vol. 38 , 4403-4415.

Pillay, A.., & Wang, J. (2003) Modified failure mode and effects analysis using approximate reasoning. *Reliability Engineering ang System Safety,79, 69-85.*

Saaty, T.L. (1990), *The Analytic hierarchy process : planning, prority, setting, resource allocation*, RWS, Pittsburgh.

Saaty, T.L. (2003), "Decision making with the AHP: Why is the Principal Eigenvector necessary?", *European Journal of Operation Research,* 145 (1) : 85 - 91.

Saaty, T.L. (2008), "Decision making with the analytic hierarchy process", *Int. J. Services Sciences,* Vol.1 No. 1, pp. 83-89.

Shih K.C., Wu, K.W. and Huang, U.P. (1996), Information of Grey Relation, Chuan-Hua Co. Ltd, Taiwan.

S.H. Huang and H. Keskar, (2007), "Comperhensive and configurable metrics for supplier selection", *International Journal of Production Economics* Vol. 105, no. 2 pp.510-523.

Whitaker Rozann, (2013), "Criticisms of the Analytic Hierarchy Process: Why they often make no sense", *Mathematical and Computer Modelling,* Vol. 46 , pp. 948 - 961.

Wu, H.H., Deng, J.L. and Wen, K.L. (1984), Introduction to Grey Analysis, Kao-Li Co. Ltd, Taiwan.

Indonesian Naval Technology College
Postgraduate International Conference, Vol. 1, No. 1, pp. 27-35
November, 16th 2017

THE INTEGRATION OF STRATEGY AND THE COUNTRY DEFENSE POLICY THROUGH THE FUND'S FISCAL DECENTRALIZATION IN EACH VILLAGES

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ABSTRACT

The purpose of the writing of this article is to give an idea of strategic and defence policy through decentralization funds given to each village. As we know that at this time every village to obtain what is known as the village fund. Through the Fund expexted the village could manage progress village in Fund expected the village could manage progress village through infrastructure development as well as the establishment of Village-owned enterprises. Namau leader areas have never thought of that not only people's welfare can be created through the production but can also be created through security, safe from terrorist threat from within the country. Through the village Fund could do, socialization desimunation about a threat to State security.

KEYWORDS : Integrasion, marketing, Funds, decentralilalizations

1. INTRODUCTION

Organizing the defense of the country intended to keep and protect the country's sovereignty, territorial integrity and the safety of our whole nation. Defense the State of the Indonesia organized into a system of Defense universe, not aggressive and not expansionary in order to protect national interests. The resolution of problems related to the defense of the country and influenced, performed with emphasis on diplomacy which is reinforced by modern military force

Addressing any dynamics, Indonesia is actively encouraging global partnerships, promote the spirit of togetherness, and realize the dynamic balance that is the condition characterized by the absence of the power of the dominant countries in a region. It is done on the basis of beliefs as opportunities for increased cooperation and partnership in building defense force for the progress of a country. Indonesia upholding non active politics by holding on to the principle of peace-loving but rather the love of freedom, as well as neighboring countries holds that was a companion who shared a commitment to maintain the stability of the security in area. Build in common view is indispensable in order to minimize the problems encountered in international relations, either bilateral or multilateral

Browse through a conflict that exists in the State could arise from abroad or within the country, the threat from abroad is easier because the coming conflict stems from a probe into the State and the country, the real fact secaara aka easier known and easy to be realized.

The emergence of the concepts of modern country through cooperation through various activities and education causes conflicts arising from outside its occurrence indicators will be easily known, but not so with covert conflict in these countries. Indonesia which consists of various islands that are scattered in different areas will be very difficult to keep konfili that exist in each region. Besides that coupled with the least amount of security apparatus in the country.

Browse an existing conflict in international relations is a very long review with an infinite limit. After the birth of the modern concept of the nation-State, the cause of conflicts began to change previously dominated by religious differences. The nation-State in the world began to change the direction of the trend to determine the nature of his own people as a nation.

Then timbulah the new interests of nation States such as the interests of a political, ideological, social and cultural security defense. Construction of the defense of the country held by keeping the Defense-oriented alignment of the country namely Indonesia actively encourage global partnerships, promote the spirit of togetherness, and realize the dynamic balance

In the terms of realizing the country's defense policy, Governments need to build up a defense force, military defense and defense nonmiliter in order to face the threats, military threats, either nonmiliter, or hybrid. The country's defense in the face of military threat, putting Indonesia national armed forces (TNI) as the main component (Komput) reinforced by a reserve Component (Komcad) and Supporting Components (Komduk). In the face of threats nonmiliter, placing the Ministry/Agency (K/L) on the outside of the field of Defense as the main elements of the Other elements of the nation's Power-assisted. In the face of the threat of hybrids, Indonesia applies the pattern of military defense, backed with the power of the nirmiliter defense diformasikan into Supporting Components according the nature of and the escalation that has occurred

To do the Defense States require no small funds, along this delivered some prosen comparison with the budget of GDP in some countries as follows :

TABLE 1 The percentage allocation of funds defense against GDP

Year	Indonesia	Malaysia	Thailand	Brunei	filipina	India
1997	1,3	2,5	2,1	7,3	1,2	2,2
1998	1,1	1,6	2,1	9,4	1,2	2.2
1999	0,9	2,1	1,8	7,3	1,1	2,3
2000	1,1	1,7	1,5	6,5	1,1	2.3
2001	1,1	2,2	1,4	7,6	1	2,3
2002	1,2	2,4	1.4	7	1	2,3

Stockholm International Peace Research Institute (SIPRI)

When noted on Table 1, then it appears that the percentage of funds used for the defence of the still relatively small when compared with other countries. It showed.

TABLE 2 Comparison of the amount of a percentage of the community who work in the institutions of Defense

Strengthen	Indonesia	Thailand	Malaysia	Singapura	australia	filipina
Total Personel						
Army	230,000	190,000	80,000	50,000	25,150	66,000
Navy	28,000	5,000	12,000	4,500	12,570	16,500
Air Force	27,000	48,000	8,000	6,000	13,200	16,000

Marine Forces	12,000	18,000	-	-	-	7500
Airplane	90	230	95	126	156	50
Helicopter	17	11	6	28	41	67
Warship	158	168	165	71	62	105
Heavy Tank	-	283	-	90	71	-
Light Tank	1,197	1,728	1,236	2,014	546	604

(Cordesman, 2003)

Since January 1, 2001 Indonesia implements the autonomous region from the side of the authorities and decentralized fiscal finances, with this system then expected the village could do the construction of respective regions by using the village Fund and develops local potential that exists in each region respectively. The policy is based on the Act Number 32 year 2004 revised into law No. 23 of 2014 on local governance as well as Act Number 33 year 2004 of Financial Equalization and regional Centre.

Regional autonomy law number 32 of 2004 concerning regional governments article 1 verse 12 mentions the village is the unity of Community law which has territorial boundaries are authorized to arrange and take care of the interests of the local community which is recognized and respected in the system of the Government of Republic Indonesia, this means the construction of the village have been regulated in this law

As it known in national budget funds transferred to the area include funding Equalization and special autonomy and funding adjustments. Equalization Fund consists of funds for the results of the funds division (DBH), General Allocation funds (DAU), and special allocation Fund (DAK). Funds for General allocation of Funds and Results of the fund division in the form of a block grant, with no rules of its use. While specific rules are NOT firmly in the utilization, while DAU and DAK as a tool of equity between regions. While DBH to equalization and the area has been conducted in the era of the new order as a correction over the exploitation of the natural resources (SDA) which was done by the Center of Government.

However, the utilization of these funds still unclear allocation, miskipun there is already legislation which already exists but is still going against the interests of Fund usage terbut. For that it would be nice if those funds are not just for the sake of people's empowerment, infrastructure for the enhancement of the economic family is small but also used a pencegahaan against the dangers people's security stability ganguan originating from within the country for example against the threat of radical groups, the ganguan the teoraris.

2. MATERIALS AND METHODOLOGY

2.1. Material.

The House of realist looking at politics as a struggle to gain power (camp of power) (R. Soeprapto, 1997). View of realism based on the assumption that the State is the most important and main actors in international relations. This is because the country has sovereignty and the power to determine policy on political, economic, and diplomatic relations with other countries. Realism recognizes actors other than the State, such as IGO, NGO, multinational corporations, and terrorist groups, but with the level of interest that's not too dominating.

Lovell argues that there are several factors that can explain the foreign policy strategy for a country that comprises sejmah other variables in analyzing foreign policy, i.e. (lovell. 1970):

(1) The environment (environment), (2) Situations (situation), (3) Capability (capability), (4)Personality (personality), (5) Organization (organization) Lovell also argued that the foreign policy strategy was applied by a country is closely related to two variables, namely the estimated decision makers over the strategy of implementation by other countries and estimates their top capabilities. Initially the use of the

terminology of the draft strategy with regard to the operation of a war, but this time it has been used in wider aspect. For example in the fields of politics and economics.

J.e. Nolan defined the cooperative security as a concept is formed to the situation after the cold war, where traditional security strategy based on deterrence and military confrontation is no longer relevant. Cooperative security is carried out with the objective of preventing the occurrence of wars. This concept replaces the preparatory action to counter the threat with precautions against such a threat. This concept emphasizes on the military aspect of cooperative security especially the prevention of conflicts and the supervision of weaponry. (Nolan, 1994).

2.2. The Development Of The Strategic Environment

The Asia-Pacific region is a strategic area, both in the aspect of economic, political, or military. In this region there are countries with a population of over one billion (India and China), the modern military-tech, human resources great military, an influential against global economics and politics. In the perspective of traditional security, the Asia-Pacific region have the opportunity and the challenge which is very complex, as well as risk factors that can cause conflict between countries. The dispute in the South China Sea, the East China Sea, Korea Peninsula, and tension in some areas of the border between Nations is addressed need to wisely. While in the perspective of non-traditional security, the area has a long history of smuggling narcotics, smuggling of human beings, smuggling of weapons, piracy at sea, the theft of natural resources, as well as separatism. In addition, in the last three decades the issue of terrorism is increasingly strengthened, caused by various factors, among others, economic problems and radical leftism. The development of the Asia-Pacific.

2.3. The development of science and technology

The progress of science and technology affect the shape and pattern of the war in the future. Although the patterns and forms of asymmetric war still going on in some areas, but a conventional war weapons technology is still growing rapidly. The war in the future are increasingly considering the reduction of the impact damage and casualties among civilians, by applying the technology of high accuracy weapons and the application of the technology of robots on a variety of weapons systems in order to reduce the use of and the deployment of personnel or equipment.

The development of information and communication technologies also create network-based warfare that relies on information superiority, as well as being able to implement digital or diranah war room of siber. The impact can make the security situation of the world, including the alarming crime siber which knew no bounds, including the utilization of biotechnology, genetic engineering and nano-technology which is difficult to detect. (Alisjahbana, 2014),

Besides engineering technology is also developing in the world of aviation, the manufacture of nuclear weapons or spacecraft rocket launchers, missile or spacecraft to fly without a crew and satellite technology are also utilized for the interests of the defense of the country. From the aspect of Defense, space siber has become the fifth domain that can serve as a battlefield of the war, in addition to the battlefield by land, sea, air and space. The use of the systems, devices, and internet-based platforms tend to be increasingly pervasive potentially be insecurity.

2.4. The Development Environment.

a. Ideology

Pancasila State ideology as the basis and it is fundamental in the life of nation and State order. As the Foundation of the country, Pancasila is the source of all the sources of applicable law in the State Union of Republic of Indonesia. As the State ideology of Pancasila is a philosophical view of life and the nation of Indonesia which consists of moral values, ethics and lofty ideals and goals will be achieved a nation of Indonesia. Implementing Pancasila in the life of nation and State in the form of values of harmony, balance and harmony, unity and oneness, family and togetherness, that always being philosophical foundation for citizens in thinking, behave and act in the framework of the Organization of the defense of the country. Development of Variety values and values of justice contained in the Pancasila was intended to prevent the emergence of other regional ego and reinforce nationalism. The application of the values of Pancasila will dampen the onset of radical peace activities in community environment (Genewati , 2002)

b. **Politics**

National political conditions are experiencing setup significantly on infrastructure aspects of politics, the political superstructure, and political culture. Issues related to political commitment should be exercised proportionately on all aspects of the temporary Government is constantly working to build political communications democratically appropriate mechanisms working relationship.

The next political dynamics that developed at this time continue to undergo improvements towards a democratic order, so the national political system can run well. Democratic system which is expected to run well, still need counting results related improvements in the general election, political will, communication with the Central Government are not optimal, the head the more interests area than national interests, blossoming and territorial border disputes, which will potentially cause a conflict.

c. **Economy**

The trend of global economic uncertainty characterized the policy requires a fast, precise and measurable in order to respond to the opportunities and challenges including the establishment of the ASEAN Economic Community (MEA). Indonesia's readiness in the face of five field includes free flow of goods, services, capital, skilled, and investment is anticipated. The Government has been adjusting its target economic growth in order to improve the performance of Indonesia's economy. These conditions will affect the business climate especially in the sector of small and Medium Businesses (SMEs) which absorbs labor.

d. **Socio-Cultural**

Globalization is laden with the spirit of the changes impact to change values that affect your mindset, attitude and pattern patterns follow the next generation the nation and nationality issues that significantly affect order of the culture of the nation. The development of science and technology bring certain values that are directly or indirectly affecting socio-cultural values of the nation which already exists.

Understanding the nation's next generation of related values that are contained in the Pancasila, the 1945 constitution of the NRI, SO sesanti, and Bhinneka Tunggal Ika, increasingly eroded by new new values that are not in accordance with the nation's identity. Degradation of sublime values nation Indonesia have influenced the decline of the attitude of nationalism, patriotism and love of homeland for citizens in affirming the unity and the unity of the nation.

e. **Homeland Security**

Separatism is still a security issue that threatens the country's sovereignty, territorial integrity and safety, SO the whole nation. Separatism is done through a political movement and armed with exploiting the weakness of the Organization of the functions of Government. The handling of security in the country as a result of horizontal conflicts triggered by the cultural diversity of the community, ethnic group, religion, ethnicity, and class, as well as social conditions still coloring conflicts that occur in certain areas.(Arismunandar, 2000)

2.5. The Functions Of The Defense Of The Country

The defense of the country serve to embody and defend the entire region as a single entity defense SO capable of protecting State sovereignty, territorial integrity, as well as the safety of all Nations from every threat, whether that comes from outside as well as those arising in the country. The effort of realizing and maintaining the entire region as a single entity defense SO held in the function penangkalan, penindakan, and recovery.

The function penangkalan is the embodiment of the country's defence effort of the whole national strength which has a psychological effect to prevent and nullify any threat, whether from outside or incurred within the country. Penangkalan implemented physical and nonphysical, with make the effort of building and fostering the ability of integrated functions of State defence accord. (Stephen , 1985)

The function the action in the face of the military threat is implemented by exerting the power of the military in accordance with the defense mechanisms of the host defense system. In the face of military threats from outside, the Organization of the penindakan functions adapted to the form of the threat to determine the type of action taken as well as the country's defense force is used. Military threat in the form of aggression faced by the war, and for Indonesia's holding of the war carried out in total in the form of war universe.

The function of action the face of threats nonmiliter, implemented by exerting the power of the defence nirmiliter in accordance with the mechanism of the defense system of the universe. The Action against the threat of nonmiliter is done with a functional approach by family outside of the field of defense based on the type and nature of the threat. The function penindakan is manifested in the form of rescue measures by exerting all its resources and national infrastructure..

The function of action the face of the threat of military force, putting hybrid and integrated nirmiliter according the nature of the threats faced by observing the ability of professionally and proportionally. The restore function is a State Defense business alignment is carried out by integrated defense force military and nirmiliter to restore the condition of the country's security has been compromised due to the war, insurgency or attack the separatist conflict, vertical or horizontal conflicts, riots, terrorist attack, natural disaster or due to the threat of other nonmiliter (Midhio,(2016).

2.6. The Purpose Of Village Development

Program development activities, both physical development as well as a non physical is for the welfare of the whole community. The nature of the need is very basic, until other needs later on can be perceived by the public at large. For that harmony and alignment in the carrying out of development should be realized since the beginning by all parties. The preparation of the development plan is primarily a result of planning from the bottom up and from top to bottom through the stages of drafting across levels of Government, ranging from village, Sub district, Regency/Municipality, province, regional until national and vice versa (Prabawa, 2015

2.7. Village Development Funds

According to the book the execution on Instruction of Village Development Fund (1986:4) in development funds, explain that the village is some money/funding provided by the Government to the villages directly, in order to carry out or the development process in the village to make it in the form of physical projects that benefit the public welfare improvement in the environment of the village and village, on the state budget burden in order to equitable the development and outcomes.

2.8. The use and supervision of village development funds

Village development funds given by Governments and third parties that should be used to build projects in need by the community of the village which is reflected in each program section Village Representative Institutions (BPD) and other activities that support the growth and improvement of people's income and activities fostering the welfare of society.

In order to support the successful implementation of the management of the village development funds formed a Team Builder as well as supervision and control on many levels of Government with the duties and responsibilities of each. At the level of the village village chief as implementing activities responsible for the successful implementation of village development funds. While the guidance and oversight of the operations funded by the village representative body (BPD) (Prabawa, 2015).

2.9. The Village Fund Allocation

The village fund allocation or abbreviated with ADD are the funds allocated by the County Government for the village were sourced from the part of the Fund's financial center and regional equalization received by District, according to Halim (2004), the key features of good financial management, namely:

a. Simple

A simple system that is more easily understood and studied by those in charge of running it, and the more likely it is followed without wrong, can deliver results more quickly, and easily inspected from inside and from outside. Practical purposes to be achieved in drawing up a financial management one is creating simple procedures in line with the objectives or results achieved.

b. Complete

Financial management should be used to achieve all the goals, and should include any financial activity in terms of area, so activities should uphold the validity of budget compiling receipts and expenses. Keep the area can always pay off their financial obligations, running the oversight from within, trying to achieve results and effectiveness in activities and extended to keep there receipts and expenditure that does not enter the plans or not included in the budget.

c. Useful

In this case, the power to have two facets:

1) Power to attached to financial management concerned should be raised, which means that high result set must be achieved at a cost of low , from a number of staff and funds are needed or results achieved should be the maximum.

2) financial management concerned should be designed in such a way so as to enlarge the power to become a tool that local governments to run activities it and not slow him down.

d. Easily adjustable

Financial management never made so stiff so it is difficult to apply it or adjust at different circumstance

2.10. Financial Reporting

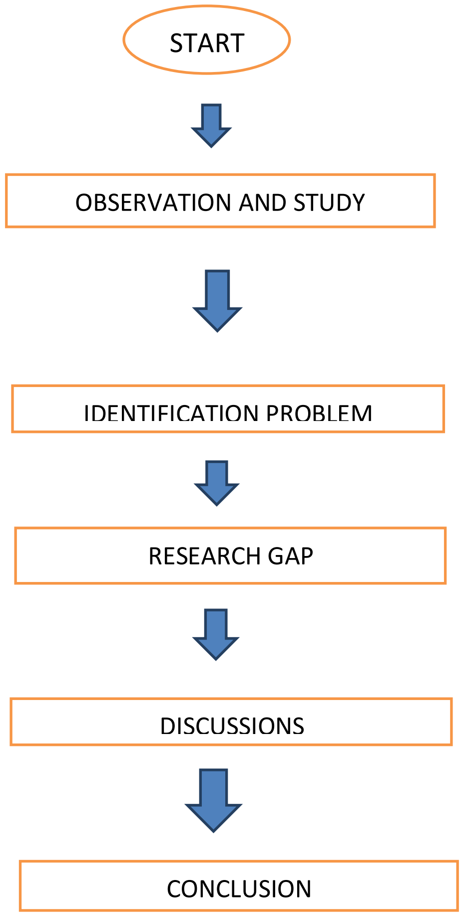
The financial report is a structured report regarding the financial position and the transactions carried out by an entity reporting. Government accounting standards (SAP) via PP. No. 24 in 2005, which is the first SAP owned by the Government of Indonesia. The Position Of Government Accounting Standards (SAP). The reporting entity is the Government unit that consists of one or more units of Government that are a mandatory statutory provisions deliver accountability in the form of financial statements, with regard to the reporting entity consist of:

a. Central Government

b. local governance

c. The units of Central Government environmental organization/region or any other organization, if the Organization's units according to the legislation in question is obligated to present the financial report

2.11. Methodology



3. RESULT AND DISCUSSION

Results and Discussion in this study the author uses realist paradigm that makes the State as the primary actor in international relations that is rational, monolith, and take into account the cost and benefit of each of its actions. Level and the unit of analysis used in this study is the nation-State (the nation-state done by the State and how the State decided to take policies based on national interests (national interest). The level of analysis is more focused on what is

Theories relevant to the discussion of the problems in this research is the theory of theory of security strategies. The design strategy is not based on moral considerations, beliefs or things emotionally, but based on rationality decision makers (Rizal,2003) Based on the strategy policy makers trying to achieve the national interests and prevent barriers over the interests of security is understood as the ability to defend yourself (survival) in real threat (existential threat). (Mochtar,1989)

For the State and the continuity of his life regarding the issue of how projecting sovereignty and how to develop and maintain their identity. Required policy alignment between all the instruments of power nasional to secure national interests. In the context of dispute facing the South China Sea, instrument and instrument of defence diplomacy Indonesia must traverse a theoretically integrated one step. The existence of the defence instruments among which is to support diplomacy, including if it deems diplomacy failed. Indonesia's efforts in the field of diplomacy between focuses on handling the issue of the South China Sea dispute in a frame

The construction of the country's defence posture is directed to improve the defense of the country. Potential threats facing Indonesia are increasingly complex and diverse, so it requires a strong State defense capability. The country's defence posture is constantly adapted and directed in order to answer the various possibilities of challenge, as well as a real threat and not real. The construction of the State's defense held for realize a military defense and defense nirmiliter towards a regional maritime power respected in the Asia Pacific region with active defensive principle in order to ensure national interests. The country's defence effort organized through the development of the country's defence posture on an ongoing basis to realize the power, the ability and the title.

Construction of posture military defense is directed at fulfilling the Principal Strength Minimum (Minimum Essential Force/MEF) major components and setting up other defense components, which prioritized the development of the maritime defense force by leveraging technology satellite systems and drones. While the construction of the defensive posture nirmiliter prioritized on: Increasing the role of family corresponding tasks and their respective functions in the face of the threat of non military; Resource management capabilities and national infrastructure; as well as in the construction of the ability of the defence nirmiliter in support of the interests of the defense of the countryn (*Muladi, 2003)*

In anticipation of the development of the security situation of the maritime region of Indonesia at this time, particularly in the area of Natuna Islands and territories of Merauke, the increase in the country's defense force development in the two areas are part of the the construction of the country's defense posture overall policy Plan National long-term development (Akmal & Pazli, 2016)

The construction of the national character as part of a mental revolution, organized through the construction of the country's defense capability and awareness for all citizens of Indonesia to prepare human resources for the defence of the country, as well as the strengthening of identity nation based on personality and cultural based on Pancasila and UUD 1945 NRI. National character development done on integrated in all family, local government, and the nation's other components. Coaching programs Awareness Bela Negara (PKBN) realized to form cadres bela negara which has awareness and ability based on the values of bela negara

Empowerment of State Defense geared to maintaining and developing the whole country's defense power and potential in an integrated and targeted by involving the entire citizens, and make use of the whole

4. CONCLUSION

Based on the discussion that is the strategy and defense policy not only performed at the central level but also can be done at the local level. The emergence of the law regarding the village Fund is an opportunity as well as a great opportunity to involve pertahanlkan at village level, especially with the existence of a village Fund then at least the village could do the socialization and anticipation about the existence of the threat terrorists from within the country. Through the village Fund at least the village could make budget on defense through the use of the village Fund.

REFERENCES

Alisjahbana, Amida S (2014), The direction of the acceleration of the development of policies and strategies of Eastern Bank Indonesia – Coordination meeting of the Central

Governmentand the Regional economic and financial Studies, Manado.

Arismunandar, Wiranto (2000), The strategy of technology development and the defense industry in order to realize the Independence of national defense

Akmal & Pazli, (2016), Indonesia's strategy of keeping the security of the border region Related to the conflict in the South China Sea, 2009-2014 *Journal of International Society*, Vol. 3, No. 1, 2016 , Universitas Riau

Buku Putih (2015), Indonesia Defancea, Ministry of Devance Republic Indonesia

Barry buzan, dkk . (2009) .“Security: A New Framework for Analysis dalam Genewati Wuryandari dkk. Security on the border of Indonesia – East Timor, sources of Threat Management Policy "& Library student, Y ogya .27-22

Cordesman, Anthony. 2003. The Asian Military Balance: An Analytic Overview. A Comparative Summary of Military Expenditures; Manpower; Land, Air, and Naval, Forces; and Arms Sales. Washington: The Center for Strategic and International Studies

Genewati Wuryandari, (2002), The legislation of the Republic of Indonesia number
3 Year 2002 On State Defense page 23-30

Kompas News Daily,(2000) August 19 Saturday, National Policy Sector Industry Agglomeration in Partnership With

Halim, Abdul, (2004). Regional Financial Management, Yogyakarta, UPP AMP YKPN

Lovell, John P. (1970). Foreign Policy in Perspective: Strategy adaption decision making. Holt

Lindsey, T. (2010). „Preposterous Caricatures‟: Fear, Tokenism, Denial and the Australia-Indonesia Relationship. Dialogue, hlm 35.

IT Press, 9.

Midhio, I Wayan (2016), The defense industry, opportunities Challenge in
perspective & State Defense , JILSE

Mochtar Mas’oed.(1989) *The study of international relations: the level of analysis and Teorisasi (Yogyakarta: between Center of University Social studies UGM*) page 21-90

Muladi, (2003), The nature of terrorism and some of the settings in the Criminalization *, Jurnal Kriminologi Indonesia FISIP UI, Vol. 2 No. III.*

Dharma Media Magazine, (2005) April, 3rd Edition, Build the defense system of the country with Manifest Independence .

Patriot Magazine, number 5/tahun-VI/2005, Strategic Defance Nationality of Industri Development

Nolan, JE et, al., (1994).*“The Concept of Cooperative Security”, in: J.E. Nolan (ed.), Global Engagement, Cooperation and Securityin the 21st Century;* Brookings, Washington, D.C., 4-5

Prabawa, Akbar, (2015). Management of village Fund Allocation on Loa Lepu Village Development at Seberang Tanggarong Regency in Kutai Kartanegara District , *eJournal Ilmu Pemerintahan*, 3, (1) 2015 : 227-238

Rizal, Sukma, (2003),.International Security Post , September 11: : Terrorisme, U,S Hegemony and Regio Implications, Denpasar

Soeprapto, R (1997). *System International Relantionship, Interaction, and Behaviour.* Jakarta: Raja Grafindo Persada

Sulistiyanto, P. (2010). *Indonesia Australia Relations in the Era of Democracy: The* View from the Indonesian Side. Australian Journal of Political Science, 45 (1), pp 117132

Stephen M. Waltz (1985), *Alliance Formation and the Balance of World Power*, The M

Indonesian Naval Technology College
Postgraduate International Conference, Vol. 1, No. 1, pp. 36-44
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THE DESIGN OF MITIGATION MODEL OF WORK ACCIDENT RISK BY APPLYING INTERPRETIVE STRUCTURAL MODELING METHOD

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ABSTRACT

Work accidents that happens in construction industry is more often comparing to others industries, it is 32%. So that construction work has risk of accident because its area is outdoor. The causes of accident comes from the worker or manpower itself. Based on this, it is important to mitigate the risk that can cause the accident. The method used in this research is Interpretive Structural Modeling (ISM). Risk mitigation that has high driver power is applying the standard of OSH for the High Rise Building worker, learning MSDS (Material Safety Data Sheet). Workers must have SKT ((Technical Skills Certificate) or TSC (Technical Skill Certificate), Upgrading OSH Management. While mitigation of giving space in setting and removing the scaffolding. All the setting of scaffolding must be checked by the certificated officer. Working method must be suited with the condition of worker and the socialization of the dangerous of spilled paint, create and obey the lifting plan, isolate the cable connection based on the PUIL 2000. Those who are in quadrant II has low level of Driver Power so that these variables have no power to influence other variables in the system. It is hoped that work accident can be decreased and it can minimize the risk (zero accident) for the construction workers.

KEYWORDS : Mitigation, Risk, Work Accident.

1. INTRODUCTION

Construction industry has significant different characteristic comparing with other industries. This difference is in the condition and work system, in construction project almost all of jobs done by manpower with many specializations that create different problems in each work (Andi, et.al 2005). Besides, this kind of work has a high risk of work accident (Handayani, 2017).

According to Sepang (2013), construction work is such a complexity that involved construction materials, construction equipment, construction method, construction cost, and manpower that may cause accidents. In line with Mohamed (2002), he states that construction industry is well known as the industry that has a low level of work safety comparing with other industries. It is same with what has been written in Kompas (2016) that the work accident which happens in construction industry is more often than other industries; it is 32%, manufacture industry 31,6%, transportation industry 9,2%, forestry industry 3,8%, mining industry 2,6%, and other industries 20,7%. It can be concluded that construction work has a high risk in work accident because this kind of working located in outdoor area (Maryani, 2012)

The risk of work accident in construction work comes from its manpower itself (Handayani, 2017) and (Andi et.al, 2015), it is different with Reason (19995) in Andi et.,al (2015) states that work accident is the result of organization and management, while Sutarto (2008) states there are 3 factors that influence the work safety in construction site, they are management, workplace condition, and the workers' awareness. The mitigation of work accident can prevent the accident so that there is a correlation between the mitigation to overcome the risk. In order to resolve the risk in work accident, it needs to understand the correlation between one mitigation of risk and others. So that in modeling the correlation between mitigation model of work accident using interpretive structural modeling (ISM), because this method is widely used in modeling the problem of systems (Sianipar, 2012). The objective of this research is modeling the mitigation plan of work accident in order to reduce accident in construction project.

2. METHODOLOGY

This research applies *Interpretive Structural Modeling* (ISM) in overcoming OSH risk that happens in construction project, and the steps are:

2.1. The Identification of Risk Mitigation.

Before identifying risk mitigation, for the first we should understand the potential risk that should be resolved. The potential risk based on the result of research from Handayani (2017). The identification of risk mitigation done by discussing with the expert toward FGD (Focus Group Discussion). Besides, identification is also done by the study of literature based on HIRARDC. This identification is aimed to understand the appropriate of mitigation in handling the risk by considering its trigger.

2.2. Deciding the type of each mitigation contextually.

Comparison is used in deciding the type of relation, it compares risk mitigation by using contextual relation, which most of it are; the influence, the cause and verbs which deals with risk mitigation (Kanungo and Jain; 2009)

2.3. Creating Structural Self-Interaction Matrix (SSIM) by using pairwise.

In analyzing the relation between elements, contextual relation with what kind of type the relation is, which one element triggers other elements, it stated in this third phase. The relation between 2 sub element (i and j) and the direction of those elements are questioned (Thakar dkk., 2007). There are four symbols in stating the relation:

V = for relation of mitigation risk i to risk j, one way, the existence of mitigation
i triggered mitigation j

A = for mitigation j to i, one way. Mitigation j exist if only mitigation i is done

X = it is for mitigation I to mitigation j and from j to i, two ways, those two
mitigations are triggered each other

O = if the relation among mitigation seems not valid (not connected)

2.4. Creating Reachability Matrix (RM) and checking the transitivity.

In this phase, it is focused on the making of Reachability, and this is a binary matrix

- If relation (i, j) noted as V so input (i, j) in RM become 1 and (j, i) become 0
- If relation (i, j) noted as A so input (i, j) in RM become 0 and (j, i) become 1
- If relation (i, j) noted as X so input (i, j) in RM become 1 and (j, i) become 1
- If relation (i, j) noted as O so input (i, j) in RM become 0 and (j, i) become 0

2.5. Matrix Test with Transitivity.

Transitivity is the basic assumption to ISM which is used to achieve Final Reachability Matrix (FRM). Transitivity states that if element A has relation with element B and element B has relation with element C. if the element of risk mitigation (i and j) from RM is zero (0), so there are no direct or indirect correlation from mitigation i to j. RM actually has no this character because there is only indirect relation from element i to j, input (i and j) and also zero (0). The direct relation can be shown up by changing FRM to successive power till there is no input, this condition is finished if it reaches $M_{n-1} < M_n = M_{n+1}$. The application of the Transitivity is done by checking cells in reachability matrix with value 0, whether it is fulfill the regulation of transitivity or not.

2.6. Deciding partitionary level from reachability matrix.

It includes the extraction from hierarchical ordering from RM by partitioning in this phase. The objective of this phase is to become the first input for the creating of digraph from RM. The level partition uses elements in sj and si. Reachability set R(si) consist of some its elements and other unsure that can be reached by si. There are also some elements that reach si that act as the antecedent A(si). Next, the interaction from some reachability and antecedent ($R(s_i) \cap A(s_i)$). The element $R(s_i) = (R(s_i) \cap A(s_i)$ is the top element from ISM hierarchy. The top element has no relation to the other element above its hierarchy. If the top element was identified so they will be separated from other elements. The same process continuous to all elements. This identification level is helpful in creating digraph and the last model of ISM.

2.7. Creating digraph with eliminated transitivity connection.

The first digraph included transitivity relation comes from the conical shape from RM. The conical matrix gained from the RM partition with the arranging of element based on its level, which mean all elements with the same level are collected, element that has most zero (0) in half of diagonal and the element that has most 1 in the below of it. To make the digraph simple, it is erased to get the last one. If there is a relation between risk i and j, it shown by the arrow which headed from i to j.

2.8. Converting graph to ISM and checking the inconsistency conceptually.

The result of digraph from this phase is converted to ISM by eliminating the information from the element point. Finally the ISM model is checked for its compatibility.

3. RESULT AND DISCUSSION

Potential risk and its causes that should be done based on the research of Handayani (2017). The plan of risk mitigation that has been identified by the experts and the literature HIRARDC shows as below in Table 1.

Table 1. Potential Risk and Mitigation Risk

No	Risk	Causes	Mitigation
1	Confined	Limited workplace	Give space when setting and removing the scaffolding
2	Fall	Scaffolding was broken	Each of the setting scaffolding must be checked by the certificated Scaffolder
3	Inhaling the chemical substance	Workers do not aware of OSH	The work method is suited with the condition of the job, and give the socialization of the dangerous of the spilled paint
			Studying MSDS (material safety data sheet
4	The material substance hit the skin	Workers do not wear the proper suit.	The working method should follow SNI (Indonesian National Standard)
			OSH Management Improvement

No	Risk	Causes	Mitigation
5	Electrocution	Shorted	Isolate the cable connection based on the PUIL 2000
6	Electrocution	Get a shock from electricity	Isolate the cable connection based on the PUIL 2000
7	Fall	The construction method is not standard	Follow the standard of OSH for working in high place
8	Scratched	The worker is unskillful	The worker must have SKT (Technical Skill Certificate)
9	Slipped and fall	There is no handle	Provide railing and board for footing
10	Confined	Mistake in manual handle	Creating and obeying the lifting plan
11	Dropped of material	In a rush	Applying OSH in High Rise Building
12	Hand cramps	Get less rest	Create the SOP
13	Fall	Working while joking	Each of the setting scaffolding must be checked by the certificated Scaffolder
14	Eyes got material, hand scratched, finger cute, get the coating liquid	Careless	Create the SOP of cutting equipment
15	Inhale the chemical substance, fall in hole, excavatgor hit, hand scratched	Less of OSH commitment	Sign located and workplace safety Do *Safety Morning* and *Safety Induction*

The risk mitigation that has been identified by OSH experts in Table 1 and the next is comparing risk mitigation in matrix relation by using contextual or correlation of each risk mitigation. The next step in building the hierarchy model of ISM. The relation between risks, for instance, for cell (i_1,j_{15}) it says got score 4, which means it has no relation, in cell (i_1,j_4) it says got 1, which means i_1 can trigger risk for j_4. While in (i_1,j_9) it says got 2 which means risk mitigation i_1 fulfilled if only risk mitigation j_9. Is done.

Table 2. Risk Mitigation

No	Mitigation
1	Give space when setting and removing the scaffolding
2	Each of the setting scaffolding must be checked by the certificated Scaffolder
3	The work method is suited with the condition of the job, and give the socialization of the dangerous of the spilled paint
4	Studying MSDS (material safety data sheet
5	The working method should follow SNI (Indonesian National Standard)

No	Mitigation
6	OSH Management Improvement
7	Isolate the the cable connection based on the PUIL 2000
8	Follow the standard of OSH for working in high place
9	The worker must have SKT (Technical Skill Certificate)
10	Provide railing and board for footing
11	Creating and obeying the lifting plan
12	Applying OSH in High Rise Building
13	Create the SOP
14	Create the SOP of cutting equipment
15	Sign located and workplace safety
16	Do *Safety Mornin*g and *Safety Induction*

3.1. Structural Self-interaction Matrix (SSIM)

The data of the relation among risk mitigation in SSIM by converting number into the letter which says relation category (AVXO). The next is creating reachability matrix (RM), it is by changing SSIM into binary matrix. It is replaces symbol V, A, X, and O with 0 and 1. The result can be seen in Table 3.

Table 3. Reachability Matrix

Variabel	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**Driver Power**
1	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	4
2	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	4
3	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	4
4	0	0	0	1	1	1	0	1	1	0	1	0	1	1	0	0	8
5	1	0	0	0	1	0	1	1	1	0	1	1	1	1	0	0	9
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
7	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	2
8	1	1	0	0	0	1	0	1	1	0	1	1	0	0	0	0	7
9	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0	13
10	0	0	0	0	0	1	0	1	0	1	0	0	0	0	1	0	4
11	0	0	0	0	0	1	0	0	1	0	1	1	1	1	0	0	6
12	1	1	0	0	0	1	0	1	0	1	1	1	1	1	1	0	10
13	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	3
14	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	3
15	0	0	0	0	0	1	0	1	0	1	1	0	0	0	1	0	5
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
Dependence	8	7	4	6	7	11	5	9	9	5	9	9	9	9	6	2	

The next is creating Conical Matrix (Lower Triangular Format) by arranging variable based on the level in Reachability Matrix Final. This Canonical Matrix will be helpful in making the Digraph Structural Model. Canonical Matrix that has been arranged can be seen on Table 4.

Table 4. Canonical Matrix

Variabel	**7**	**9**	**6**	**13**	**14**	**11**	**12**	**1**	**1**	**4**	**16**	**5**	**8**	**3**	**15**	**10**	**DP**	**Level**
7	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	2	**I**
9	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0	13	**I**
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	**I**
13	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	3	**II**
14	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	3	**III**
11	0	0	0	0	0	1	0	0	1	0	1	1	1	1	0	0	6	**IV**
12	1	1	0	0	0	1	0	1	0	1	1	1	1	1	1	0	10	**IV**
1	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	4	**IV**
2	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	4	**V**
4	0	0	0	1	1	1	0	1	1	0	1	0	1	1	0	0	8	**V**
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	**V**
5	1	0	0	0	1	0	1	1	1	0	1	1	1	1	0	0	9	**V**
8	1	1	0	0	0	1	0	1	1	0	1	1	0	0	0	0	7	**VI**
3	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	4	**VI**
15	0	0	0	0	0	1	0	1	0	1	1	0	0	0	1	0	5	**VI**
10	0	0	0	0	0	1	0	1	0	1	0	0	0	0	1	0	4	**VI**
Dependence	8	7	4	6	6	11	5	9	9	5	9	9	9	9	6			

The score of Driver Power gained from the sum of scores in column horizontal j, while Dependence Power gained from the sum of scores in vertical i.

3.2. Driver Power Dependence Matrix

The next step is classifying the key variable which is important to develop the program. Those variables are divided into 4 parts, those are; driver, linkage, autonomous, and dependent (Pfohl, 2011). Dependence from those variables is in the Figure 1

.

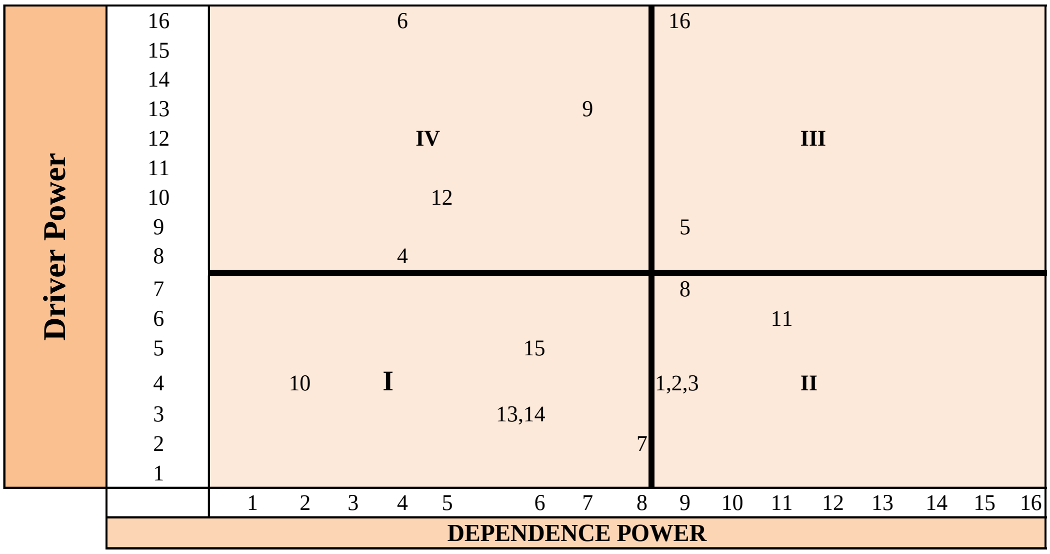

Fig. 1 Driver Dependent Matrix

Risk mitigation in 12, 4, 9, and 6 which is located in quadrant IV have a high driver power, so that this variable has power to influence other variables in the system (Retno, 2013) and these risk mitigation as a key factor in managing risk events. These mitigations are: Applying standard of OSH in High rise Building, Learning MSDS (Material Safety Data Sheet), workers must have the certificate SKT (Technical Skills Certificate) or TSC (Technical Skill Certificate), Upgrading OSH Management. While mitigation of giving space in setting and removing the scaffolding. All the setting of scaffolding must be checked by the certificated officer. Working method must be suited with the condition of worker and the socialization of the dangerous of spilled paint, create and obey the lifting plan, isolate the cable connection based on the PUIL 2000. Those who are in quadrant II has low level of Driver Power so that these variables have no power to influence other variables in the system (Laili, 2014)

Quadrant I. Weak Driver-Weak Dependent Variable (Autonomus), risk mitigation in this quadrant has a relatively small or unrelated influence (Mirah, 2014). Risk mitigation in quadrant I that are: Create the SOP, Create the SOP of cutting equipment, Sign located and workplace safety, Provide railing and board for footing, Isolate the cable connection based on the PUIL 2000

Quadrant III: Strong driver-strongly dependent variable (linkage). Risk mitigation in this position will support the success in addressing the causes of OSH risk that may lead to risk events. Where as if action is not taken from this risk mitigation then the risk incident cannot overcome. Risk mitigation in quadrant III that is work method must follow SNI (Indonesian national standard), Conduct Safety Morning And Safety Induction.

3.3. Structured Hierarchy of OSH Risk Mitigation

Preparation of hierarchical structure model based on Driver Power and level. (Pfohl 2010), The results of the study put the overall mitigation in 6 levels as shown in Figure 2. The hierarchy level determination indicates the dependence between mitigation at the lower level.

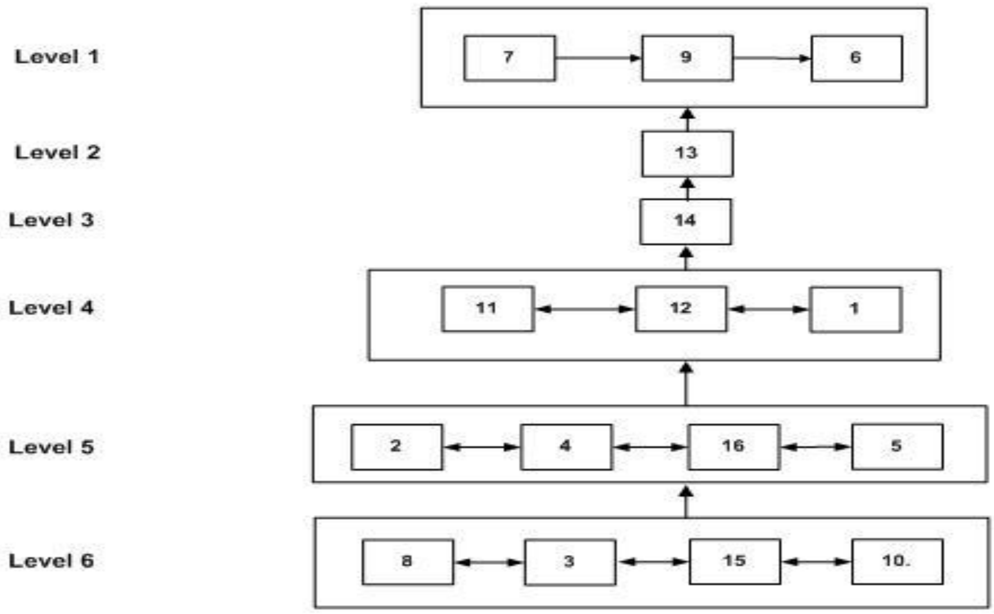

Fig. 2 Structured Hierarchy Model of OSH Risk Mitigation

4. CONCLUSION

The ISM technique produces a structural model of risk mitigation and a DP-D matrix to interact the hierarchy and linkages between each risk mitigation. The risk mitigation that should be done in overcoming the work accident is by applying the standard of OSH in the work of High rise Building. Learning MSDS (Material Safety Data Sheet), workers must have SKT (Technical Skill Certificate), Upgrading OSH Management. By having this risk mitigation, it is hoped that work accident can be decreased and it can minimize the risk (zero accident) for the construction workers.

REFERENCES

Andi., Alifin dan Candra (2005), Structural Equation Model Of The Effect Occupational Safety Culture On Worker Behavior In Construction Projects, Civil Engineering Journal Vol 12 No 3

Anny Maryani, (2012), Comprehensive Construction Work Accident Modeling To Control K3 Cost, Master Thesis, Sepuluh Nopember Institute of Technology, Surabaya, pp 3-5

Handayani Dwi Iryaning (2017) Causal Effects Diagram In Modeling K3 Risk By Considering The Linkage Of Risk Causes In Levely Buildings, National Seminar of Industrial Engineering (SNTI) And National Seminar on Integrated Industrial Engineering Sciences (Satellite)

Http://Properti.Kompas.Com/Read/2016/.../
Accident Numbers Are still high who cares accessed, March 15, 2016

Kanungo, S. and Jain, V. (2009), Using Interpretive Structural Modeling to Uncover Shared Mental Models in IS Research, *presented at European Conference on Information Systems*, Verona, Italy.

Mohammed S., (2002), safety Climate in Contruction site environment, journal of contruction engineering management.

Mirah Dharmaputra Arie (2014), Determination Of Key Elements Of Agroindustry Livestock Development With Interpretative Structural Modeling, Zootek Journal Vol 34 No. 2 Issn 0852-2626.

Pfohl, H.C., Kohler, H, Thomas, D. (2010). State of the art in supply chain risk management research : empirical and conceptual findings and a roadmap for the implementation in practice, Logistics Research, Vol. 2 Iss: 1, pp. 33-44.

Pfohl, H.C., Gallus, P., Thomas, D. (2011), Interpretive structural modeling of supply chain risks, *International Journal of Physical Distribution & Logistics Management*, Vol. 41 Iss: 9, pp. 839 – 859.

Sepang Bryan Alfons Willyam (2013) Safety And Health Safety Risk Management In Ruko Ovens Fashion Manado Development Projects, Journal Statik Civil Vol 1 No 4 March (282-288) Issn 2337-6732

Sianipar Makmur (2012), The Application Of Intrepretative Structural Modeling (ISM) In The Determination Of The Actors Element In Institutional Development Of The System For The Results Of Koi Farmers And Coffee Agro-Industry, AGROINTEK, Volume 6 No 1, March 2012

Sutarto Agung (2008) The Role Of Safety Safety Management System In Improvement Of Construction Project Performance, Civil Engineering & Planning, Number 2 Volume 10 - July 2008

Thakkar, J, Deshmukh, S.G., Gupta, A.D., Shankar, R. (2007), Development of a balanced An integrated approach of Interpretive Structural Modeling (ISM) and Analytic Network Process (ANP), *International Journal of Productivity and Performance Management*, Vol. 56 No. 1, pp. 25-59.

Retno Astuti (2013), Risks and Risks Mitigations in the Supply Chain of Mangosteen: A Case Study, Operations And Supply Chain Management, Vol. 6, No. 1, 2013, pp. 11 – 25, ISSN 1979-3561| EISSN 1979-3871

Laili Yetri (2014) The Design of Institutional Structural Models For Upgrading The Components of Upstream Oil And Gas Industry, Indonesia, Thesis, University of Indonesia, Salemba.

Indonesian Naval Technology College
Postgraduate International Conference, Vol. 1, No. 1, pp. 45-61
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DETERMINATION OF LANDING BEACH LOCATION IN AMPHIBIOUS OPERATIONS ON SORONG OF THE WEST PAPUA SEA WATER USING BORDA METHOD AND ANALITIC HIERARCY PROCESS

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ABSTRACT

Determination of landing beach is the most important ability of Indonesian Marines Troop as an element of the Landing Forces in order to carry out a special amphibious operation task to determine the ideal landing beach location for the successful execution of the task. Requirements on the determination of ideal landing beaches should be in accordance with predetermined parameters and serve as an important component in determining the weighting value of landing beach selection criteria. This study aims to determine the location of landing beaches by using Borda method combined into Analytic Hierarcy Process (AHP). The research stages started from the determination of the value of the weight of the selection criteria and the value of the alternative weight of the landing beach result of the analysis with Borda method then processed again in the framework of AHP method arranged in the hierarchy model by performing pairwise comparison analysis to obtain the result of landing beach selection which is logical and has an objective value in accordance with accurate data and is very helpful for decision makers to solve multi-criteria problems. The result of the analysis with Borda method is known that the physical properties of Hydro-Oceanography become the first sequence with the value of weight of 0.207 followed by the criterion of reference point with the weight value of 0.193 in the second sequence and the type of beach criterion with the weight of 0.171 on the third sequence. From the results of analysis with AHP method can be seen that Beach 2 with a value of weight of 0.639 was chosen to be the most appropriate beach location for amphibious landing operations. While for the second order is Beach 1 with a weight value of 0.259 and the third is Beach 3 with a weight of 0.101.

KEYWORDS : Amphibious Operations, Landing beach, Borda method, AHP method.

1. INTRODUCTION.

As an archipelagic country, especially in the eastern part of Indonesia with its abundant natural resources, it has not been optimally utilized so that it is very vulnerable to illegal activities, such as illegal fishing, illegal mining, illegal logging and other illegal activities (Headquarter, 2017). World Maritime Axis Policy issued by the President of the Republic of Indonesia demands that Indonesia should anticipate able to maintain security stability in the jurisdiction of NKRI. For that reason it is necessary a thought that can answer the problems faced by Indonesia in the eastern part of Indonesia (Headquarter, 2017).

The expansion process in the Papua region contributes well to establish Third of The Sea Area Command and Marine Force in Sorong West Papua due to infrastructure development(Headquarter, 2017), facilities and infrastructure of the local area is getting better. In order to carry out the function of empowering the marine defense area requires the ability of sea defense and also the ability to maintain all the natural resources potential (Brink, 2000).

Understanding about the coastal characteristics of Sorong especially related to determination of landing beach is a should be for landing troop element in order to carry out the task of amphibious operation especially to determine the ideal landing beach location (Headquarter, 2013)(Brink, 2000). Requirements to determinate the ideal landing beach should be in accordance with predetermined parameters (Brink, 2000) and serves as an important component in determining weight value of landing beach selection criteria (Koc & Burhan, 2015).

By using Borda method which is combined into AHP method, the research stage starts from determination of the criteria weight value and the alternative weight value (Velazques & Hestler, 2013) (Koc & Burhan, 2015). Analysis results with the Borda method is then reprocessed in the AHP framework which arranged in the hierarchical model by performing pairwise comparison analysis, it is processed in the form of a complete matrix with consistency analysis (Koc & Burhan, 2015). So it is expected to get the result of alternative landing beach are logic and objective value in accordance with accurate data and is very helpful for decision makers to solve multi-criteria problems(Velasquez & Hester, 2013).

The systematic study of this research is as follows: Chapter 2 contains a literature review on the definition of Amphibious Operations, landing beach and basic theories which used for the Borda and AHP methods. In chapter 3 the results and discussion are presented and the last is chapter 4 conclusions.

2. LITERATURE REVIEW.

2.1. Amphibious Operations.

The amphibious operation is an attack carried out from the sea by a naval unit and a landing troop of the Indonesian Navy loaded in ships and amphibious landing means and landed on the beach or coastal potential of the enemy (Headquarter, 2013).

2.2. Landing Beach.

The landing beach is part of the coastline required for landing one Battalion of Landing Team or equivalent unit (Staff, 2014). Beach landing can also be part of a coastline that has tactical values, such as a bay beach that can be used to land a smaller entity than the Battalion of the Landing Team (Headquarter, 2013). In landing beach selection, some types of oceanographic data (Brink, 2000) should be given enough consideration so that the Marines can safely carry out their landings (Staff, 2014)(Brink, 2000). These types of data include the concept of landing troop operations, coastal capacity to maneuver amphibious landing troops, coastal approaches, natural obstacles, coastal backdrop traits, communications infrastructure including railroads and weather and other hydro-oceanographic data (Collins, 1998).

2.3. Borda Method.

Borda's method proposed by its founder Jean Charles de Borda in the 18th century is one of the methods used to determine the best alternative of selected alternatives (Costa, 2017). Each alternative decision-maker choice will be judged by its weight based on its ranking. The greatest weight is the best alternative for decision makers (Mohajan, 2012) (Costa, 2017). The privilege of this method can overcome the difficulties of other methods where people or things that are not in the first rank will be automatically eliminated (Ishida, 2017). The basic idea in Borda Method is by assigning weight to each of the first rank, second rank, and so on (Ishida, 2017).

2.4. AHP Method.

AHP method is a method of decision-making analysis that applies pairwise comparison theory to decision variables that become the main criteria of decision as a derived element of the predetermined objectives(Saaty, 2012) where the determination of the priority scale of these criteria depends on the assessment of experts in order to determine the alternative choice of solutions (Saaty, 2008).

3. RESEARCH METHODOLOGY.

3.1. Flowchart of Research.

In this study is divided into four stages of research activities are arranged sequentially starting from the stage of identification, data collection phase, analysis and data processing and conclusions. Its can be seen as Figure 1. as follows (Saaty, 1990) :

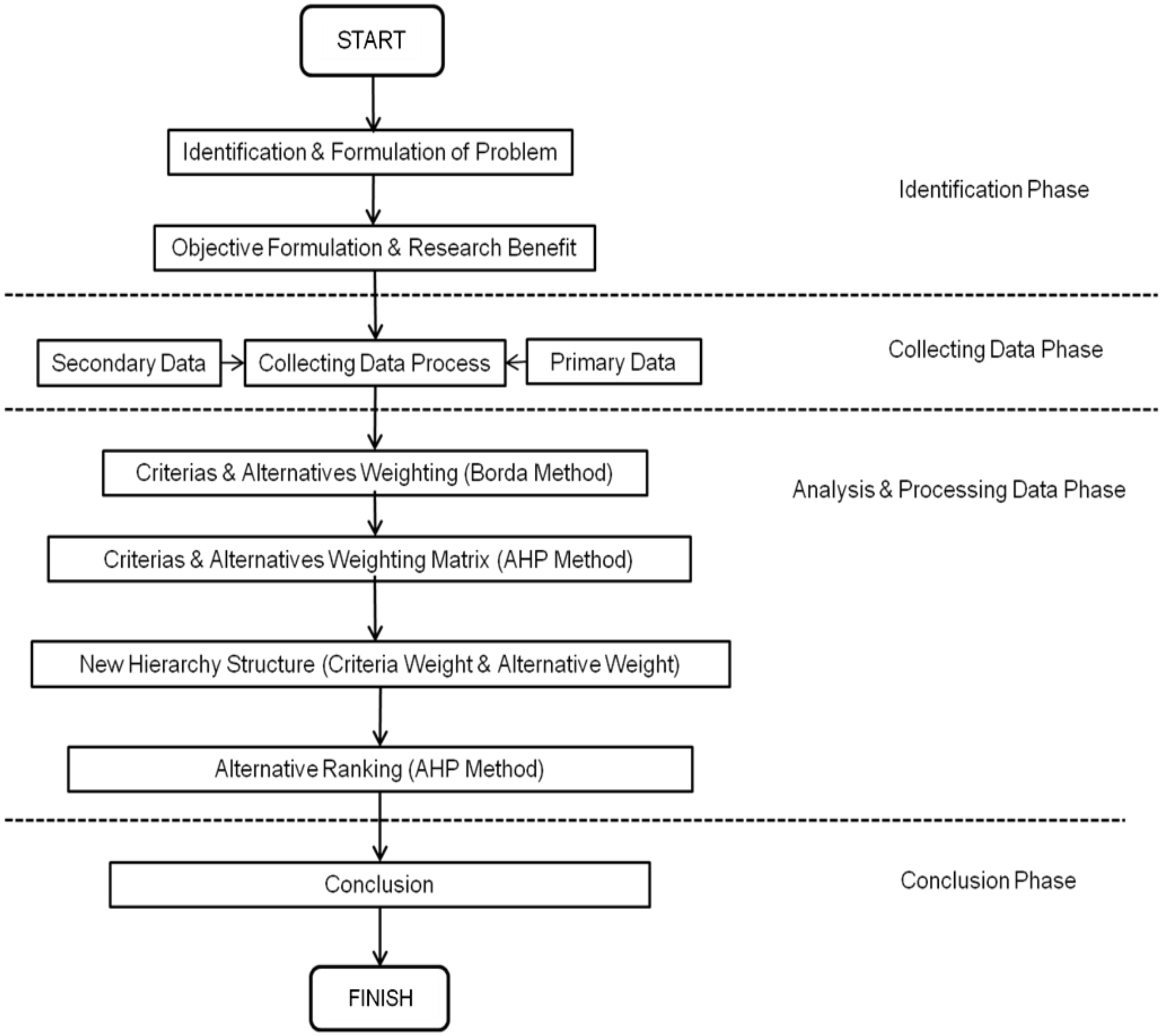

Fig. 1. Flow Chart of Research.

3.2. Research Object.

This research focuses on the process of choosing the ideal landing beach location analysis so that the variables that become the main criterion in landing beach location should be analyzed according to the prepared method. The location of the research was conducted at TPI Jetty of Sap Papua West Papua (Figure 2) located at 01 ° 07 '34.71 "S - 131 ° 13' 29.98" E (Headquarter, 2012).

Sorong district of West Papua has an area of 13,603.46 km² which consists of land area of 845,71 km² and an area of ocean 514.65 km² (Headquarter, 2012). .

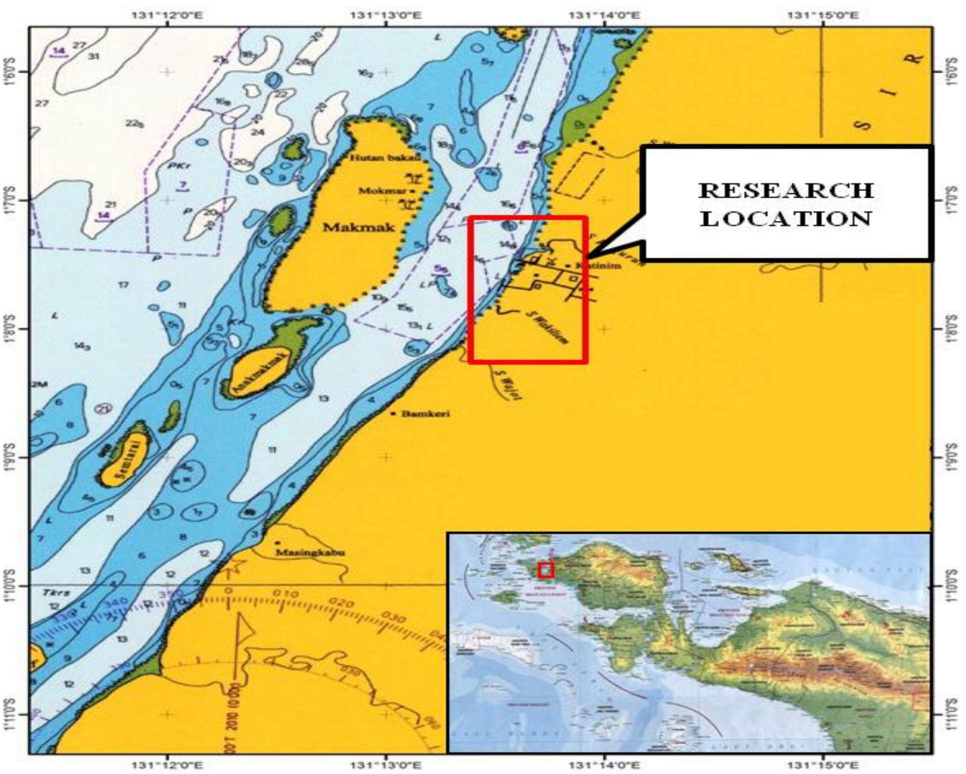

Fig.2. Research Location Map.

3.3. Research Stages.

In this research, there are several stages of data processing analysis using a combination of two different methods where Borda method as the initial determination of the criteria weighting value and the alternative of landing beach selection followed then next stage is the analysis of AHP method which is used as the main framework of decision maker system builder as well as determining the value of alternative weighted value through the process of pairwise comparison analysis up to the final stages of the research (Michela, 2015).

3.3.1. Determination of landing beach criteria weight value.

The criteria of landing beach selection in this research can be seen in table 1 as follows (Collins, 1998):

Table 1. Criteria for selection of landing beach (Collins, 1998).

NO	CRITERIA	INFLUENCE IN AMPHIBIOUS OPERATIONS	IDEAL PARAMETER
1	**2**	**3**	**4**
1	**Type of Shorelines.** a. Straight shoreline. b.Convex shoreline. c.Concave shoreline.	a. Influence on currents and waves. b. Effect on the direction of the shot the opposing coastal defense.	Straight shoreline
2	**Composition of the seafloor.** a. Sand. b. Sand pabbles. c. Muddy sand. d. Rocky gravel.	Influence on surface manuver	Sand.
3	**Coastal gradient.** a. Steep (gradient 1:15) b.Moderate (1:15 >gradient≥ 1:30) c.Gentle (1:30 > gradient≥ 1:60) d.Mild (1:60>gradient≥1:120) e. Flat (gradient > 1:120)	a. Influence on determination of ship type & landing lifeboat. b. Influence on type of break wave in shallow water area	a. Moderate gradient. 1:15 > gradient ≥ 1:30 b. Gentle gradient 1:30 > gradient ≥ 1:60
4	**Physical hydro-oceanography** a. Wave b. Tidal c. Current	a. Effect on landing lifeboat and amphibious vehicle. b.To determinate type of lifeboat & amphibious vehicle to be used.	a. spilling wave type. b.Semidiurnal and Mixed Semidiurnal tidal type c. Current parallel shoreline velocity < 1 knots.
5	**Back area of beach**	a. Influence on manuver of troops & amphibious vehicles. b. Defence area for protection after landing.	a. Flat with an elevated beach backdrop. b. There is a ramp to the rear of the beach.
6	**Point of reference for landing beach.**	a. To help identification process about landing beach. b. As a navigation mark when on sea surface.	Can be a known terrain sign for its position
7	**Coastal obstacles.** a. Natural obstacles	a. Influence in motion power of combat materials and troops	Selected beaches which minimum natural obstacle.
1	**2**	**3**	**4**

	b. Artificial obstacles	b. Can make amphibious vehicle and lifeboat become broken.	
8	**Beach access**	Make easy to manuver for troops & vehicle on landing beach.	Selected beach which have enough total access.

.

Determination of the criteria weighting value was analyzed by using Borda method after obtaining the table of values of criteria ranking value from expert choice as in table 2. below

:

Table 2. Obtaining the rating criteria (Costa, 2017).

NO	CRITERIA	RANK		
		1	2	3
1	CRITERIA 1			
2	CRITERIA 2			
3	CRITERIA 3			

The determination of the ratio value for all rankings is weighted across all criteria (R_1) (Ishida, 2017):

$$R_1 = \sum_{j=1}^{n} R_{ij} \qquad (1)$$

Determination of the weight value of each criteria (W_1) (Ishida, 2017):

$$W_1 = \frac{R_1}{\sum_{i=1}^{m} R_1} \qquad (2)$$

Where:

R_1: The sum of all rankings is weighted for all criteria 1.

R_{ij}: The rankings are evaluated by *j* for the criteria 1.

W_1: Weight criteria 1 for the evaluator *n*.

The steps for calculation with Borda method are as follows (Mohajan, 2012):

a. Each decision maker assigns n-1 to first choice criteria or alternative, n-2 for second choice, n-3 for third option and so on up to 0 for last choice criteria or alternative (Ishida, 2017).
b. The optional alternative with the highest amount is the winner (Ishida, 2017).

3.3.2. Determination of alternative weighted value of landing beach option.

Determination of the weight value of landing beach alternative is also analyzed by Borda method as in table 3 as follows (Ishida, 2017) :

Table 3. Obtaining the rating criteria (Mohajan, 2012).

NO	CRITERIA	RANK		
		1	2	3
1	ALTERNATIVE 1			
2	ALTERNATIVE 2			
3	ALTERNATIVE 3			

As for the determination of the weight value of each alternative in the same process as the formula (1) and (2).

3.3.3. Weighting matrix of criteria with AHP Method.

In order to make a decision in the AHP method it is necessary to process the problem with the following stages (Saad, et al., 2016):

a. Create a hierarchy structure.

The multicriteria problem in AHP is arranged in the form of hierarchy consisting of three main components namely the main objectives, assessment criteria and alternative choice (Koc & Burhan, 2015). The structure of the hierarchy can be illustrated as shown in Figure 3 following (Taha, 2007) :

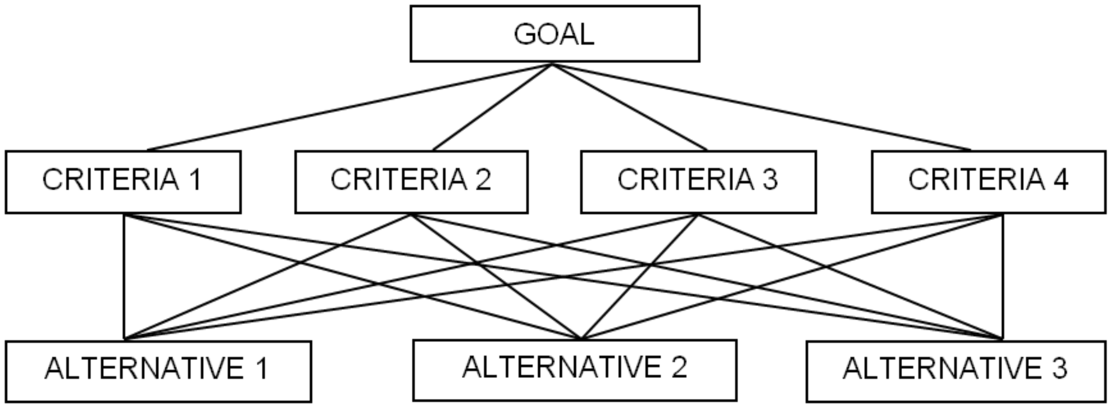

Fig. 3. Hierarchy structure (Taha, 2007).

b. Create a pairwise comparison matrix.

1) Pairwise comparison based on Saaty Scale.

At this stage begin pairwise comparison in order to determine the weighting value of assessment criteria based on the Saaty Scale as in table 4 below (Saaty, 2008) :

Table 4. Assessment of criteria weighting based on Saaty scale (Koc & Burhan, 2015).

Value	Definition	Explanation
1	The same important	
3	Slightly more important	
5	More important	
7	Very important	
9	Absolute is very important	
2,4,6,8	Average	When in doubt between two adjacent values
1/3,1/5,1/7,1/9	The opposite of the value 1,3,5,7,9 (Reciprocal)	If the value of A to B is 4 then the value of B to A is ¼

2) Calculates the criteria weight (priority vector).

Calculation of the value of criteria weight by normalizing the matrix value of pairwise comparison by dividing all matrix values by the sum of each matrix column(Triantaphyllou & Mann, 1995). After that is done the calculation of the average value of the sum in each line matrix according to the following formula (Saaty, 2008) (Triantaphyllou & Mann, 1995):

$$A = (a_{ij}) = \begin{bmatrix} 1 & W_1/W_2 & \cdots & W_1/W_n \\ W_2/W_1 & 1 & \cdots & W_2/W_n \\ \vdots & \vdots & \cdots & \vdots \\ W_n/W_1 & W_n/W_2 & \cdots & 1 \end{bmatrix} \quad (3)$$

The matrix value generated from the process is the value of the priority vector (Triantaphyllou & Mann, 1995).

3) Testing Consistency Ratio (CR).

At this stage tested the level of consistency ratio of matrix comparison in pairs of criteria assessment that has been determined the value of weight criteria (priority vector) (Triantaphyllou & Mann, 1995). If *CR*>0,1 then the pairwise comparison process should be repeated again until it gets results *CR*≤0,1. CR value is derived from the division between Consistency Index (*CI*) with Index Ratio (*IR*) with the following calculation phases (Koc & Burhan, 2015):

a) Determine λ_{maks} by formula (Saaty, 2008):

$$[Ax = \lambda_{maks} x] \quad (4)$$

Where x is *eigen vector* value obtained from the calculation *priority vector.* After process (4) has obtained λ_{maks} matrix and than determine average value of λ_{maks}.

b) Determine Consistency Index (*CI*) by formula (Saaty, 2008):

$$CI = \frac{(\lambda_{maks} - n)}{(n-1)} \quad (5)$$

Where:

CI : Consistency Index.

λ_{maks} : Average value $\frac{Ax}{x}$.

n :Total weight.

c. Determine *CR* value by formula (Saaty, 2008):

$$CR = \frac{CI}{IR} \quad (6)$$

Where Index Ratio value determined in accordance with Table 5 as follows:

Table 5. *Index Ratio (IR)* (Saaty, 2008).

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
IR	0,00	0,00	0,58	0,90	1,12	1,2	1,3	1,4	1,5	1,49	1,51	1,48	1,56	1,57	1,59

At this stage it should be ensured that CR values must be consistent (*CR*≤0,1) (Triantaphyllou & Mann, 1995).

4) Develop a new hierarchy complete with criteria weight.

The preparation of a new hierarchy is needed to reinforce the key assessment criteria that will be used in the next weighting process ie the choice of alternative weighting against each assessment criterion(Gorener, et al., 2012). The preparation of the new hierarchy can be seen as shown in Figure 4 following (Triantaphyllou & Mann, 1995) :

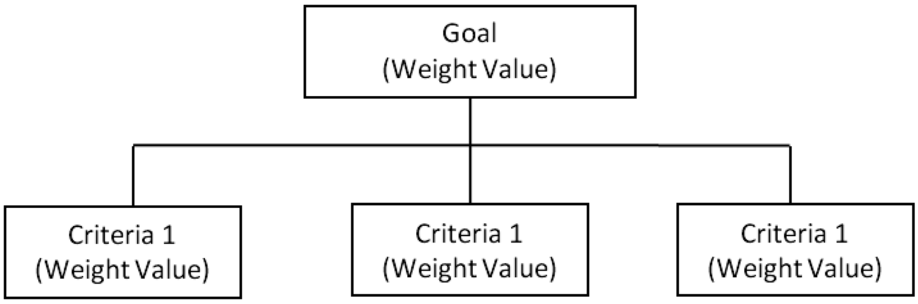

Fig. 4. Hierarchy structure with weight value (Triantaphyllou & Mann, 1995).

5) Calculation of the value of alternative weight for each criteria.

The calculation of the value of alternative weight for each criterion is needed in order to construct a pairwise comparison matrix between the alternative elements of choice in the operation of the assessment criteria matrix(Yogi, et al., 2017). This process carried out a number of assessment criteria such as table 6 as follows (Saaty, 2012) :

Table 6. Matrix Table of Assessment Criteria (Saaty, 2012).

Criteria	Alternative 1	Alternative 2	Alternative 3	...	Alternative n
Alternative 1	1	...	...	...	...
Alternative 2	...	1	...	...	...
Alternative 3	...	...	1	...	...
...	...	...	...	1	...
Alternative n	...	...	...	...	1

6) Develop a new hierarchy complete with the value of the weighting criteria and the value of alternative weight.

The preparation of a new hierarchy structure with the value of the criteria weight and the value of alternative weight is required in order to display the weight values of the matched comparison matrix results of all alternative alternatives in each assessment criterion that will produce alternative weighting for each criteria (priority vector). The preparation of the new hierarchy can be seen in Figure 5 as follows (Saaty, 2012) :

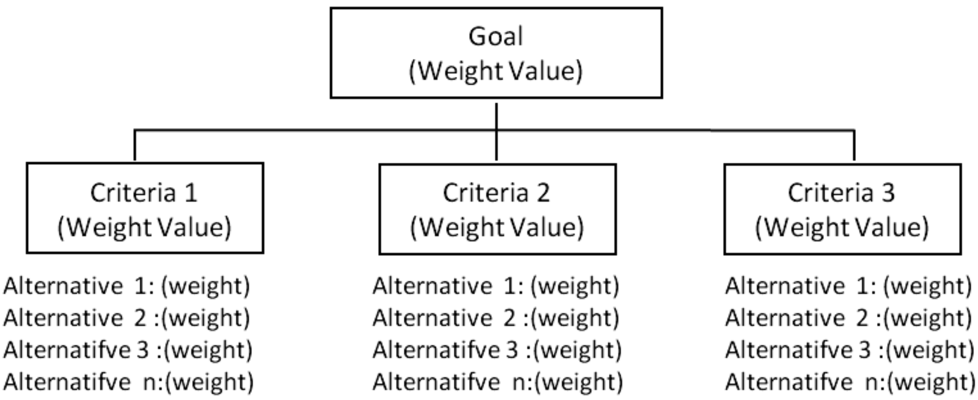

Fig. 5. Structure hierarchy with weight value (Saaty, 2012).

c. Determine the preferred alternative ranking.

The determination of the optional alternative rank corresponds to the following matrix calculations (Saaty, 2012) (Triantaphyllou & Mann, 1995):

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} k \\ l \\ m \end{bmatrix} = \begin{bmatrix} x \\ y \\ z \end{bmatrix} \quad (7)$$

In determining the rankings in the alternative option is done multiplication process between matrix of alternative weight value (Triantaphyllou & Mann, 1995) as the priority matrix element with the matrix of the corresponding criteria weighting value as the criteria weights element so that the final priority value of the alternative matrix is ready to be sorted according to the rank (Koc & Burhan, 2015).

4. RESULT AND DISCUSS

4.1. Determination of the weight value of landing beach criteria.

From the results of data collection filling questionnaire of choice of experts filled by 10 experts according to their respective fields and obtained data table 7 as follows :

Table 7. The result of filling the questionnaire of coastal criteria criterion

NO	CRITERIA	RANK							
		I	II	III	IV	V	VI	VII	VIII
1	TYPE OF SHORELINE	1	3	1	4		1		
2	HYDRO-OCEANOGRAPHY	3	3	3	1				
3	COASTAL GRADIENT			1	3	3		1	2
4	COMPOSITION OF SEAFLOOR	1	1	2	1	4	1		
5	POINT OF REFERENCE	4	2	2		1		1	
6	BACK AREA OF BEACH	1	1			1	4		3
7	COASTAL OBSTACLES			1	1		3	4	1
8	BEACH ACCESS					1	1	4	4

a. Determination ratio value for all of ranking in all criteria (R_1):

$$R_1 = \sum_{j=1}^{n} R_{ij}$$

R_1=$[(1x7) + (3x6) + (1x5) + (4x4) + 0 + (1x2) + 0 + 0]$+ $[(3x7) + (3x6) + (3x5) + (1x4) + 0 + 0 + 0 + 0]$+$[0 + 0 + (1x5) + (3x4) + (3x3) + 0 + (1x1) + 0]$+$[(1x7) + (1x6) + (2x5) + (1x4) + (4x3) + (1x2) + 0 + 0]$+$[(4x7) + (2x6) + (2x5) + 0 + (1x3) + 0 + (1x1) + 0]$+$[(1x7) + (1x6) + 0 + 0 + (1x3) + (4x2) + 0 + 0]$+$[(0 + 0 + (1x5) + (1x4) + 0 + (3x2) + (4x1) + 0]$+$[(0 + 0 + 0 + 0 + (1x3) + (1x2) + (4x1) + 0]$

R_1= 48+58+27+41+54+24+19+9

R_1= 280

b. Determination criteria weight value (W_1):

$$W_1 = \frac{R_1}{\sum_{i=1}^{m} R_1}$$

W_1=$[(1x7) + (3x6) + (1x5) + (4x4) + 0 + (1x2) + 0 + 0]$/280

W_1= 48/280 = 0,171

W_2= $[(3x7) + (3x6) + (3x5) + (1x4) + 0 + 0+0+0]$/280

W_2= 58/280 = 0,207

W_3=$[0 + 0 + (1x5) + (3x4) + (3x3) + 0 + 1x1+0]$/280

W_3= 27/280 = 0,096

W_4=$[(1x7) + (1x6) + (2x5) + (1x4) + 4x3+1x2+0+0]$/280

W_4= 41/280 = 0,146

W_5=$[(4x7) + (2x6) + (2x5) + 0 + (1x3) + 0+(1x1)+0]$/280

W_5=54/280 = 0,193

W_6=$[(1x7) + (1x6) + 0 + 0 + (1x3) + (4x2) + 0 + 0]$/280

W_6=24/280 = 0,086

W_7=$[(0 + 0 + (1x5) + (1x4) + 0 + (3x2) + 4x1+0]$/280

W_7=19/280 = 0,068

W_8=$[(0 + 0 + 0 + 0 + (1x3) + (1x2) + 4x1+0]$/280

W_8=9/280 = 0,032

c. The ranking sequence of landing beach selection criteria in Table 8 below:

d.

Table 8. The sequence of landing beach selection criteria

NO	CRITERIA	RANK								WEIGHT VALUE	LEVEL
		I	II	III	IV	V	VI	VII	VIII		
1	TYPE OF SHORELINE	1	3	1	4		1			0,171	**3**
2	HYDRO-OCEANOGRAPHY	3	3	3	1					0,207	**1**
3	COASTAL GRADIENT			1	3	3		1	2	0,096	**5**
4	COMPOSITION OF SEAFLOOR	1	1	2	1	4	1			0,146	**4**
5	POINT OF REFERENCE	4	2	2		1		1		0,193	**2**
6	BACK AREA OF BEACH	1	1			1	4		3	0,086	**6**
7	COASTAL OBSTACLES			1	1		3	4	1	0,068	**7**
8	BEACH ACCESS					1	1	4	4	0,032	**8**

4.2. Determination of alternative weighted value of landing beach option.

The data was filled by 10 experts who filled in the alternative questionnaire table landing beach selection and obtained the results as in table 9 as follows :

Table 9. Results of filling questionnaires for alternative beaches

NO	CRITERIA	RANK		
		I	II	III
1	BEACH 1	4	3	3
2	BEACH 2	3	6	1
3	BEACH 3	3	1	6

a. Determination of the ratio value for all weighted rankings (R_1):

$$R_1 = \sum_{j=1}^{n} R_{ij}$$

R_1=$[(4x2) + (3x1) + 0]$+$[(3x2) + (6x1) + 0]$+$[(3x2) + (1x1) + 0]$

R_1= 11+12+7

R_1= 30

b. Determination of the weight value from each criterion (W_1):

$$W_1 = \frac{R_1}{\sum_{i=1}^{m} R_1}$$

W_1=$[(4x2) + (3x1) + 0]$/30

W_1= 11/30 = 0,367

W_2= $[(3x2)+(6x1)+0]$/30

W_2= 12/30 = 0,4

W_3= $[(3x2)+(1x1)+0]$/30

W_3= 7/30 = 0,233

c. The ranking sequence of landing beaches alternative in Table 10. follows:

Table 10. Alternative ranking sequence of landing beach selection

NO	CRITERIA	RANK			WEIGHT VALUE	LEVEL
		I	II	III		
1	BEACH 1	4	3	3	0,367	**2**
2	BEACH 2	3	6	1	0,4	**1**
3	BEACH 3	3	1	6	0,233	**3**

4.3. Matrix weighting criteria with AHP Method.

a. Create a hierarchy structure.

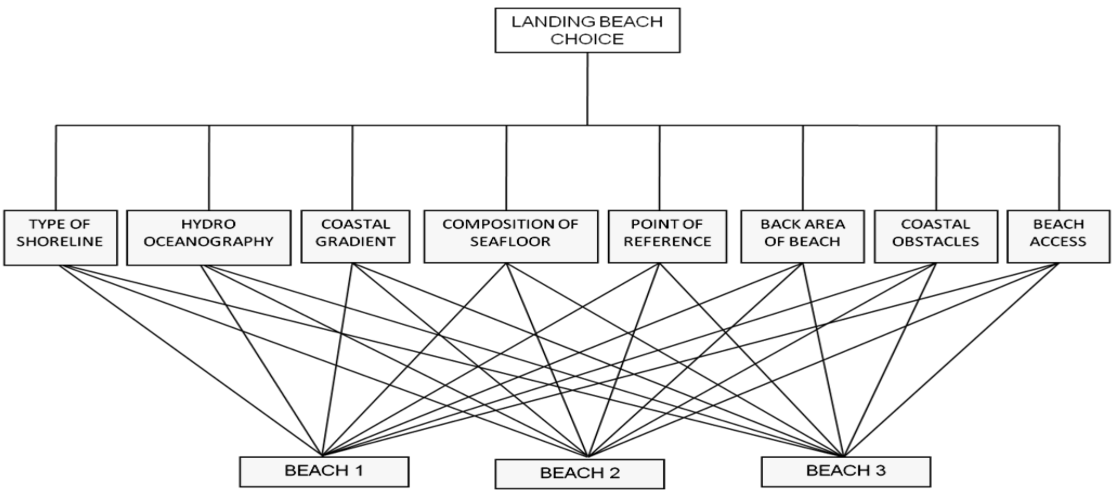

Fig. 6. Hierarcy structure

b. Determine pairwise comparison matrix.

The ranking sequence of weighted criteria by Borda method in the previous stage makes the basis of determining preference at this stage so it is helpful decision maker to determine the numbers in pairwise comparison matrix with Saaty scale like table 11. below :

Table 11. Criteria pairwise comparison matrix

NO	CRITERIA	TYPE OF SHORELINE	HYDRO-OCEANOGRAPHY	COASTAL GRADIENT	COMP. SEAFLOOR	POINT REFERENCE	BACK AREA OF BEACH	COASTAL OBSTACLES	BEACH ACCESS
1	TYPE OF SHORELINE	1	0,333333	2	0,5	0,333333	3	4	5
2	HYDRO-OCEANOGRAPHY	3	1	4	3	2	5	7	9
3	COASTAL GRADIENT	0,5	0,25	1	0,5	0,333333	2	3	5
4	COMPOSITION OF SEAFLOOR	2	0,333333	2	1	0,333333	3	4	5
5	POINT OF REFERENCE	3	0,5	3	3	1	4	5	7
6	BACK AREA OF BEACH	0,3333333	0,2	0,5	0,333333	0,25	1	2	3
7	COASTAL OBSTACLES	0,25	0,142857	0,3333333	0,25	0,2	0,5	1	2
8	BEACH ACCESS	0,2	0,111111	0,2	0,2	0,142857	0,333333	0,5	1
JUMLAH		10,283333	2,870634921	13,033333	8,783333	4,5928571	18,83333333	26,5	37

c. Determine priority vector.

Priority vector is generated from 2 stages of calculation, the first step is to normalize the value of each pairwise comparison matrix column and then the second stage is to calculate the average of the sum of each matrix row. The normalization result matrix and priority vector can be seen in table 12:

Tabel 12. Priority vector

MATRIX A								X	AX	λmax (AX/X)
1	0,333	2	0,5	0,333	3	4	5	0,1177	0,972	8,254
3	1	4	3	2	5	7	9	0,3121	2,631	8,430
0,5	0,25	1	0,5	0,333	2	3	5	0,0871	0,708	8,129
2	0,333	2	1	0,333	3	4	5	0,1370	1,158	8,451
3	0,5	3	3	1	4	5	7	0,2307	1,982	8,590
0,333	0,2	0,5	0,333	0,25	1	2	3	0,0553	0,448	8,100
0,25	0,143	0,333	0,25	0,2	0,5	1	2	0,0362	0,295	8,151
0,2	0,111	0,2	0,2	0,143	0,333	0,5	1	0,0239	0,196	8,219
									TOTAL =	66,325
									AVERAGE =	**8,291**

d. Test Consistency Ratio (CR).

If $CR > 0{,}1$ then the pairwise comparison process should be repeated again until it is obtained $CR \leq 0{,}1$. Determine λ_{maks} by formula: $[Ax = \lambda_{maks} x]$,where *x* is the eigenvector.

Table 13. Table of λ_{maks} matrix

NO	CRITERIA	TYPE OF SHORELINE	HYDRO-OCEANOGRAPHY	COASTAL GRADIENT	COMP. SEAFLOOR	POINT REFERENCE	BACK AREA OF BEACH	COASTAL OBSTACLES	BEACH ACCESS	PRIORITY VECTOR
1	TYPE OF SHORELINE	0,0972447	0,11611833	0,1534527	0,056926	0,0725765	0,159292035	0,1509434	0,135135	0,1177
2	HYDRO-OCEANOGRAPHY	0,2917342	0,34835499	0,3069054	0,341556	0,4354588	0,265486726	0,26415094	0,243243	0,3121
3	COASTAL GRADIENT	0,0486224	0,087088748	0,0767263	0,056926	0,0725765	0,10619469	0,11320755	0,135135	0,0871
4	COMPOSITION OF SEAFLOOR	0,1944895	0,11611833	0,1534527	0,113852	0,0725765	0,159292035	0,1509434	0,135135	0,1370
5	POINT OF REFERENCE	0,2917342	0,174177495	0,230179	0,341556	0,2177294	0,212389381	0,18867925	0,189189	0,2307
6	BACK AREA OF BEACH	0,0324149	0,069670998	0,0383632	0,037951	0,0544323	0,053097345	0,0754717	0,081081	0,0553
7	COASTAL OBSTACLES	0,0243112	0,049764999	0,0255754	0,028463	0,0435459	0,026548673	0,03773585	0,054054	0,0362
8	BEACH ACCESS	0,0194489	0,03870611	0,0153453	0,02277	0,0311042	0,017699115	0,01886792	0,027027	0,0239
TOTAL		1	1	1	1	1	1	1	1	

Consistency Index (CI) obtained by formula:

$CI = (\lambda_{maks} - n)/(n-1)$

CI = (8,291-1)/(8-1) = 0,291/7 = 0,0416.

Consistency Ratio (CR) testing:

Table 14. Table of *Index Ratio (IR)*

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
IR	0,00	0,00	0,58	0,90	1,12	1,2	1,3	1,4	1,5	1,49	1,51	1,48	1,56	1,57	1,59

$CR = CI/IR$ (n=8)

$CR =$ 0,0416/1,41 = 0,0295 ($CR \leq 0{,}1$ so consistent).

e. Develop a new hierarchy structure based on the criteria weighting value.

Tabel 15. Criteria weight matrix

NO	CRITERIA	WEIGHT
1	TYPE OF SHORELINE	0,1177
2	HYDRO-OCEANOGRAPHY	0,3121
3	COASTAL GRADIENT	0,0871
4	COMPOSITION OF SEAFLOOR	0,1370
5	POINT OF REFERENCE	0,2307
6	BACK AREA OF BEACH	0,0553
7	COASTAL OBSTACLES	0,0362
8	BEACH ACCESS	0,0239

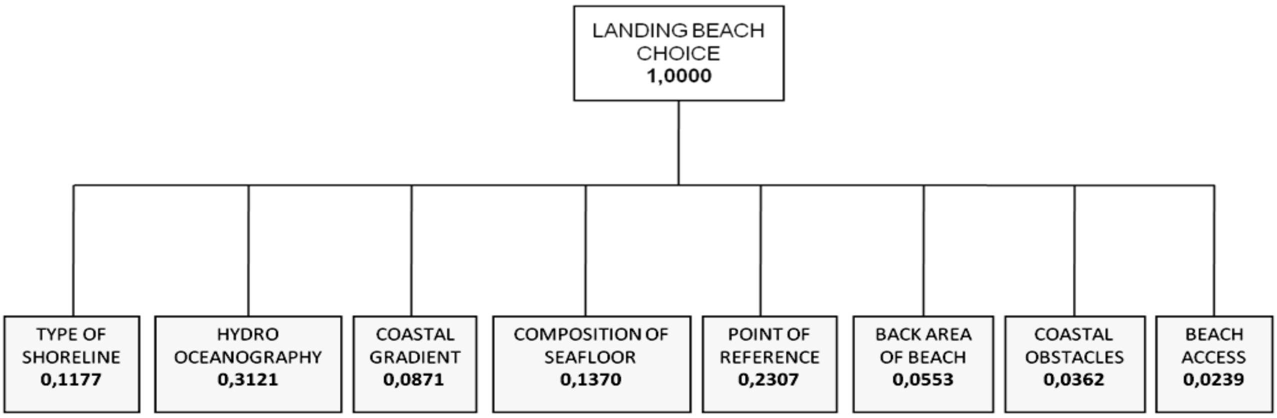

Fig. 7. New Hierarcy structure with criteria weight

f. The result of calculating alternative weight values for each criteria.

1. TYPE OF SHORELINE

TYPE OF SHORELINE	BEACH 1	BEACH 2	BEACH 3	NORMALIZIED MATRIX			PRIORITY VECTOR
BEACH 1	1	0,25	4	0,190	0,167	0,444	0,267
BEACH 2	4	1	4	0,762	0,667	0,444	0,624
BEACH 3	0,25	0,25	1	0,048	0,167	0,111	0,108
TOTAL	5,25	1,5	9	1	1	1	

2. HYDRO-OCEANOGRAPHY

HYDRO-OCEANO	BEACH 1	BEACH 2	BEACH 3	NORMALIZIED MATRIX			PRIORITY VECTOR
BEACH 1	1	0,2	5	0,161	0,149	0,385	0,232
BEACH 2	5	1	7	0,806	0,745	0,538	0,697
BEACH 3	0,2	0,142857	1	0,032	0,106	0,077	0,072
TOTAL	6,2	1,342857	13	1	1	1	

G.

3. COASTAL GRADIENT

COASTAL GRADIENT	BEACH 1	BEACH 2	BEACH 3	NORMALIZIED MATRIX			PRIORITY VECTOR
BEACH 1	1	0,33333	3	0,231	0,200	0,429	0,286
BEACH 2	3	1	3	0,692	0,600	0,429	0,574
BEACH 3	0,3333	0,33333	1	0,077	0,200	0,143	0,140
TOTAL	4,3333	1,66667	7	1	1	1	

4. COMPOSITION OF SEAFLOOR

COMP. OF SEAFLOOR	BEACH 1	BEACH 2	BEACH 3	NORMALIZIED MATRIX			PRIORITY VECTOR
BEACH 1	1	0,333333	3	0,231	0,211	0,375	0,198
BEACH 2	3	1	4	0,692	0,632	0,500	0,608
BEACH 3	0,333333	0,25	1	0,077	0,158	0,125	0,120
TOTAL	4,333333	1,583333	8	1	1	1	

5. POINT OF REFERENCE

POINT OF REFERENCE	BEACH 1	BEACH 2	BEACH 3	NORMALIZIED MATRIX			PRIORITY VECTOR
BEACH 1	1	0,25	5	0,192	0,179	0,385	0,252
BEACH 2	4	1	7	0,769	0,718	0,538	0,675
BEACH 3	0,2	0,14286	1	0,038	0,103	0,077	0,073
TOTAL	5,2	1,39286	13	1	1	1	

6.BACK AREA OF BEACH

BACK AREA OF BEACH	BEACH 1	BEACH 2	BEACH 3	NORMALIZIED MATRIX			PRIORITY VECTOR
BEACH 1	1	0,5	2	0,286	0,273	0,333	0,297
BEACH 2	2	1	3	0,571	0,545	0,500	0,539
BEACH 3	0,5	0,333333	1	0,143	0,182	0,167	0,164
TOTAL	3,5	1,833333	6	1	1	1	

7. COASTAL OBSTACLES

COASTAL OBSTACLE	BEACH 1	BEACH 2	BEACH 3	NORMALIZIED MATRIX			PRIORITY VECTOR
BEACH 1	1	0,5	3	0,300	0,250	0,500	0,350
BEACH 2	2	1	2	0,600	0,500	0,333	0,478
BEACH 3	0,3333	0,5	1	0,100	0,250	0,167	0,172
TOTAL	3,3333	2	6	1	1	1	

8. BEACH ACCESS

BEACH ACCESS	BEACH 1	BEACH 2	BEACH 3	NORMALIZIED MATRIX			PRIORITY VECTOR
BEACH 1	1	0,5	2	0,286	0,250	0,400	0,312
BEACH 2	2	1	2	0,571	0,500	0,400	0,490
BEACH 3	0,5	0,5	1	0,143	0,250	0,200	0,198
TOTAL	3,5	2	5	1	1	1	

The new hierarchy arrangement is complemented by the criteria and alternative weights.

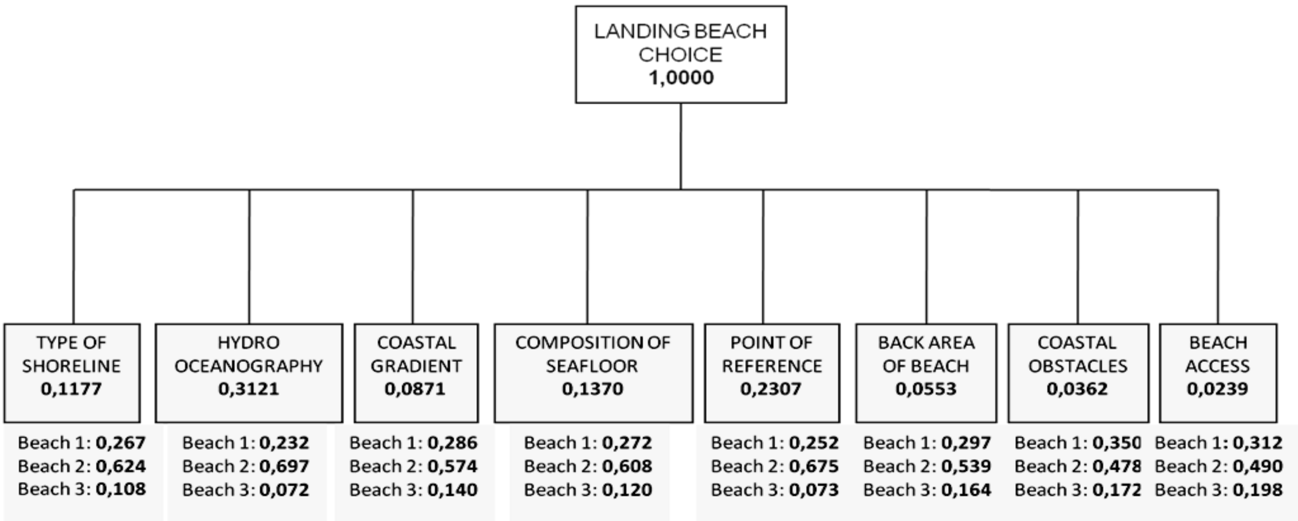

Fig. 8. New hierarcy structure with criteria and alternative weights.

g. Determine the preferred alternative ranking (Final Priority).

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} k \\ l \\ m \end{bmatrix} = \begin{bmatrix} x \\ y \\ z \end{bmatrix}$$

The calculation of priority matrix with the criteria weight can be seen in the following matrix multiplication:

$$\begin{bmatrix} 0,267 & 0,232 & 0,286 & 0,272 & 0,252 & 0,297 & 0,350 & 0,312 \\ 0,624 & 0,697 & 0,574 & 0,608 & 0,675 & 0,539 & 0,478 & 0,490 \\ 0,108 & 0,072 & 0,140 & 0,120 & 0,073 & 0,164 & 0,172 & 0,198 \end{bmatrix} \begin{bmatrix} 0,1177 \\ 0,3121 \\ 0,0871 \\ 0,1370 \\ 0,2307 \\ 0,0553 \\ 0,0362 \\ 0,0239 \end{bmatrix}$$

[0,259]
Priority Matrix

Then we get the result of alternative choice of landing beach based on the value of weight on matrix final priority:

Tabel 16. Final result from rank of beach

PRIORITY MATRIX	FINAL PRIORITY	RANGKING
BEACH 1	0,259	**2**
BEACH 2	0,639	**1**
BEACH 3	0,101	**3**

The ranking results show that Beach 2 is the first rank, Beach 1 is the second rank and the last is Beach 3.

5. CONCLUSION

Based on the results of research conducted through data analysis conducted obtained the following results:

a. The result of the analysis with Borda method on the determination of the criteria rank and the landing beach alternative choice is known that the physical properties of Hydro-Oceanography become the first sequence with the value of weight of 0.207 followed by the criterion of reference point with the weight value of 0.193 in the second sequence and the type of beach criterion with the weight of 0.171 on the third sequence. As for the other criteria in order of rank that has been presented complete with the value of each weight. The results of this analysis can be used as a basis of preference for the decision maker in determining the preference of the next stage.

b. From the results of analysis with AHP method Final Priority each 2 with a value of weight of 0.639 was chosen to be the most appropriate beach location for amphibious landing operations. While for Criteria Weight r is Beach 1 with a weight value of 0.259 and the third is Beach 3 with a weight of 0.101.

c. The integration between the Borda and AHP methods is well worth using in solving the landing beach location problem in amphibious operations where in the early stages of processing and data analysis the Borda method is able to provide preference support for decision makers to analyze data at a later stage (AHP) according to the stage of the process so that the results of the resulting alternative rankings are logical and objective.

d. In determining ideal landing beaches to carry out amphibian operations, there is a need for an analysis of the components to be used as the main criterion for selecting and alternating landing beach options that are multi-criteria.

REFERENCES

Brink, K. H., 2000. *Oceanography and Mine Warefare, Ocean Studies Board Commision on Geoscience, Environment and Resource.* Washington, DC(USA): National Research Council.

Collins, J. M., 1998. *Military Goegraphy for Professional and Public.* Washington, DC(USA): National Defence University Press.

Costa, H. G., 2017. AHP-De Borda: Hybrid Multicriteria Ranking Method. *Brazilian Journal of*

Operation and Production Management 14, pp. 281-287.

Gorener, A., Toker, K. & Ulucay, K., 2012. Application of Combined SWOT and AHP: A Case Study for a Manufacturing Firm. pp. 1525-1534.

Headquarter, E. F. C. o. T. I. N., 2017. *Fleet Command III Development in West Papua to Make Preventive Power for Keep Security Stabilitation on The Eastern of Indonesian Ocean.* s.l.:Headquarter, Eastern Fleet Command of The Indonesian Navy;.

Headquarter, I. A. F., 2013. *The Indonesian Armed Forces Doctrine about Amphibious Operations.* Jakarta: Indonesian Armed Forces Headquarter.

Headquarter, I. N., 2012. *Survey Operation and Mapping on Sorong of The West Papua Sea Water (Survey Report).* Jakarta: s.n.

Ishida, R., 2017. Borda Count Method for Fiscal Policy. *Policy Research Institute Discussioan Paper Series,* pp. 17A-07.

Koc, E. & Burhan, H. A., 2015. An Applications of Analitic Hierarcy Process (AHP) in a Real World Problem of Store Location Selection. Volume 5, pp. 41-50.

Michela, L. P., 2015. Analysis of AHP Methods and Pairwise Majority Rule (PMR) for Collective Preference Rangkings of Sustainable Mobility Solutions. Volume 6(1), pp. 19-31.

Mohajan, H. K., 2012. Majority Judgement in an Election with Borda Majority Count. *International Journal of Management and Transformation,* pp. 6(1) 19-31.

Saad, S. M., Kunhu, N. & Mohamed, A. M., 2016. A Fuzzy-AHP Multicriteria Decision Making Model for Procurement Process. Volume 23.

Saaty, T., 1990. How To Make Decision The Analytic Hierarcy Process. *European Journal of Operational Research,* pp. 9-26.

Saaty, T., 2008. Decision Making with The Analytic Hierarcy Process. *International Journal Services Sciences,* Volume 1.

Saaty, T., 2012. *Model, Method, Concepts and Application of Analytic Hierarcy Process.* New York(USA): International Series in Operations Research and Management Science.

Staff, J. C. o., 2014. *Amphibious Operations.* USA: Join Publication 3-02 July,18,2014.

Taha, H. A., 2007. *Operations Research: An Introduction.* New Jersey(USA): Pearson Prentice Hall.

Triantaphyllou, E. & Mann, S. H., 1995. Using The Analytic Hierarcy Process for Decision Making in Engeenering Applications. Volume 2.

Velasquez, M. & Hester, P. T., 2013. An Analysis of Multi-Criteria Decision Making Methods. Volume 10 No.2, pp. 56-66.

Velazques, M. & Hestler, P. T., 2013. An Analysis of Multi-Criteria Decision Making Methods. Volume 10, pp. 56-66.

Yogi, P., Rizal, O., A. & Suharyo, O. S., 2017. Feasibility Analysis of Naval Base Relocation Using SWOT and AHP Method to Support Main Duty Operations.

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Postgraduate International Conference, Vol. 1, No. 1, pp.62-74
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SELECTION OF COMPATIBLE BATTERIES USING ANP FOR SUBMARINES

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Abstract

The Navy as a defense and security force has its combat equipment and its supporting facilities projected within the Integrated Fleet Weapon System (SSAT) with several components consists of KRI, marines, aircraft and bases. One of the KRI's strengths is the submarine where the current condition is over 30 years old resulting in the decrease of combat and cruising power. In order to improve the capabilities of submarine warfare, the Navy has made new procurement and extension of submarine life, the constraint in extending its life span is the discharged battery life of the submarine. This paper described the selection of submarine batteries in the extended life of the ship by using the Analytic Network Process method to determine the value of the priority weight of the alternative management system attributes based on the criteria. The results of the research was alternative submarine batteries. The chosen one was KSB SEBANG made in Korea with a priority weighting value of 0.474. Priority types of battery were Durability with weight of 0.201, 0.143 as operational weight, 0.129 as maintenance weight, 0.122 of spare part convenience weight, 0.115 as complexity weight, 0.110 as power weight, 0.076 as power weight, 0.071 as reliability weight and 0.033 as dimension weight.

Keywords: Battery, Submarine, Analytic Network Process.

6. INTRODUCTION.

The Navy as a defense and security force has its own combat tools and supporting facilities in the Integrated Fleet Weapon System (SSAT) consists of KRI, marines, aircraft and bases. The arrangement of the Navy's combat strength is aimed at achieving a minimum essential force (MEF), which means a capability designed force to face threats in order to guard and protect the sovereignty of the state, the Republic of Indonesia Unity and the safety of the entire nation with the assumption that possible risks is greater than the designed capabilities.

One of the KRI's strengths is the submarine. The current condition of the submarine is over 30 years old. So, the combat and cruising power is decreased. In order to improve the capabilities of submarine warfare, the Navy has made new procurement and extension of submarine life. The constraint in the extended life span is the submarine battery itself, where current batteries are depleted and outdated in the latest technology, reducing the submarine's movement.

A more compatible battery replacement was required to be able to perform the technological functions of submarine batteries that have been depleted. This paper aimed to provide an explanation of the submarine batteries selection as a new replacement in the ship using Analytic Network Process method to determine the value of the priority weight of alternative management system attributes based on the criteria prepared.

An ANP method is a mathematical theory that allows a decision maker to deal with dependent factors and systematic feedback. ANP is the latest method of multi-criteria decision making that is able to explain systematic interaction especially problems in supply chain strategy. ANP was developed to overcome the weaknesses of AHP that allows modeling problems in the form of Network. ANP is a method of solving an unstructured problem and the dependence of relationships between elements, permitting the interaction and feedback of elements in the cluster (inner dependence) and between clusters (outer dependence).

In decision-making, the ANP method has several advantages including its ability to assist decision makers in measuring and synthesizing a number of factors in the hierarchy or network, making it more general and more applicable to various qualitative studies (Nguyen et al 2014) .

Some of international journal were used in this study. The title of article journals used were described as follow, The Theoritical Structure of Fuzzy Analytic Network Process (FANP) with Interval Type-2 Fuzzy Sets (Senturk, et al., 2016). Designing a Decision Support System to Evaluate and Select Supplier Using Fuzzy Analytic Network Process (Razmi, et al., 2009). An Analytic network Process Model for Financial-Crisis Forecasting (Niemiraa & Saaty, 2004). A Hybrid Approach for Fuzzy Multi-Attribute Decision Making in Machine Tool Selection with Consideration of The Interaction of Attributes (Nguyen, et al., 2014). Analytic Network Process (ANP) Approach for Product Mix Planning in Railway Industry (Toroudia, et al., 2016). Applying Fuzzy Analytic network Process in quality Function Deployment Model (Afsharkazemi, et al., 2012). An analytic network process-based approach for location problems:the case of a new waste incinerator plant in the Province of Torino (Italy) (Bottero & Ferretti, 2011). Location selection for the construction of a casino in the greater London region (Ishizaka, et al., 2013). An ANP based TOPSIS approach for Taiwanese service apartment location selection (Chang, et al., 2015). Selection of non-traditional machining processes using analytic network process (Das & Chakraborty, 2011). Fundamentals of the analytic network process (Saaty, 1996). A fuzzy ANP approach to shipyard location selection (Guneri, et al., 2009). Fuzzy group decision-making for facility location selection (Kahraman, et al., 2003). Selection of the optimal tourism site using the ANP and fuzzy TOPSIS in the framework of Integrated Coastal Zone Management: A case of Qeshm Island (Morteza, et al., 2016). Supplier Selection: A Fuzzy-ANP Approach (Dargi, et al., 2014). Cutting tool material selection using grey complex proportional assessment method (Maity, et al., 2012). An integrated fuzzy synthetic evaluation approach for supplier selection based on analytic network process (Pang & Bai, 2013). Application of fuzzy analytic network process for supplier selection in a manufacturing organisation (Vinodh, et al., 2011).

Benefits of performing this studies was to provide a basic alternative decision-making to stakeholders in the selection of submarine batteries in the extended life of use.

This paper presented systematics flow as follows, part 1 was Introduction, part 2 was the material and methodology used, part 3 was results and discussion, section 4 was the conclusion.

2. METHODOLOGY

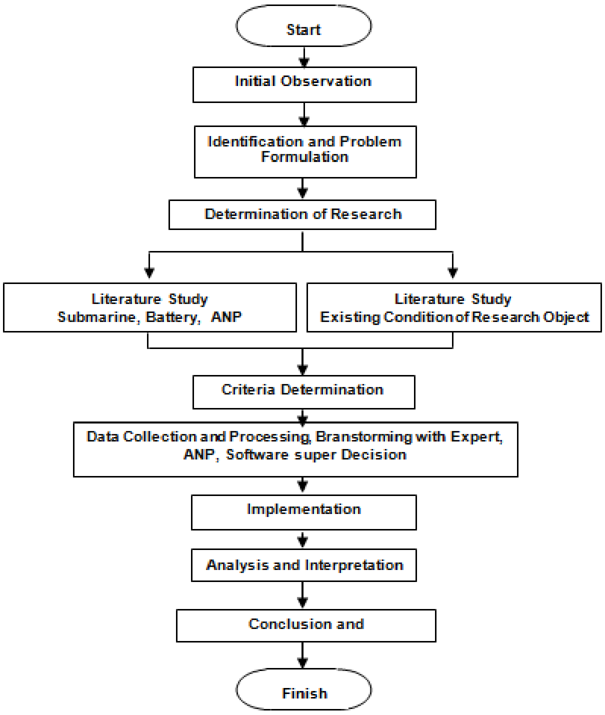

Fig. 1 Research Flow Chart

2.1. Initial Observation.

Initial observation was a preliminary activity of the research implementation to find ideas of research held by researchers, because of that the results of this research can be implemented and useful in solving problems faced by the students.

2.2. Identification and Problem Formulation.

After the preliminary observation, problem identification was subsequently performed. It would be used as research material in this study which was the selection of compatible Submarine batteries to support the essential tasks as Striking Forces Submarine in Navy Fleet.

2.3. Objective of The Study.

The next stage was to determine the purpose of this research which was to get a model to select the submarine batteries.

2.4. Literature Study.

In solving the problems, this study used of decision making theory basis using ANP (Analytic Network Process) to analyze the qualitative and quantitative criteria. Meanwhile, the supporting reference was a strategic policy of the Navy that had relevance about the election of compatible Submarine batteries.

2.5. Field Study.

Literature studies were performed to study the various theories that support the research. Some sources of literature study were reference books, Scientific Journals and similar research that discusses the concept of Multi Criteria Decision Making MCDM and Analytic Network Process (ANP). Field study conducted at KRI Nanggala 402 Submarine Command Unit Head of Eastern Fleet Command, PT. PAL Surabaya, School Submarine at Kobangdikal and STTAL. The objective was to find out the current state of the submarine battery and the conditions of alternative batteries that would serve as a substitute for references and Brainstroming with the experts.

2.6. Criteria Determination for Selecting Submarine Batteries.

Determination of criteria in the selection of available and compatible submarine batteries obtained by brainstorming with battery energy experts from PT. PAL Surabaya, and expert/user such as Commander and Head of Machine Department in KRI Cakra 401, Commander and Head of Machine Department in KRI Nanggala 402, Commander of Koarmatim Submarine Unit, Submarine School Commandant and STTAL Officer with submarine as their research concentration.

The minimal initial criteria that were compatible for the selection of submarine batteries were mentioned as follows:

a. Weight, or the weight of submarine battery.

b. Dimension, or the size of submarine battery.

c. Reliability of submarine battery.

d. Power resulted from submarine battery.

e. Spare Part Convenience.

f. Maintenancebility, or the convenience in maintaining Submarine battery

g. Operational of submarine battery.

h. Durability of the submarines.

i. Complexity against all vessel propulsion system.

Those criteria were initial criteria that would be developed after brainstorming with experts was performed.

2.7. Data Collection and Processing.

The next step was data collection and processing. The data were collected from the documents and interviews with Experts as mentioned above. These data include data on the influence factors of battery type and battery characteristics selection. The collection of data based on the collecting way were called primary data and secondary data. Primary data obtained from the data collection through filling questionnaires and interviews with correspondents who were decision makers and experts about Submarine. Secondary data was obtained from the results of the study or reference book related to criteria and alternatives.

Data processing data were performed by calculating relationship extent of a criterion using ANP Method. The results would be recorded in the program model, then will be processed using the software Superdecision.

2.8. Implementation.

Weighting results from each criterion were obtained from the data processing. It will be implemented to the real condition of submarine battery selection.

2.9. Interpretation and Analysis.

The analysis of data obtained from data processing was performed. This analysis was focused on the results of the weighting and ranking obtained in data processing.

2.10. Conclusion and Recommendation

In this final section, a thorough conclusion was drawn based on the results obtained to solve the problems that had been formulated upfront. The recommendation was an input to the Leader in the form of a suitable alternative and compatible battery for submarines to replace old batteries that had been expired.

3. RESULT AND DISCUSSION.

Steps of data collection needed in this research would be explained at this stage. The data collection was determination of submarine batteries criteria and modeling of network ANP along with analysis and discussion.

3.1. Criteria and Alternatives Determination.

Alternatives and Criteria used for submarines battery collection was obtained from brainstorming. Based on the results of interviews and brainstorming with experts and literature studies that had been implemented, the criteria had been arranged and described in Table 1 along with the alternatives that would be presented in Table 2.

Table. 1 Criteria Used

No.	Raised Criteria	Definition/Assessment Parameter
1	Operational Requirements (Opsreq)	Requirements related to usage operational of submarines battery
2	Technical Requirements (Techreq)	Technical Requirements related to design and specification of submarines battery

Table. 2 Alternatives Used

No.	Requirements	VARTA BZM (Jerman)	HAGEN (Jerman)	KSB SEBANG (Korea)
I	**Operational Requirements (Opsreq)**			
1	Operational	√	√	√
2	Complexity	√	√	√
3	Maintanancebility	√	√	√
4	Spare Part Convenience	√	√	√
II	**Technical Requirements (Techreq)**			
1	Weight	480 cell x59 kg √	480cell x 61kg √	480cell x55kg √
2	Dimension 1 cell	133x29x45 cm√	145x30x45 cm√	130x25x45 cm√
3	Power	1,5-2,7V,200 A√	1,5-2,5V,200 A√	1,5-3V,220 A √
4	Reliability	√	√	√
5	Durability	10-12 th√	9-11 th√	10-15 th√

Notes: √ Met the requirements for submarines.

The alternatives shown in Table 2 were the results of Brainstroming about Battery Submarines that had met all operational and technical requirements. The criteria mentioned in Table 3.1 was subcriteria that had been reviewed by experts in which the Operational Requirements (Opsreq) criteria had 4 (four) subcriteria while for Technical Requirements (Techreq) criteria had 5 (five) subcriteria. In Table 3 and Table 4 was a brief description of each subcriteria of the two criteria.

Table. 3 Sub-criteria on Operational Requirements (Opsreq) Criteria.

No.	Subcriteria Raised	Definition/Assessment Parameter
1	Operational	Operational convenience of how to use the battery from start until finish.
2	Complexity	The complexity condition of the battery system that was capable of working with other systems in the submarine includes trouble shooting convenience.
3	Maintanance	Convenience of care and maintenance period.
4	Spare part convenience	Convenience to obtain component/spare part for repairing and maintenance.

Table. 4 Sub-criteria on Technical Requirements (Techreq) Criteria

No.	Subcriteria Raised	Definition/Assessment Parameter
1	Weight	Battery weight that affects overall stability and speed of submarine
2	Dimension	Dimension/battery size that affects overall stability and speed of submarine.
3	Power	The system and the amount of power that can be generated and integrated with populsion and electrical system of submarine.
4	Reliability	Battery reliability at critical times required including reliability of supporting components.
5	Durability	Durability and battery life in normal maintenance condition.

The description was summarized in Table 5 below:

Table. 5 Criteria dan Sub-criteria Selection Submarine.

No.	Sub-criteria	Criteria
1	Operational	Operational Requirements (Opsreq)
2	Complexity	
3	Maintanance	
4	Spare part convenience	
5	Weight	Technical Requirements (Techreq)
6	Dimension	
7	Power	
8	Reliability	
9	Durability	

3.1.2. The Making of ANP Model Network. After determining the assessment criteria, then the ANP hierarchy model as shown in Figure 2 was arranged.

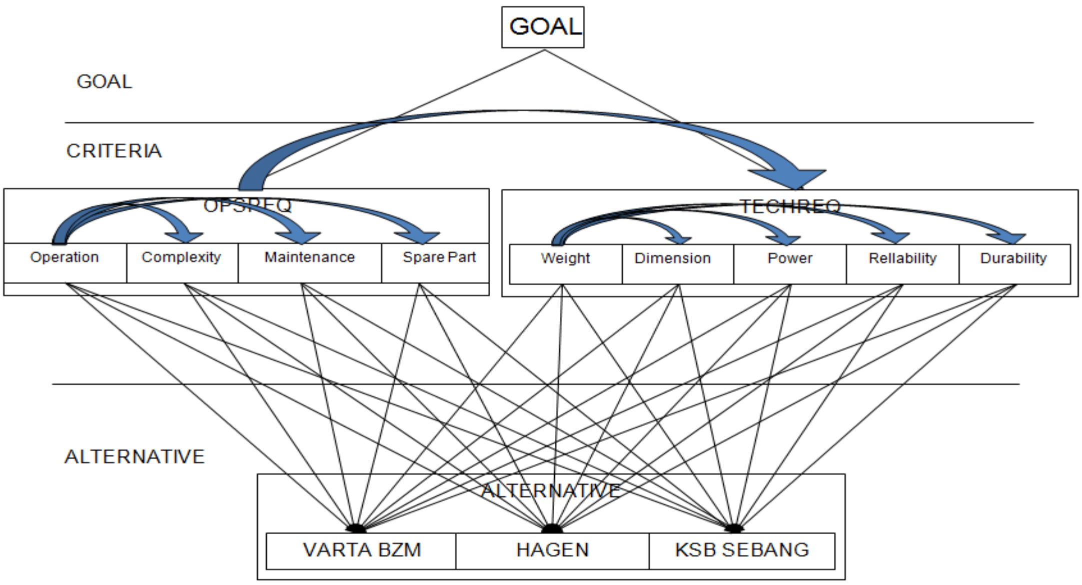

Fig. 2 ANP Hierarchy Model.

Based on the concept of existing models, a model using Super Decisions software was created to identify the existence of relationships that affect logically. There were 9 (nine) sub-criteria that were grouped into 2 cluster criteria: Operational Requirements (Opsreq) and Technical Requirements (Techreq) which had 5 (five) sub-criteria plus 1 (one) Goal. In Figure 3, a Network ANP model using Super Decisions software would be described.

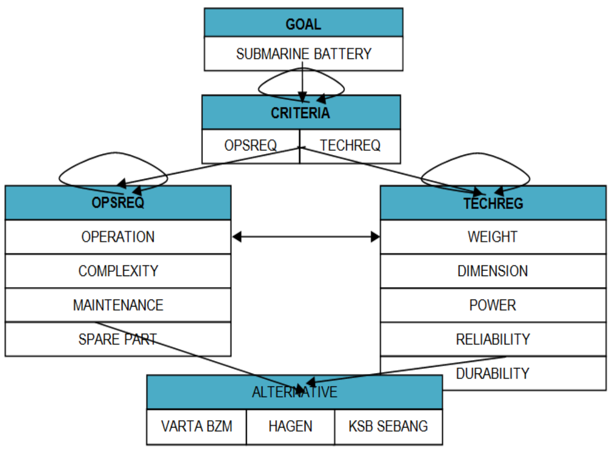

Fig. 3 ANP Model Network using Super Decisions.

The arrows in Figure 3 showed that there was effect. The base of the arrow means that the cluster had effect, while the arrow direction means the cluster that was affected. For example, the elements in Opsreq affected the Alternatives cluster in Figure 3. While the two-way arrow showed the relationship of mutual influence between two clusters or the intended element (feedback). In Figure 3, the two-way arrows on the Opsreq and Techreq clusters indicated that the Opsreq cluster affected the Techreq cluster and vice versa, the Techreq cluster affect Opsreq cluster.

3.1.3. Innerdependence and Outerdependence Relationship

In the ANP network model there were a whole of innerdependence and outerdependence of the clusters and elements in it. The arrows in the picture were the influence, the base of the arrow means the element of the affected criterion, while the incoming arrow means that the element of the criterion that influences. Relationships that occur in determining the relationship innerdependence and outerdependence was the result of brainstorming according to the experience of experts as experienced officials.

a. **Innerdependence Relationship in Each Cluster.**

The following is an explanation of the relationship of each cluster's Innerdependence criterion:

1) Innerdependence relationship in Opsreq. Cluster

Table. 6 Innerdependence relationship in Opsreg Cluster

No.	Innerdependence	Definition/Assessment Parameter
1	Operation with Complexity	How to operate submarine battery from start until finish, affecting on condition of electrical power complexity system and submarine propulsion.
2	Operation with Maintenance	How to operate submarine battery from start until finishing, affecting on the battery maintanance type of submarines.
3	Complexity with Maintenance	Complexity of Battery System affecting on the battery maintanance type of submarines.
4	Complexity with Spare Part Convenience	Condition The complexity of the battery system requires the existence of an easy and good spare part procurement system.
5	Maintenance with Spare Part Convenience	battery maintanance type of submarines. requires the existence of an easy and good spare part procurement system.

In Table 6 innerdependence relationship between the criterion elements present in one Opsreq cluster.

2) Innerdependence relationship in Techreq Cluster.

Table. 7 Innerdependence Relationship in Techreq Cluster

No.	Innerdependence	Definition/Assessment Parameter
1	Weight with Dimension	The weight condition of the submarine's batteries is influenced by the size / dimensions of the Battery.
2	Weight with Power	Condition The battery's weight on the submarine requires enough power to drive the submarine.
3	Dimension with Power	The weight condition of the submarine's batteries requires enough power to drive the submarine.
4	Power with Reliability	Power / daya baterei mempengaruhi kehandalan atau reliability dari baterei Kapal selam.
5	Power with Durability	Power / battery power affects the reliability of the Battery armored submarine.
6	Reliability with Durability	The reliability of submarine batteries is strongly influenced by the durability of submarine batteries.

In Table 7, innerdependence relationship between the criterion elements present in one Techreq cluster was described.

b. **Outerdependence Relationship among Clusters.**

In addition to the relationship of Innerdependence that occurs within each cluster, there is also an Outerdependence relationship between the clusters in the network, which are described as follows:

Table. 8 Outerdependence Relationship among clusters.

No.	Outerdependence	Definition/Assessment Parameter
1	Opsreq -- Techreq	The subcriteria present on **(Opsreq)** affects the technical specifications of submarine batteries purchased later on, so as to support the entire mission. Similarly, it is vice versa with the more complete and fulfillment of Sub technical criteria **(Techreq)** that exists, then the tactical and operational values obtained will be better and higher.

In Table 8, the outerdependence relationship between the Opsreq cluster and the Techreq cluster was explained.

3.1.4. Questionnaire Data Collection.

Preparation of questionnaires were done using reference network model that had been formed. The questionnaire was based on the relationship between the criterion elements of innerdependence and outerdependence and the preference relationship between the criteria along with the goals by pairwise comparison between the cluster or the cluster elements.

This questionnaire aimed to find out about how big the relationship was, based on the assessment of the respondents. The respondents were the experts, who were directly related of the submarine such as Navy officers / direct users

Reasons for selecting different respondents to fill out this questionnaire was because the stakeholder representation was expected to give different point of view so the result would be close to the actual conditions.

This questionnaire led to 2 (two) assessment objectives that were determining the submarine's alternative priorities and determining the criteria for ultimate/critical selection of submarines.

In answering the questions in this questionnaire, respondents did not need to do discrete weighting by numbers but only intuitively through linguistic variables. The linguistic variable was a variable whose value was words or sentences. Here, we would use a statement to compare two criteria with five basic linguistics that were equally important, slightly more important, more important, very important and most important. The composition of the questionnaire that had been made can be seen in Appendix I of this Final Project.

3.2. Data Processing.

The next stage after obtained data, was the activity of data processing. The method used in this study was ANP method and the data processing was performed through Super Decisions software. The questionnaire data which was filled with respondent perception about submarine selection was the data that being processed.

To facilitate the data processing, a new notation on alternatives criteria and sub-criteria was created The notation list was presented in Table 9.

Table. 9 List of Notation

No.	**Name**	**Code**
1	Submarine Battery Selection	G
2	Operational Requirements	O
3	Technical Requirements	T
4	Operational	O1
5	Complexity	O2
6	Maintenance/	O3
7	Spare Part Convenience	O4
8	Weight	T1
9	Dimension	T2
10	Power	T3
11	Reliability	T4
12	Durability	T5
13	VARTA BZM	A1
14	HAGEN	A2
15	KSB SEBANG	A3
16	Respondent 1 / PT. PAL	R1
17	Respondent 2 / Dan KRI 401	R2
18	Respondent 3 / Kadepsin 401	R3
19	Respondent 4 / Dan KRI 402	R4
20	Respondent 5 / Kadepsin 402	R5
21	Respondent 6 / Dan Satsel	R6

No.	Name	Code
22	Respondent 7 / Dan Sekasel	R7
23	Responde8 8 / Pwa STTAL	R8

3.2.1 Matched Comparison Matrices.

Once the network model was created, the value pairwise comparison between criteria and alternatives for each subcriteria could be determined. The pairwise comparison value was obtained by using questionnaire. The priority weight value for each category obtained based on pairwise comparison value would be compared to get the final priority weight value.

The data obtained from the questionnaire distribution were pairwise comparison values between criteria and inter-alternatives for each subcriteria. Assessment of respondents wouldl be incorporated by using the geometric mean as follows:

$$\sqrt[n]{\prod_{i=1}^{n} X_i} \qquad (1)$$

X_i = Decision on comparison of the first criterion

The calculation of the average geometric of pairwise comparison value from the questionnaire results could be seen in Appendix III. Geometric mean recap of pairwise comparisons between criteria and sub-criteria was presented in Table 10

Table. 10 Geometrical Average Record Value Pairwise Comparison.

Matched Comparison	Geomean
For G	
O vs T	1,00
For O	
O1 vs O2	3,00
O1 vs O3	3,54
O1 vs O4	1,17
O2 vs O3	3,91
O2 vs O4	1,03
O3 vs O4	0,28
For T	
T1 vs T2	0,98
T1 vs T3	0,98
T1 vs T4	1,17
T1 vs T5	0,29
T2 vs T3	0,94
T2 vs T4	0,78
T2 vs T5	0,31
T3 vs T4	3,17
T3 vs T5	0,31
T4 vs T5	0,29
For O2	
O1 vs O3	4,31
O1 vs O4	2,47
O3 vs O4	0,31
For O2	
T1 vs T2	2,77
T1 vs T3	1,12
T1 vs T4	3,00
T1 vs T5	0,90
T2 vs T3	0,32
T2 vs T4	1,12
T2 vs T5	0,31
T3 vs T4	3,04
T3 vs T5	0,86
T4 vs T5	0,34
For O3	
T3 vs T5	1,06
For O4	
T2 vs T4	1,00
T2 vs T5	0,36
T4 vs T5	0,27
For T3	
O1 vs O2	3,72
O1 vs O3	3,77
O2 vs O3	3,03
For T3	
T1 vs T4	1,10
T1 vs T5	0,29
T4 vs T5	0,33
For T4	
O2 vs O4	0,96
For T4	
T1 vs T2	0,28
T1 vs T3	0,29
T1 vs T5	0,99
T2 vs T3	0,45
T2 vs T5	0,30
T3 vs T5	0,93
For T5	
O2 vs O4	0,28
For T5	
T1 vs T3	1,05
T1 vs T4	2,04
T3 vs T4	2,74

The calculated geometric mean was subsequently inserted into pairwise comparison matrices. For example, Table 11 showed a pairwise comparison matrix between subcriteria on Opsreq criteria. Other pairwise comparison matrices could be seen in Appendix **III**.

Table. 11 Match Comparison Matrices Opsreg criteria

O	O1	O2	O3	O4
O1	1,00	3,00	3,54	1,17
O2	0,33	1,00	3,91	1,03
O3	1,00	0,26	1,00	0,28
O4	3,91	1,00	3,54	1,00

After obtaining one pairwise comparison value for each relationship, the calculation of local priority weighting was subsequently performed. This calculation aimed to determine the weight of each interconnected element. Each time the weighting of local priorities was performed, the value of consistency was needed to be considered. The value of inconsistency should not exceed 0.1. For example, it could be seen in Table 8. which showed the inconsistency value of pairwise comparisons between subcriteria on Opsreq criteria.

Apparently, Table 12 showed that the Inconsistency Index was obtained at 0.057779. The value was still below 10% or 0.1 which means that the answers given by the respondents in this questionnaire had been consistent.

Table. 12 Inconsistency Index on Matching Comparison between Sub-criteria on Opsreq Criteria.

Inconsistency Report

Rank	Row	Col	Current Val	Best Val	Old Inconsist.	New Inconsist.	% Improvement
1. Tom	O1	O2	3.000000	1.775379	0.057779	0.016134	72.08 %
1. Exp. Choice	O1	O2	3.000000	1.012598	0.057779	0.001316	97.72 %
1. Bill	O1	O2	3.000000	1.012598	0.057779	0.001316	97.72 %
2. Tom	O1	O3	3.540000	5.149719	0.057779	0.039687	31.31 %
2. Exp. Choice	O1	O3	3.540000	7.395784	0.057779	0.035308	38.89 %
2. Bill	O1	O3	3.540000	7.395784	0.057779	0.035308	38.89 %
3. Tom	O2	O3	3.910000	2.900631	0.057779	0.043709	24.35 %
3. Exp. Choice	O2	O3	3.910000	2.195911	0.057779	0.038541	33.30 %
3. Bill	O2	O3	3.910000	2.195911	0.057779	0.038541	33.30 %
4. Tom	O1	O4	1.170000	1.505585	0.057779	0.050997	11.74 %
4. Exp. Choice	O1	O4	1.170000	1.900808	0.057779	0.050267	13.00 %
4. Bill	O2	O4	1.030000	1.408070	0.057779	0.048143	16.68 %
5. Tom	O2	O4	1.030000	1.179195	0.057779	0.051045	11.65 %
5. Exp. Choice	O2	O4	1.030000	1.408070	0.057779	0.048143	16.68 %
5. Bill	O1	O4	1.170000	1.900808	0.057779	0.050267	13.00 %
6. Tom	O3	O4	3.571400	3.420411	0.057779	0.057654	0.22 %
6. Exp. Choice	O3	O4	3.571400	3.285665	0.057779	0.057729	0.09 %
6. Bill	O3	O4	3.571400	3.285665	0.057779	0.057729	0.09 %

3.2.2 Data Processing with Super Decisions Software.

After inserting all geometric mean into the questionnaire format in the Super Decisions software, the software did all the ANP method steps by running Synthesize, which contained alternate weight values as seen in the red circled value in Table13.

Table 13 Alternatif Weight Value.

New synthesis for: Super Decisions Main Window: Pemilihan Kapal ...

Here are the overall synthesized priorities for the alternatives. You synthesized from the network Super Decisions Main Window:

Name	Graphic	Ideals	Normals	Raw
A1		0.305049	0.116920	0.044132
A2		0.294356	0.112821	0.042585
A3		0.539628	0.206830	0.078069

SELECTION BATTERIES FOR SUBMARINES

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As for knowing the overall alternative and criteria, Priorities menu on Super Decisions can be used to obtain the weight value of alternatives and criteria as seen in Table 14.

Table 14 Alternatives and Criteria Weight Value.

Super Decisions Main Window: Pemilihan Kapal Selam.mod: ...

Here are the priorities.

Icon	Name	Normalized by Cluster	Limiting
No Icon	A1	0.11692	0.044132
No Icon	A2	0.11282	0.042585
No Icon	A3	0.20683	0.078069
No Icon	O	0.00000	0.000000
No Icon	T	0.00000	0.000000
No Icon	G	0.00000	0.000000
No Icon	O1	0.28133	0.089076
No Icon	O2	0.22634	0.071664
No Icon	O3	0.25315	0.080153
No Icon	O4	0.23919	0.075735
No Icon	T1	0.15462	0.047301
No Icon	T2	0.06727	0.020580
No Icon	T3	0.22448	0.068672
No Icon	T4	0.14460	0.044235
No Icon	T5	0.40903	0.125127

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3.2.3. Analysis and Results of Processing Data Analysis.

At this stage results from data processing in the previous sub-chapter would be analyzed and interpreted.

3.2.4. Consistency Ratio Analysis

Based the results of data processing in the form of questionnaires, Consistency Ratio (consistency ratio) could be obtained, where all the value of consistency ratio was below 10% (0.1). So, according to the fact that stated by (Saaty, 1996), the assessment system had been called consistent.

3.2.5. Alternative Priority Analysis.

In the data processing by using Super Decisions software, priority alternatives could be known by looking at the weight value of each alternative. From Table 13, we could get an alternative priority sequence based on the weight value of each alternative as follows:

a. First Priority was alternative 3 (A3) with a weight value of 0.20683.

b. Second Priority was alternative 1 (A1) with weight value 0.11692.

c. Third Priority was alternative 2 (A2) with weight value 0,11282.

So, if the normalization of weight values was performed, then the Priority Order of Nanggala Class Selected Submarine Batteries could be labeled as follows:

Table 15 Final Weighting of Battery Type Selected

Priority	Kode	Jenis Baterei	Nilai Bobot	Normalisasi Nilai Bobot Akhir
1	A3	KSB SEBANG	0,20683	0,474
2	A1	VARTA BZM	0,11692	0,268
3	A2	HAGEN	0,11282	0,258
Jumlah			0,43657	1,000

3.2.6. Criteria Process Analysis

In addition to alternative priorities, the results of data processing using Super Decisions software also included priority criteria for submarine batteries. The priority sequences of Battery Criteria were based on the weight value of each alternative as follows:

a. First Priority was Criteria T5 with the weight of 0,125127.

b. Second Priority was Criteria O1 with the weight of 0,089076.

c. Third Priority was Criteria O3 with the weight of 0,080153.

d. Forth Priority was Criteria O4 with the weight of 0,075735.

e. Fifth Priority was Criteria O2 with the weight of 0,071664.

f. Sixth Priority was Criteria T3 with the weight of 0,068672.

g. Seventh Priority was Criteria T1 with the weight of 0,047301.

h. Eight Priority was Criteria T4 with the weight of 0,044235.

i. Ninth Priority was Criteria T2 with the weight of 0,020580.

So if the normalization of weighted values was performed, then the Priority Order of Battery Criteria Submarine could be labeled as follows:

Table 16. Final Weighting of Submarine Battery Criteria.

Priority	Kode	Kriteria	Nilai Bobot	Normalisasi Nilai Bobot Akhir
1	T5	Durability	0,125127	0,201
2	01	Operasional/Cara Pemakaian	0,089076	0,143
3	03	Maintenance/Perawatan	0,080153	0,129
4	04	Kemudahan Spare Part	0,075735	0,122
5	02	Complexity/Kompleksitas	0,071664	0,115
6	T3	Power/Daya	0,068672	0,110
7	T1	Weight/berat	0,047301	0,076
8	T4	Reliability/Kehandalan	0,044235	0,071
9	T2	Dimension/Dimensi	0,020580	0,033
		Jumlah	**0,622543**	**1,000**

4. CONCLUSION.

Selection of Submarine batteries could be solved by Analytical Network Process (ANP) method, which was a selection method with many criteria of MCDM (multi criteria decision making) that was structured, systematic and had the ability to accommodate interconnectedness between criteria or alternatives. Based on the results of brainstorming with the experts, the criteria obtained were: Operational Requirements (Opsreq) with 4 (four) sub-criteria include operational, complexity, maintenance, ease of spare parts. Meanwhile, Technical Requirements (Techreq) criteria had 5 (five) sub-criteria such as weight, dimension, power, reliability, durability.

Result of the research was alternative of submarine battery chosen. The chosen one was KSB type made in Korea with priority weight value 0,474. In sequence, the next alternative priority was Varta BZM batteries made in Germany with a priority weight of 0.268 and the next was Hagen German-made batteries with a priority weight of 0.258

In addition to the priority of alternative types of batteries, this research had also resulted in the priority of battery criteria. The priority sequence of Battery Criteria was as follows: Durability with weight of 0.201, operational with weight of 0.143, maintenance with weight of 0.129, spare part convenience with weight of 0.122, complexity with weight of 0.115, power with weight of 0.110, weight of 0.076, reliability with weight of 0.071, and dimension with weight of 0.033.

Based on the above research, the priority weight of each battery was not much different so it only needs a suitable price for the purchase of these batteries.

REFERENCES

Afsharkazemi, M. A., Khodabakhsh, M. & Motadel, M. R., 2012. Applying Fuzzy Analytic network Process in quality Function Deployment Model. *Management Science Letters,* pp. 1325-1340.

Bottero, M. & Ferretti, V., 2011. An analytic network process-based approach for location problems:the case of a new waste incinerator plant in the Province of Torino (Italy). *Journal of Multi-Criteria Decision Analysis-elsevier,* Volume 17, pp. 63-84.

Chang, K.-L., Liao, S.-K., Tseng, T.-W. & Liao, C.-Y., 2015. An ANP based TOPSIS approach for Taiwanese service apartment location. *Asia Pacific Management Review elsevier,* pp. 1-7.

Dargi, A. et al., 2014. Supplier Selection: A Fuzzy-ANP Approach. *Procedia Computer Science,* Volume 31, pp. 691-700.

Das, S. & Chakraborty, S., 2011. Selection of non-traditional machining processes using analytic network process. *Journal of Manufacturing Systems-elsevier,* Volume 30, pp. 41-53.

Guneri, A., Cengiz, M. & Seker, S., 2009. A fuzzy ANP approach to shipyard location selection.

Expert Systems with Applications-elsevier, Volume 36, pp. 7992-7999.

Ishizaka, A., Nemery, P. ,. & Lidouh, K., 2013. Location selection for the construction of a casino in the greater:a triple multi-criteria approach. *Tourism Management-elsevier,* Volume 34, pp. 211-220.

Kahraman, C, R. & Dogan, I., 2003. Fuzzy group decision-making for facility. *Inf.Sci-elsevier,* Volume 157, pp. 135-153.

Maity, S. R., Chatterjee, P. & Chakraborty, S., 2012. Cutting tool material selection using grey complex proportional assessment method.. *Materials & Design,* Volume 36, pp. 372-378.

Morteza, Z. et al., 2016. Selection of the optimal tourism site using the ANP and fuzzy TOPSIS in the framework of Integrated Coastal Zone Management: A case of Qeshm Island. *Ocean & Coastal Management,* Volume 130, pp. 179-187.

Nguyen, H.-T., Dawal, S. Z. M., Nukman, Y. & Aoyama, H., 2014. A Hybrid Approach for Fuzzy Multi-attribute Decision Making in Machine Tool Selection with Consideration of Interactions of Attributes. *Elsevier,* pp. 3078-3090.

Niemiraa, M. P. & Saaty, T. L., 2004. An Analytic network Process Model for Financial-Crisis Forecasting. *Elsevier,* pp. 573-587.

Pang, B. & Bai, S., 2013. An integrated fuzzy synthetic evaluation approach for supplier selection based on analytic network process. *Journal of Intelligent,* Volume 24(1), pp. 163-174.

Razmi, J., Rafiei, H. & Hashemi, M., 2009. Designing a Decision Support System to Evaluate and Select Supplier Using Fuzzy Analytic Network Process. *Elsevier,* pp. 1218-1290.

Saaty, T. L., 1996. *Decision making with dependence and feedback: The analytic network process.* Pittsburgh: RWS Publication.

Senturk, S., Binici, Y. & Erginel, N., 2016. Theoritical Structure of Fuzzy Analytic Network Process (FANP) with Interval Type-2 Fuzzy Sets. *Elevier,* pp. 1318-1322.

Toroudia, H. P., Madanib, M. S. & Sarlak, F., 2016. Analytic Network Process (ANP) Approach for Product Mix Planning in Railway Industry. *Management Science Letter,* pp. 535-540.

Vinodh, S., Anesh Ramiya, R. & Gautham, S., 2011. Application of fuzzy analytic network process for supplier selection in a manufacturing organisation. *Expert Systems with Applications - elsevier,* Volume 38(1), pp. 272-280.

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OPTIMIZATION OF USE OF SHIP AND AIRCRAFT PATROLY MARITIME IN ALL NATIONAL SEA SECURITY OPERATIONS IN SELECTIVE AIRPORT AREA EASTERN EASTERN FLEET REGIONAL WITH LINIER PROGRAMMING APPROACH
(Case Study of Command of the eastern fleet Operations Staff)

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ABSTRACT

Various limitations that exist in meeting the security needs of the marine territory of the State of the Republic of Indonesia through Sea Security Operations, resulted in the need for demands of thought and careful calculation in optimizing the assignment of elements of marine vessels and maritime patrols to the security operations sectors sea area of the Eastern Fleet, so as to obtain the maximum coverage area to cover the entire area of Eastern Indonesia operating sector. A combination of the interests of the operation and logistics of Navy patrol boats and aircraft with budgetary constraints, technical capabilities of marine vessels and maritime patrols, the breadth of Indonesia's marine operations sector, ship maintenance schedule and patrol aircraft, and sector vulnerability. This optimization study identifies the related decision variables, then sets the objective function as well as the constraints as the optimization model to be developed. Problem solving using Linear Integer Programming approach and calculation using Solver tool. Optimization obtained information about the optimum number of ships and aircraft patrols are assigned to the sector of operation with coverage area maximum. With comparative analysis it is known that the built model is valid.. The final result in the form of an assignment table can be used as a reference in making Sea Security Operation planning implemented in East Eastern fleet region. The results of the optimization schedule of one-year patrol boat deployment with real conditions of assignment with a coverage area of 275,825,100 Nm ^{2}, resulting in a wider coverage area / up 12.054% of the previous area coverage area. Another optimization result is the one-year assignment schedule of patrol aircraft to the sector of operation with maximum coverage area, with coverage area 1,308,272,950 Nm^2, the coverage area is wider / up 11,217% from the previous area coverage area by using Linear Integer Programming optimization calculation.

KEYWORDS : Optimization Model, Linear Programming Integer, Solver, Ship and Aircraft Navy Patrol, Coverage Area, Operation Marine safety .

1. INTRODUCTION

The potential of natural resources in Indonesia's abundant sea is the potential for entry of violations and threats both from within and from outside (Bateman, 2005). Operation of Marine Security is a marine presence operation that has strategic value for the existence of national sovereignty and maritime security in the territory of national jurisdiction of Indonesia (Navy, 2004). While the government has not been able to maximize coastal and marine resources, due to the limitations that exist such as the readiness of human resources and the availability of capital

(Navy, 1994). On the other hand, many foreign countries now enter and take existing resources both legally and illegally, and this presents the challenge of controlling as well as securing the marine territory on a very wide scale of special dimensions in accordance with the provisions of the United Nations Convention on the Law of the Sea (Cribb, et al., 2009) as well (Nordquist & Nandan, 2011) which has been ratified in Law No. 17 of 1985 and 1994 (Fleet, 2009). This requires resources, among them are the operational costs that are not small in the effort of controlling and securing the sea. This area is carried out through the activities of Operation or Patrol of Marine Security held by the elements of the Navy Fleet (Navy, 2006). Thus, (Adi, 2009) the concept of security at sea is arranged to be able to overcome any incidents of violation of sovereignty and law in the sea that has legal legality both nationally and internationally where in this case the Navy should be able to carry out the early detection of such violations of marine security patrols with elements of the Indonesian Fleet for the entire Indonesian archipelago with an area of 3.9 million km2 of sea.

However, in terms of the ability of Eastern fleet elements as well as operating costs associated with the vastness of the marine security operations sector is felt to be still not optimal, so the Navy in this case. Operations Staff command of the eastern fleet need to think and do a mature calculation in the assignment of ships and aircraft maritime patrol Navy so it can secure the sectors of marine security operations (Navy, 2004).

The aim of this paper is to find a solution to solving the problem of assigning and placing elements of navy maritime patrol boats and aircraft in selective prone areas on the degree of maritime operations of the East Fleet (Navy, 2005) and determining the number of elements of naval patrol boats and aircraft patrolling the the framework of marine security operations in selective prone areas in the Eastern Fleet region with limitations covering budget, technical capability of ship elements and maritime patrol aircraft of the Navy, extent of Indonesian marine operations sector, marine maintenance schedule and maritime patrol aircraft and sector vulnerability level (Crawford, 2006). Approach model by using Integer Linear Program to optimize the composition of Assignment of Fleet elements in selective areas of vulnerability in the operation of marine security in Eastern Fleet region (Ballestero & Romero, 1991).

Based on the above description then the formulation of the problem in this writing is "How to determine the ideal number and optimization of the assignment of elements of navy maritime patrol boats and aircraft in selective areas selective in the framework of sea security operations of East Fleet region"

The Integer Linear Programming (ILP) model or integer program is another form of Linear Programming that arises because in reality not all decision variables can be fractions. ILP is a Linear Programming with the addition of a requirement that all or some of the variables are non-negative integers (Carter & Price, 2001).

In constructing model formulation of an optimization problem used ILP characteristics are (Roth & Yih, 2004) : Decision Variables, Destination Functions, Limiters, Non Negative variables. From the above illustration can be drawn conclusions about the definition of linear programa problem as follows :

The problem of ILP (Rardin, 1997) is an optimization problem by doing the following:

a. Maximize and / or minimize a linear function of decision variables called goal function Z.

b. The price of the decision variables (Xi) must satisfy a set of constraints, each delimiter must be a linear equation or linear inequality.

c. A mark marker is associated with each variable. For each Xi variable must be non negative (Xi ≥ 0) or Xi is not limited in mark.

(Michalewicz & Fogel, 2004) The transportation model is to determine the plan of transporting a number of goods from source to destination. This model data includes the needs and budget to be used, the purpose of transportation is to determine the amount of goods to be shipped and which tools are used so that the cost of miniumum.

Logistics planning (Winston, 2004) is a process of strategy in organizing a procurement, transfer and storage, final inventory through organizations and channels of companies / civil and military agencies, so that current and future benefits can be maximized through cost effectiveness. Logistics management provides many ways to improve efficiency and productivity with significant contributions to lower unit costs. The objective of logistics cost planning is to achieve the lowest cost target, with a mission to plan and coordinate all important activities in the operation.

In order to, this writing is limited to marine security operations planning by staff of the eastern fleet command operation. Marine security patrol (Navy, 2005) and do not discuss weaponry Ship and maritime aircraft patrol the Navy.

Benefits that can be obtained in this paper is to provide input to the Navy leadership in planning the assignment and selection of elements of maritime vessels and aircraft maritime indonesian navy optimal in the sector operations. And produce an optimization formulation that can be applied in Staff Operations Command of the eastern fleet in order to assign vessels and aircraft maritime patrol Navy to the sector of operation.

This paper was organized as follows. Section 2 is about Material and Methodology. Section 3 is the result and discussion of the research. Finally, in section 5 presents conclusion of this paper.

2. METHODOLOGY

A series of steps are taken to find the solution of a problem through the process of collecting and processing data to be analyzed and interpreted as shown in the flow chart Figure 1 as below :

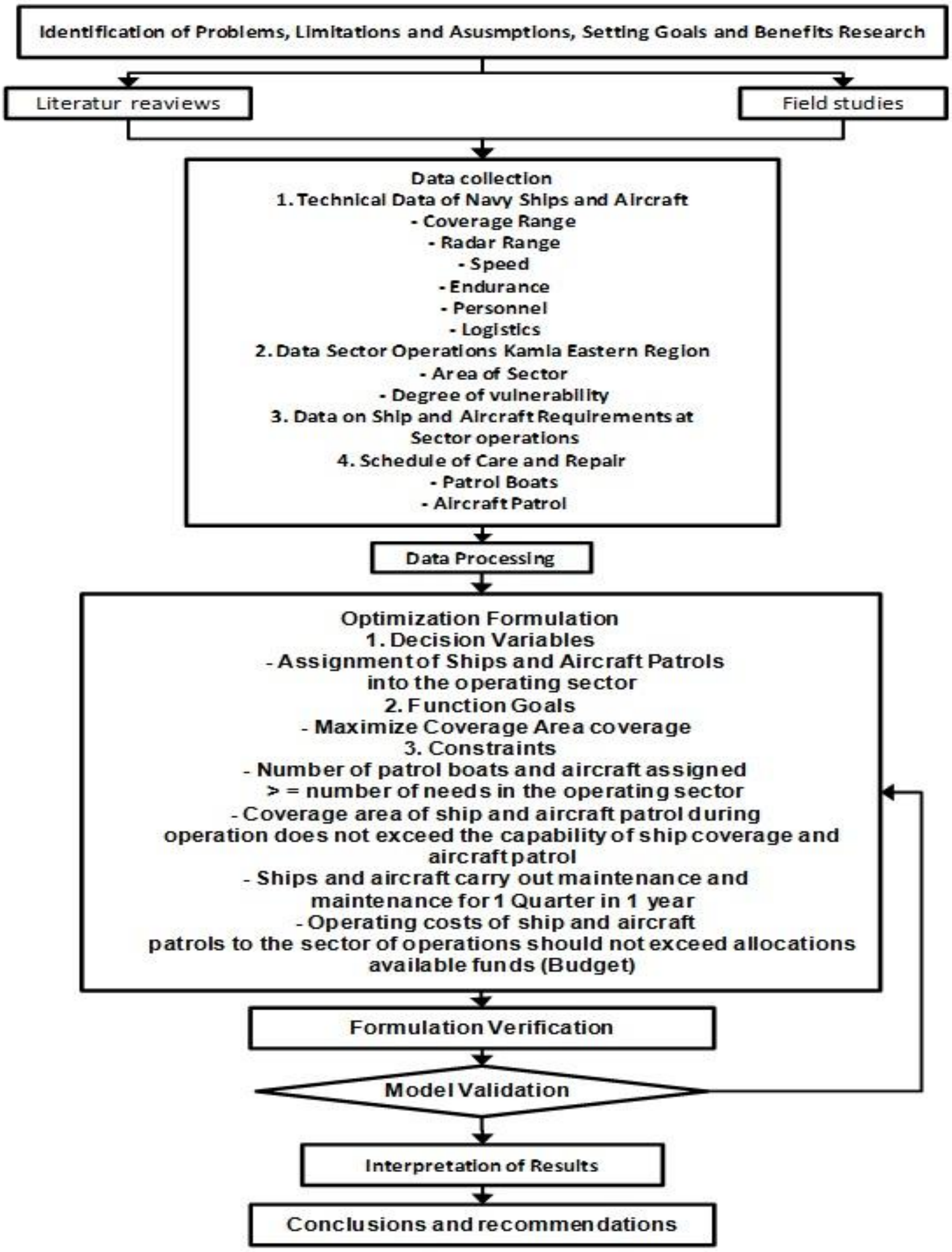

Fig 1. Optimization of naval maritime vessel work and aircraft patrols

Data collection on this research activity was conducted in Command of the eastern fleet environment including Operation Staff, Intelligence Staff, Logistic Staff and Wing Air Command of the eastern fleet and patrol unit as executor of marine security operation in East Fleet region. The data obtained in the form of data that is qualitative and quantitative that consists of primary and secondary data obtained by conducting direct interviews with relevant agencies and also with journals on the field. Efforts in data collection are intended to obtain valid data, so that it can be used in accordance with research objectives. Determination of Variables Decision of Assignment of Ships and Aircraft Patrols to the Sector of Operations. Check out Table 1. and Table 2. below

.

Table 1. Ships matrix and sector of operations

SHIP	SECTOR OPERATIONS						
	S-1	S-2	S-3	S-4	S-5	S-6	S-7
1	X 1,1	X 1,2	X 1,3	X 1,4	X 1,5	X 1,6	X 1,7
2	X 2,1	X 2,2	X 2,3	X 2,4	X 2,5	X 2,6	X 2,7
3	X 3,1	X 3,2	X 3,3	X 3,4	X 3,5	X 3,6	X 3,7
4	X 4,1	X 4,2	X 4,3	X 4,4	X 4,5	X 4,6	X 4,7
5	X 5,1	X 5,2	X 5,3	X 5,4	X 5,5	X 5,6	X 5,7
6	X 6,1	X 6,2	X 6,3	X 6,4	X 6,5	X 6,6	X 6,7
7	X 7,1	X 7,2	X 7,3	X 7,4	X 7,5	X 7,6	X 7,7
8	X 8,1	X 8,2	X 8,3	X 8,4	X 8,5	X 8,6	X 8,7
9	X 9,1	X 9,2	X 9,3	X 9,4	X 9,5	X 9,6	X 9,7
10	X 10,1	X 10,2	X 10,3	X 10,4	X 10,5	X 10,6	X 10,7
11	X 11,1	X 11,2	X 11,3	X 11,4	X 11,5	X 11,6	X 11,7
12	X 12,1	X 12,2	X 12,3	X 12,4	X 12,5	X 12,6	X 12,7
13	X 13,1	X 13,2	X 13,3	X 13,4	X 13,5	X 13,6	X 13,7
14	X 14,1	X 14,2	X 14,3	X 14,4	X 14,5	X 14,6	X 14,7
15	X 15,1	X 15,2	X 15,3	X 15,4	X 15,5	X 15,6	X 15,7
16	X 16,1	X 16,2	X 16,3	X 16,4	X 16,5	X 16,6	X 16,7
17	X 17,1	X 17,2	X 17,3	X 17,4	X 17,5	X 17,6	X 17,7
18	X 18,1	X 18,2	X 18,3	X 18,4	X 18,5	X 18,6	X 18,7
19	X 19,1	X 19,2	X 19,3	X 19,4	X 19,5	X 19,6	X 19,7
20	X 20,1	X 20,2	X 20,3	X 20,4	X 20,5	X 20,6	X 20,7
21	X 21,1	X 21,2	X 21,3	X 21,4	X 21,5	X 21,6	X 21,7
22	X 22,1	X 22,2	X 22,3	X 22,4	X 22,5	X 22,6	X 22,7
23	X 23,1	X 23,2	X 23,3	X 23,4	X 23,5	X 23,6	X 23,7
24	X 24,1	X 24,2	X 24,3	X 24,4	X 24,5	X 24,6	X 24,7
25	X 25,1	X 25,2	X 25,3	X 25,4	X 25,5	X 25,6	X 25,7
26	X 26,1	X 26,2	X 26,3	X 26,4	X 26,5	X 26,6	X 26,7
27	X 27,1	X 27,2	X 27,3	X 27,4	X 27,5	X 27,6	X 27,7
28	X 28,1	X 28,2	X 28,3	X 28,4	X 28,5	X 28,6	X 28,7

Table 2. Aircraft matrix and operation sector

AIRCRAFT	SECTOR OPERATIONS						
	S-1	S-2	S-3	S-4	S-5	S-6	S-7
1	P 1,1	P 1,2	P 1,3	P 1,4	P 1,5	P 1,6	P 1,7
2	P 2,1	P 2,2	P 2,3	P 2,4	P 2,5	P 2,6	P 2,7
3	P 3,1	P 3,2	P 3,3	P 3,4	P 3,5	P 3,6	P 3,7
4	P 4,1	P 4,2	P 4,3	P 4,4	P 4,5	P 4,6	P 4,7
5	P 5,1	P 5,2	P 5,3	P 5,4	P 5,5	P 5,6	P 5,7
6	P 6,1	P 6,2	P 6,3	P 6,4	P 6,5	P 6,6	P 6,7
7	P 7,1	P 7,2	P 7,3	P 7,4	P 7,5	P 7,6	P 7,7
8	P 8,1	P 8,2	P 8,3	P 8,4	P 8,5	P 8,6	P 8,7
9	P 9,1	P 9,2	P 9,3	P 9,4	P 9,5	P 9,6	P 9,7
10	P 10,1	P 10,2	P 10,3	P 10,4	P 10,5	P 10,6	P 10,7
11	P 11,1	P 11,2	P 11,3	P 11,4	P 11,5	P 11,6	P 11,7
12	P 12,1	P 12,2	P 12,3	P 12,4	P 12,5	P 12,6	P 12,7
13	P 13,1	P 13,2	P 13,3	P 13,4	P 13,5	P 13,6	P 13,7
14	P 14,1	P 14,2	P 14,3	P 14,4	P 14,5	P 14,6	P 14,7
15	P 15,1	P 15,2	P 15,3	P 15,4	P 15,5	P 15,6	P 15,7
16	P 16,1	P 16,2	P 16,3	P 16,4	P 16,5	P 16,6	P 16,7

Benefits that can be obtained in this paper is to provide input to the Navy leadership in planning the assignment and selection of elements of maritime vessels and aircraft maritime Indonesian navy optimal in the sector operations. And produce an optimization formulation that can be applied in Staff Operations Command of the eastern fleet in order to assign vessels and aircraft maritime patrol Navy to the sector of operation.

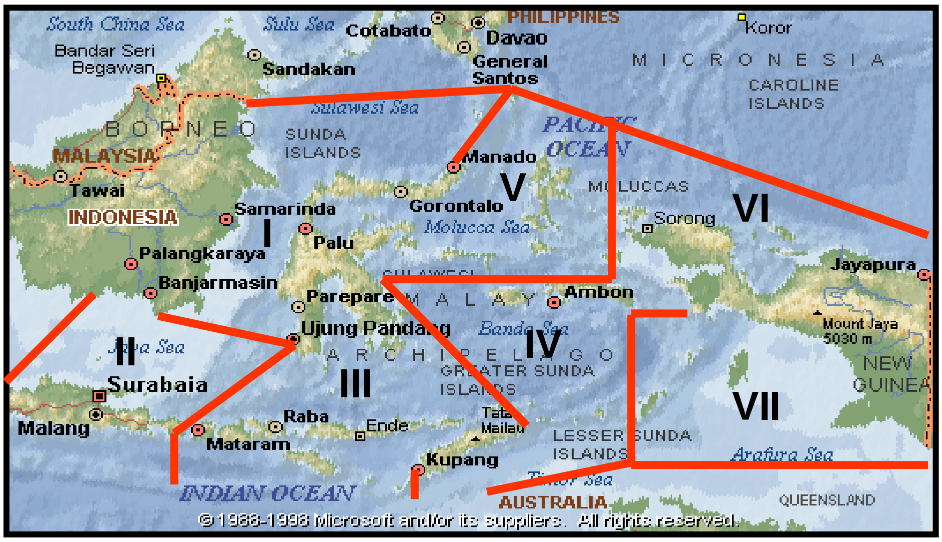

Fig 2. Marine safety field operations sector map eastern fleet

2.1 Function Objectives can be formulated as follows (Hamdan, 2003) **:**

Maximize the coverage area coverage of patrol boats, mathematical models as follows:

Maximize

$$Z_{max} = \sum_{i=1}^{n} C_{ij} \cdot X_{ij} \quad (1)$$

Maximizing the coverage area coverage of aircraft patrol, the mathematical model as follows:

Maximize

$$Z_{max} = \sum_{j=1}^{n} C_{ij} \cdot P_{ij} \quad (2)$$

2.2 For the First Limit / Obstacle is:

The number of patrol boats assigned to the operating sector is greater than the number of vessel sectors required based on the operating sector vulnerability, the mathematical model as follows:

$$\sum_{i}^{n} \mathbf{X_{ij}} \geq \mathbf{N_{ij}} \quad (3)$$

The number of patrol aircraft assigned to the operating sector is greater than the number of aircraft requirements of the sectors prepared based on the level of operating sector vulnerability, the mathematical model as follows :

$$\sum_{i}^{n} \mathbf{P_{ij}} \geq \mathbf{N_{ij}} \quad (4)$$

2.3 Second Limit / Constraint:

Coverage area patrol boats achieved during operation does not exceed the capability of patrol boat coverage, the mathematical model as follows:

$$\sum \mathbf{X_{ij} \cdot C_{ij}} \leq \mathbf{K_{ij}} \quad (5)$$

Coverage area of the patrol aircraft reached during operation does not exceed the capability of aircraft patrol coverage, the mathematical model as follows:

$$\sum \mathbf{P_{ij} \cdot C_{ij}} \leq \mathbf{K_{ij}} \quad (6)$$

Table 3. Sector and Area of Operation Area Marine safety Eastern fleet Area

NO	SECTOR	LUAS AREA (Mil ^{2})	SUPPORT BASE
1.	SECTOR I	136.000	NAVAL MAIN BASE : Makassar, Manado NAVAL BASE : Sangata, Balikpapan, Tarakan, Palu Nunukan, Toli-toli
2.	SECTOR II	273.030	NAVAL MAIN BASE : Surabaya NAVAL BASE : Cilacap,Semarang, Banyuwangi, Benoa
3.	SECTOR III	191.050	NAVAL MAIN BASE : Makssar, Kupang NAVAL BASE : Rote, Maumere, Mataram, Kendari
4.	SECTOR IV	140.102	NAVAL MAIN BASE : Ambon NAVAL BASE : Tual, Aru
5.	SECTOR V	171.375	NAVAL MAIN BASE : Menado NAVAL BASE : Tahuna, Ternate, Manokwari
6.	SECTOR VI	165.775	NAVAL MAIN BASE : Jayapura NAVAL BASE : Sorong, Biak, Manokwari
7.	SECTOR VII	107.610	NAVAL MAIN BASE : Ambon NAVAL BASE : Maumere, Timika, Tual, Aru
	Total Luas :	1.184.942 MIL ^{2}	

2.4 Third Limit / Constraint.

The patrol boat according to its class carries out maintenance and maintenance for 1 quarter (3 months) in 1 year, the mathematical model as follows :

$X\ i - n = 0 \rightarrow$ The ship carries out maintenance on schedule.

$X\ i - n = 1 \rightarrow$ The ship performs the operation.

Class-grade patrol aircraft perform maintenance and maintenance for 1 quarter (3 months) in 1 year, mathematical model as:

$P\ i - n = 0 \rightarrow$ Aircraft carries out maintenance on schedule

$P\ i - n = 1 \rightarrow$ Aircraft conducts the operation

2.5 The Fourth Constraint Constraint

Operating costs of patrol boat deployment to the operating sector should not exceed the allocation of available funds (budget).

$$X_{i,j} . B_{i,j} \leq \text{Budget}_{i,j} \quad (7)$$

Operating costs of patrol boat deployment to the operating sector should not exceed the allocation of available funds (budget).

$$\sum P_{i,j} . B_{i,j} \leq \text{Budget}_{i,j} \quad (8)$$

2.6 The Process of Optimizing the Assignment of Ships and Aircraft Patrols.

The process of optimization in the deployment of ships and aircraft patrol is using the Solver program from Microsoft Office 2007 (Apte & Aruna, 2014). The steps are as follows:

1. Model Preparation
2. Decision Variable. Matrix zero-one ship assignment and aircraft patrol.
3. Constraint.
4. Objective Function. Maximize operating sector coverage to be secured by ship / aircraft patrol.

Running Program.

The program start is started by entering the data as follows:

a. Set Target Cells = objective function.

b. By Changing Cells = decision variable.

c. Subject to the constrain = Constraint function.

d. Option

- select Assume Linear Model.

- choose Non Negative Variable.

e. Solver = Program is run

3. OPTIMIZATION DATA ANALYSIS

Solving this model produces an assignment table with a zero-one number (0-1). Xij = 1 means that the naval patrol vessel is assigned operations to sector - j and Xij = 0 means that the i-patrol vessel is not assigned to the sector-j operation. While Pij = 1 means the i-th patrol plane is assigned to the j-sector and Pij = 0 means that the i-th patrol plane is not assigned to the j-sector operation.

Table 4. Decision Variable of Aircraft

DECISION VARIABLE							
AIRCRAFT	SECTOR OPERATIONS						
	S-1	S-2	S-3	S-4	S-5	S-6	S-7
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	1
3	0	0	0	0	0	0	1
4	0	0	0	0	0	1	0
5	0	0	0	0	0	0	0
6	0	0	0	0	1	0	0
7	0	0	0	1	0	0	0
8	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0
10	0	0	1	0	0	0	0
11	0	1	0	0	0	0	0
12	0	0	1	0	0	0	0
13	0	0	0	0	0	0	0
14	1	0	0	0	0	0	0
15	0	1	0	0	0	0	0
16	1	0	0	0	0	0	0

Table 5. Decision Variable of Ship

DECISION VARIABLE							
SHIP	SECTOR OPERATIONS						
	S-1	S-2	S-3	S-4	S-5	S-6	S-7
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	1
3	1	0	0	0	0	0	0
4	0	0	0	0	0	0	1
5	0	0	0	0	0	0	0
6	1	0	0	0	0	0	0
7	1	0	0	0	0	0	0
8	1	0	0	0	0	0	0
9	0	0	0	0	0	0	0
10	0	0	0	0	1	0	0
11	0	0	1	0	0	0	0
12	0	0	1	0	0	0	0
13	0	0	0	0	0	0	0
14	0	0	1	0	0	0	0
15	0	0	0	0	1	0	0
16	0	0	0	1	0	0	0
17	0	0	0	0	0	0	0
18	0	0	0	0	0	1	0
19	0	0	0	0	0	0	1
20	0	0	0	0	0	1	0
21	0	0	0	0	0	0	0
22	0	1	0	0	0	0	0
23	0	1	0	0	0	0	0
24	0	1	0	0	0	0	0
25	0	0	0	0	0	0	0
26	0	0	0	0	0	0	1
27	0	0	0	1	0	0	0
28	0	1	0	0	0	0	0

Precious table:

= Ship / Aircraft carry out repairs, maintenance (not surgery)

0 = Ship / Aircraft to - i carry out operations to sector – j

1 = Ship i / Aircraft vessel i does not carry out operations to sector – j

Table 6. Table Of Results And Appeals Coverage Area Ship Patroli On Operating Release

SECTOR	LARGE (Nm²)	QUARTERLY. I PATROLI SHIP ASSIGNMENT	QUARTERLY. II PATROLI SHIP ASSIGNMENT	QUARTERLY. III PATROLI SHIP ASSIGNMENT	QUARTERLY. IV PATROLI SHIP ASSIGNMENT
SECTOR I	136,000	X 7, X 14, X 19, X 27	X 2, X 17, X 15, X 21	X 1, X 8, X 13, X 20	X 1, X 6, X 13, X 24
SECTOR II	273,030	X 3, X 6, X 10, X 26	X 3, X 9, X 14, X 18	X 7, X 12, X 24, X 25	X 3, X 16, X 19, X 22
SECTOR III	191,050	X 5, X 15, X 18	X 7, X 22, X 26	X 9, X 19, X 21	X 8, X 14, X 16
SECTOR IV	140,102	X 9, X 16	X 6, X 23	X 5, X 11	X 6, X 11
SECTOR V	171,375	X 2, X 4	X 1, X 8	X 2, X 23	X 2, X 5, X 17
SECTOR VI	165,775	X 11, X 17	X 11, X 24	X 10, X 16	X 21, X 28
SECTOR VII	107,610	X 1, X 12, X 13, X 22	X 12, X 20, X 25	X 4, X 15, X 18, X 26	X 4, X 10, X 25, X 27
AMOUNT	**1,184,942**	**22 SHIP ON ASSIGNMENT**	**20 SHIP ON ASSIGNMENT**	**21 SHIP ON ASSIGNMENT**	**22 SHIP ON ASSIGNMENT**
MAX COVERAGE AREA (NM²)		68,303,400	67,170,600	70,245,700	70,105,400
TOTAL COVERAGE AREA (NM²)		**275,825,100**			
INFORMATION :		DISCLAIMER	DEFICIENCY/EMPTY		
(SOURCE : OPERATING STAFF)					

Table 7. Table Of Results And Appeals Coverage Area Air Craft Patroli Maritime All (Cassa) On Operating Release

SECTOR	LARGE (Nm²)	QUARTERLY. I PATROLI AIRCRAFT ASSIGNMENT	QUARTERLY. II PATROLI AIRCRAFT ASSIGNMENT	QUARTERLY. III PATROLI AIRCRAFT ASSIGNMENT	QUARTERLY. IV PATROLI AIRCRAFT ASSIGNMENT
SECTOR I	136,000	P 1, P 7, P 2	P 4, P 12	P 5, P 9	P 2, P 10
SECTOR II	273,030	THERE IS NO	P 8, P 16	P 3, P 6	P 4, P 8
SECTOR III	191,050	P 5, P 10	P 11, P 13	P 13, P 14	P 6, P 3
SECTOR IV	140,102	P3	P 14	THERE IS NO	P 12
SECTOR V	171,375	P 6, P 12	P 1, P 15	P 4, P 16	P 5, P 13
SECTOR VI	165,775	P 11	P 7	P 8	P 9
SECTOR VII	107,610	P 9, P 16	P 2, P 10	P 11, P 15	P 1, P 7
AMOUNT	1,184,942	11 AIRCRAFT	12 AIRCRAFT	11 AIRCRAFT	12 AIRCRAFT
MAX COVERAGE AREA (NM²)		324,578,550	327,178,200	325,167,600	331,348,600
TOTAL COVERAGE AREA (NM²)		1,308,272,950			
INFORMATION :		DISCLAIMER	DEFICIENCY/EMPTY		
(SOURCE : OPERATING STAFF)					

The optimization results show that the number of vessels assigned to the operations sector is 21 vessels of 28 vessels, the maximum coverage area secured by patrol boats in all sectors for one year is 309,073,045 Mil². The maritime patrol aircraft assigned to the sector are 12 aircraft from 16 aircraft available, the maximum coverage area covered by patrol aircraft in all sectors for one year is 1,473,575,931 Mil².

The width of the sector of operations 1 to 7 is 1,184,942 mil², meaning that the coverage area is more than the calculation, it means that the presence of maritime operations by marine elements and maritime patrol aircraft is increasingly conducted in selective areas with the composition of the assignment above.

Visible on the results of table 6 and table 7, All maritime patrol boats and aircraft are uniformly distributed and there is no stacking or even shortage of boats or aircraft patrols in any of the operating sectors and all ships or aircraft patrols operate in accordance with their technical capabilities in the operations sector. All areas of operation are covered optimally (optimization results).

4. CONCLUSION

From a series of data processing and analysis conducted in this case study can be drawn some conclusions such as the optimization results of the schedule of assignment of a year patrol boats to the operating sectors with coverage of the maximum area, which amounted to 309,073,045 Nm ². Compared with real assignment condition with coverage area of 275,825,100 Nm², so coverage area is more extensive / up 12,054% from previous area coverage area.

Another optimization result is the schedule of one year assignment of patrol aircraft to the operating sectors with maximum coverage area, which is 1,473,575,931 Nm². Compared with real assignment condition with coverage area 1,308,272,950 Nm², so coverage area is more wide / up 11,217% from previous area coverage area by using Linear Integer Programming optimization calculation.

Table 8. Optimization Results

NO	SECTOR	CATAGORY OF OPERATION AREA	THE NUMBER OF PATROL NEEDS BASED ON THE LEVEL OF VULNERABILITY (N)	
			SHIP	AIRCRAFT
1.	SECTOR I	VERY VURNERABLE	4	2
2.	SECTOR II	PRONE	4	2
3.	SECTOR III	PRONE	3	2
4.	SECTOR IV	PRONE	2	1
5.	SECTOR V	PRONE	2	2
6.	SECTOR VI	PRONE	2	1
7.	SECTOR VII	VERY VURNERABLE	4	2

The optimization results show that all maritime naval vessels and aircraft operates in the marine safety sector according to the number of ships and aircraft patrols required by the persector based on the vulnerability with the following details:

a. Coverage of sector areas In the writing of this Final Project the achievement of operation is still the main thing in the optimization of ship assignment / aircraft to the operating sector. The cost factor of patrol boat operation / aircraft which in this optimization as constraint function can be developed into the objective function that is minimize the cost, this can be continued for the next research study.

b. The optimization model in this study is flexible to data changes and can be applied to other types of fleet element operations. Changes on ship / aircraft data, sector data and operating costs can be input to this model and can be re-run.

c. This Optimization Model can be used as consideration in decision making of Navy Leadership. Command of the eastern fleet Operations Staff on the assignment of maritime naval vessels / aircraft in the operations sector so that it can be implemented / applied in the future.

REFERENCES

Adi, M., 2009. *The Aplication of The Law of The Sea.* New York: Nippon Foundation Fellow.

Apte & Aruna, 2014. *Optimizing Resources of United States Navy for Hummaitarian Operations,* Monterey: NPS-LM-14-180.

Ballestero, E. & Romero, C., 1991. A theorem connecting utility function optimization and Compromise Programming. 10(7).

Bateman, S., 2005. *Security and the law of the sea in Asia,* London: SLS.

Carter, M. W. & Price, C. C., 2001. *Operations Reseach : A Practical Introduction.* First Edition ed. Florida: CRC Press LCC.

Crawford, J., 2006. *The Creation of State in International Law.* Second Edition ed. New York: Oxford University Press Inc.

Cribb, Ford, R. & Michele, 2009. *Indonesia as an Archipelago: Managing Islands, Managing the Seas.* Singapore: ISEAS-Yusof Ishak Institute.

Fleet, N. B. E., 2009. *Book of Naval Base East Fleet Action Facing Contingencies Year 2009 For Military Operation Other Than War (OMSP).* Surabaya: s.n.

Hamdan, A., 2003. *Operation Research, An Introduction.* Sevevth Edition ed. New Jersey, USA: Prentice Hall.

Michalewicz, Z. & Fogel, D. B., 2004. *How to Solve It: Modern Heuristics.* New York: Spinger-Verlag Heidelberg.

Navy, 1994. *Nusantara Marine Defense Strategy Concept.* Jakarta: s.n.

Navy, 2004. *Marine Safety Operations Hanbook.* Jakarta: Operations Staff of Kasal.

Navy, 2004. *Navy Operations Concept In Order of Sea Sustenance and Security Enforcement.* Jakarta: Operation Staff of Kasal.

Navy, 2005. *Depelopment of Navy Force 2005 until 2024.* Jakarta: s.n.

Navy, 2005. *Maritime Airborne Combat Instruction Manual.* KUAT 130.007 ed. Jakarta: s.n.

Navy, 2006. *Posture of Indonesian Navy Until 2024.* Jakarta: s.n.

Nordquist, M. & Nandan, S. N., 2011. *United Nations Convention on the Law of the Sea 1982, Volume VII:A Commentary.* First Edition ed. Leiden, Boston: Martinus Nijhoff Publishers.

Rardin, R. L., 1997. *Optimization in Operations Research Author.* 1 st Edition ed. Jakarta: ISBN number: 0023984155.

Roth, D. & Yih, W. t., 2004. *A Linear Programming Formulation for Global Inference in Natural Languange Tasks,* Illinois: ILLINOIS UNIV AT URBAN-CHAMPAINGN DEPT OF COMPUTER SCIENCE.

Winston, W. L., 2004. *Operations Research: Applications and Algorithms.* 4 th edition ed. Phillidephia: Indian University.

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APPLICATION PERFORMANCE CALCULATION MODEL FOR NAVAL MARITIME SECURITY OPERATION IN EASTERN REGION WITH CAUSAL MAPPING APPROACH

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ABSTRACT

Indonesian Navy (TNI AL) as the main defense component of the country at sea obliged to protect the territorial integrity and maintain stability and security at sea. The implementation of Naval Maritime Security Operation (OPSKAMLA) is still not measurable of it's performance, the effectiveness and efficiency of the Navy's capability in executing Opskamla and measuring the factors (variables) that affect it and implementing the optimization of maritime security facilities and infrastructures which is inadequate. This study aims to arrange a Bayesian Network model with Causal Mapping approach that can be used as an instrument / tool in determining the performance of variables that build Opskamla model. This model is utilize expert opinions and literature studies as the basis for the preparation of variables and interdependence relationships. The results of TNI AL existing performance capabilities at 64 %. From 25 independent variables that generate 4 variables with the greatest contribution namely Navy leadership policy, quality of teaching staff, fuel quota and government regulation.

KEYWORDS : Naval Maritime Security Operations, Bayesian Network, Causal Mapping.

1. INTRODUCTION.

Republic of Indonesia (NKRI) is the largest archipelagic state in the world that has ± 17,400 islands, with 5.8 million km^2 sea vast and ± 81.000 km along the coastline. The territory of NKRI lies in world cross position between two continents and two ocean, this geographical position caused the sea between the islands to be a sea channel which is very important for international shipping traffic. In the vast sea contained potential marine resources are very abundant and have strategic value for the development of national sustainability, but still not managed optimally.

TNI AL as the main defense component of the country at sea obliged to protect the territorial integrity and maintain stability and security at sea and protecting natural resources in the sea of various forms of security disturbances and violations in the territorial waters of Indonesia's national jurisdiction. Current conditions in TNI AL still can not measure the performance, the effectiveness and efficiency its abbility in executing OPSKAMLA and measuring the factors (variables) that affect it and implementing the optimization of maritime security facilities and infrastructures which is inadequate.

According the background, the author tries to apply performance calculation model for Opskamla capabilties in the eastern region. Mutual between the variables will be solved by causal mapping approach as the basis to arrange Bayesian Network model which accommodates elements of uncertainty that accommodates existing uncertainty elements.

This paper describes the determination and measurement of TNI AL capability performance implementing OPSKAMLA in eastern region is as expected or not and perform an accurate measurement of any strongly contribute factors (variables) to OPSKAMLA performance. The objective of this paper is assist TNI AL leader to improve OPSKAMLA ability in the eastern region thus can minimize violation at sea.

This paper have any literature to support the research about it, for example paper with title Guidelines for Using Bayesian Networks to Support The Planning and Management Of Development Programmes In The Water Sector And Beyond (Cain, 2001), Navy Operation Concept to enforce sovereignty and security at sea (Asops, 2004), Maritime Security Operations Guide Book (Asops, 2004), Applying Bayesian Belief Networks In Sun Tzu's Art Of War (Ang, 2004), An Introduction to Bayesian Belief Networks and their Applications to Land Operations Departement of Defence (Starr & Shi, 2004), Principles of TNI AL Policy (Kasal, 2011), The Environment and Disease: Asociation or Causation? (Hill, 1980), Effective Strong with Applications to Information and Complexity (Hitchcock, 2001), Journal : Modelling The Effect of Behaviour for Simulation Based Human Factors Design (Reilly, et al., 2004), Appreciation on the Optimization of Duties of the Navy in Order to Enforce Laws and Keep Security At Sea National Jurisdiction of Indonesia (Koarmatim, 2013), Maritime Security White Book (Mabesal, 2002), The Posture of the Navy until 2024 (Mabesal, 2011), Navy Standard Operating Procedure for Law Enforcement and Maritime Security in National Jurisdiction Sea (Mabesal, 2009), Maritime Air Surveys Guide Book (Mabesal, 2005), Causal Mapping Approach to Construction Bayesian Networks (Nadkarni & Shenoy, 2004), Learning Bayesian Network (Neapolitan, 2004), Qualitative and Quantitative Approaches (Neuman, 2000), Principles of Maritme Security (Mabesal, 2011), A Bayesian network of eutrophication models for synthesis, prediction, and uncertainty analysis (Borsuk, et al., 2003), United Nations Convention on the Law of the Sea 1982 (NATIONS, 1982), Laws of the Republic of Indonesia number 34 of 2004 concerning Armed Foces (Goverment, 2004), Laws of the Republic of Indonesia number 17 of 2008 concerning Shipping (Goverment, 2008), Cognitive Mapping and Certainty Neuron Cognitive (Tsaridas & amd Margaritis, 1997) , Strategy maps: A spatial representation of (Day, et al., 1987), Network Anaysis (Knoke & Kuklisnki, 1982) and An Overview of Bayesian Network Applications in Uncertain Domains (Iqbal, et al., 2015)

This Paper is organized as follows. Section 1 Introduction, Section 2 review about Material and Methodology. Section 3 gives result and discussion of research. Finally, in section 4 present conclusion this paper.

2. MATERIALS/METHODOLOGY.

2.1. Maritime Security Operation

Maritime Security Operation (OPSKAMLA) is a daily operation at sea carried out by Indonesian Warship (KRI) and Navy maritime patrol aircraft which has a strategic value to enforce national sovereignty and security stability at sea in NKRI jurisdiction expected to prevent and take action against all forms of security threat at sea from violation and crime such as smuggling, wood theft, fish theft by foreign ships and other marine natural resources theft (Mabesal, 2011).

Due to implementation of sovereignty and law enforcement at sea in accordance with the united nations convention on the law of the sea (UNCLOS 1982) (NATIONS, 1982) mentioned that a national warship has the right to pursuit, inspect and prosecute violation by foreign ships such as piracy, hijacking, unauthorized fishing, territorial border violations, and others.

There are several elements / units involved in Opskamla implementation, among them :

a. KRI as direct prosecute againts offenders at sea (Kasal, 2011)

b. Maritime Patrolling Aircraft (MPA) used for continuous surveillance marine activities (Mabesal, 2005).

c. TNI AL base which has an important role in support the operating units and forces dispersion especially in the aspects of maintenance support, repair and supply (Mabesal, 2002)

2.2. Causal Maps

A causal map is a network diagram representing causes and effects. The diagram contains two basic elements: concepts which are the nodes in the network and causal relationships which are represented by the arcs between the nodes. Concepts are considered as the variables of the system and in some notations carry either positive or negative sign implying the type of the causal relationship and effect (Tsaridas & amd Margaritis, 1997). Causal mapping has been used extensively in strategy (Day, et al., 1987). Causal maps are cognitive maps that represent the causal knowledge of subjects in a specific domain (Nadkarni & Shenoy, 2004). Causal maps may be used as tools to facilitate decision making and problem solving within the context of organizational intervention (Nadkarni & Shenoy, 2001). The three components of a causal map are node representing causal concept, link representing causal connection among causal concepts (can be positive or negative), and strength representing causal value of a causal connection (Nadkarni & Shenoy, 2001).

2.3 Bayesian Networks

Bayesian Networks or Bayesian Belief Network is a probabilistic model in the form of Directed Acyclic Graph / DAG which is used to describe probabilistic and probabilistic inference relationships between variables (Neapolitan, 2004). BN is defined by 2 components: Directed Acyclic Graph / DAG and Conditional Probability Table / CPT. The first component is a DAG in the form of nodes and arrows. The second component is the Conditional Probability Table (CPT) for each variable contained in the network. CPT for variable B, specializing conditional distribution P(B|Parent(B)), parent (B) is the parent node of B.

Bayesian network model is represented at two levels, qualitative and quantitative. At the qualitative level, we have a directed acyclic graph in which nodes represent variables, and directed arcs describe the conditional independence relations, the dependence relations are expressed in terms of conditional probability distributions for each variable in the network (Nadkarni & Shenoy, 2004).

BN is very effective for modeling situations where some data is known and incoming data is uncertain or some are not available. Uncertainty can appear in many situations. For example, experts may be unsure of the knowledge they possess, the uncertainty attached to the situation that is modeled or uncertainty about the accuracy and availability of information

2.4 Methodology

The design of this research is divided into three stages : preparation stage, implementation stage and termination stage. The preparation stage includes identification of problems and research objectives, literature study, preliminary study and method identification. Implementation stages include data collection, modelling, discussion and sensitivity analysis. While at termination stage will be determined conclusions and suggestions from the results of research. The research flowchart shown in Fig.1

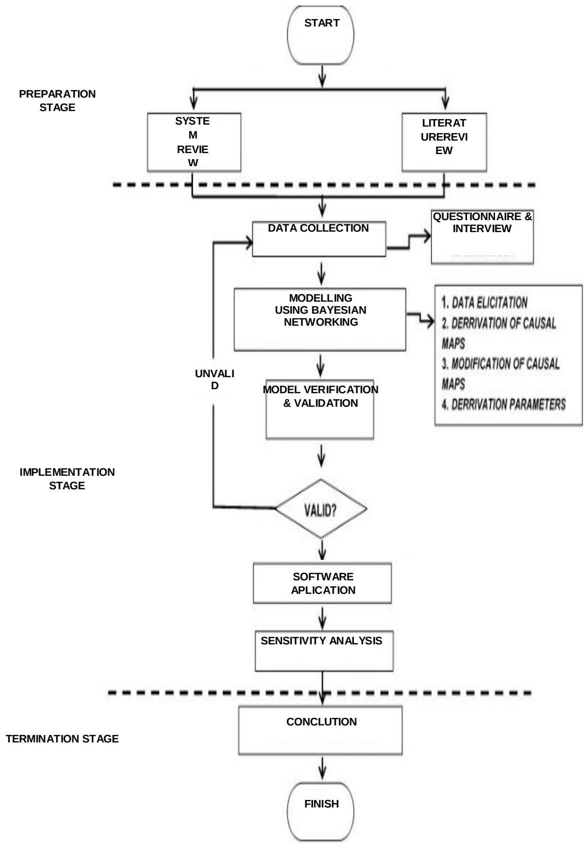

Fig.1. Flowchart Diagram

2.5 Data Collection

The data collection process is conducted using interviews and questionnaires with the following objectives :

a. Earn exist OPSKAMLA Performance Data conducted by TNI AL in Eastern Region (prior probability)

b. Eliciting Probability Tables from expert to fulfill CPT value

c. Model Validation appropriate with existing systems

2.6 Modelling

The causal knowledge of the experts is represented in the causal map and the graphical structure of the causal map is modified to Bayesian networks model

2.6.1 Data Elicitation

Domain information is elicited from the expert. Two different types of elicitation techniques are typically employed to capture domain information: *structured* and *unstructured* (Nadkarni & Shenoy, 2004). In the this modelling process used unstructured approach by exploring the information domain from the OPSKAMLA experts.

2.6.2 Derivation of Causal Maps

There are four different steps in deriving causal maps using narrative or text yielded by the interview (Nadkarni & Shenoy, 2004).

a. Identification of Causal Statement in the Narrative. A causal statement links two different concepts through a causal connector. The list of causal statements that have been made by the researcher is shown in Table.1.

Table 1 . Causal Statements

No	Causal Statements	No	Causal Statements
1.	Opskamla performance is determined by four perspectives including organizational structure, human resources (HR), operational and mechanism / procedure.	9.	OPSKAMLA education is determined by the quality of teachers and the teaching pattern.
2.	The organizational structure perspective is determined by several parameters which consists of the Organization's strategy, information technology/Data Exchange and Coordination optimization	10.	OPSKAMLA Knowledge is determined by the OPSKAMLA Education, Socialization of maritime law and maritime law access capability.

	/ communication.		
3.	The Human Resources Perspective (HRD) is determined by several parameters consisting of OPSKAMLA Education, OPSKAMLA Knowledge and Officer with investigator skills.	11.	Officer with investigator skills is determined by the investigating officers course and legal studies scholarship program.
4.	The operational perspective is determined by several parameters integration, consists of Elements / units capabilities (KRI, MPA), logistic distribution system, support naval base and OPSKAMLA sector.	12.	Elements / units capabilities (KRI, MPA) is determined by integration of KRI Capability, Naval Command Center Capability (early detection), MPA Optimization, Seaman Professionalism and Support Naval Base.
5.	Mechanism / Procedure perspective is determined by two parameters namely Law / Government Regulation and OPSKAMLA SOP.	13.	Logistic distribution system have constraints and influenced by fuel quota and the pattern of fuel distribution to Naval Base.
6.	Organizational Strategy is determined by the Policy of TNI AL leaders and the TNI AL Duties Implementation.	14.	Naval Base Support is determined by the integration of infrastructure including mooring / anchorage / Runways Facility, Fuel Facilities, Repair Facility, juristic Support and Intelligence Function Optimization.
7.	Information Technology / Exchange Data quality is determined by Integration of Infrastructure Facilities and TNI AL leaders policy.	15.	OPSKAMLA Sector is determined by the Level of operation area vulnerability and threats / violations forms
8.	Coordination / communication optimization is determined by organizational strategy and coordination pattern.		

b. Construct Raw Causal Maps

Following causal statement is identified, the next step is to breakdown into causal phrases, causal connector and effect phrases. (Table 2)

Table 2 . Causal Components

No.	Causal Phrases	Causal Connector	Effect Phrases	No.	Causal Phrases	Causal Connector	Effect Phrases
1.	The organizational structure, Human Resources (HRD),	Determinant	OPSKAMLA Performan	9.	the quality of teachers and the teaching pattern.	Determinant	OPSKAMLA educatio

	operational and Mechanism / Procedure.		ce				n
2.	Organizational Strategy, Information Technology / Exchange Data and Coordination / communication optimization.	Determinant	Organizational Structure	10.	OPSKAMLA Education, Socialization of maritime law and maritime law access capability	Determinant	OPSKAMLA Knowledge
3.	OPSKAMLA Education, OPSKAMLA Knowledge and Officer with investigator skills	Determinant	Human Resources (HRD)	11.	The Investigating Officers Course and Legal Studies Scholarship Program	Determinant	Officer with investigator skills
4.	Elements / units capabilities (KRI, MPA), logistic distribution system, support naval base and OPSKAMLA sector.	Determinant	Operational	12.	KRI Capability, Naval Command Center Capability (early detection), MPA Optimization, Seaman Professionalism and Support Naval Base	Determinant	Elements / units capabilities (KRI, MPA)
5.	Government Regulation and OPSKAMLA SOP.	Determinant	Mechanism / Procedure	13.	Fuel quota and the pattern of fuel distribution to Naval Base	Determinant	Logistic distribution system
6.	Policy of TNI AL leaders and the TNI AL Duties Implementation	Determinant	Organizational Strategy	14.	Berthing / anchorage / Runways Facility, Fuel Facilities, Repair Facility, juristic Support and Intelligence Function Optimization.	Determinant	Support Naval Base
7.	Integration of Infrastructure Facilities and TNI AL leaders policy.	Determinant	Information Technology / Exchange Data	15.	the Level of operation area vulnerability and threats / violations forms	Determinant	Support Naval Base

			quality				
8.	Organizational strategy and coordination pattern	Determinant	Coordination / communication optimization				

c. Design Coding Scheme.

Raw causal maps encoding process which is an expert language into certain codes to facilitate the process of final cognitive maps construction. Table 3 shows the code or password for each of basic phrases in the variable.

Table 3. Code wording

NO.	BASIC PHRASES	CODEWORD	NO.	BASIC PHRASES	CODEWORD
1.	OPSKAMLA PERFORMANCE	KAMLA	10.	OPSKAMLA KNOWLEDGE	KNOWLEDGE
2.	ORGANIZATIONAL STRUCTURE	ORGANIZATION	11.	OFFICER WITH INVESTIGATOR SKILLS	OFFICER
3.	HUMAN RESOURCES (HRD)	HRD	12.	ELEMENTS / UNITS CAPABILITIES (KRI, MPA)	CAPABILITIES
4.	OPERATIONAL	OPERATIONAL	13.	LOGISTIC DISTRIBUTION SYSTEM	LOGISTIC
5.	MECHANISM / PROCEDURE	PROCEDURE	14.	SUPPORT NAVAL BASE	NAVAL BASE
6.	ORGANIZATIONAL STRATEGY	ORGANIZATIONAL STRATEGY	15.	OPSKAMLA SECTOR	SECTOR
7.	INFORMATION TECHNOLOGY / EXCHANGE DATA	DATA INFORMATION	16.	COORDINATION PATTERN	COORDINATION
8.	COORDINATION / COMMUNICATION OPTIMIZATION	COORDINATION OPTIMIZATION	17.	THE TNI AL DUTIES IMPLEMENTATION	TNI AL DUTIES
9.	OPSKAMLA EDUCATION	EDUCATION	18.	POLICY OF TNI AL LEADERS	POLICY
19.	INTEGRATION OF	INFRASTRUCTU	30.	FUEL QUOTA	FUEL

	INFRASTRUCTURE FACILITIES	RE			QUOTA
20.	THE QUALITY OF TEACHERS	TEACHERS QUALITY	31.	THE PATTERN OF FUEL DISTRIBUTION TO NAVAL BASE	FUEL DISTRIB UTION
21.	THE TEACHING PATTERN	TEACHING PATTERN	32.	BERTHING / ANCHORAGE / RUNWAYS FACILITY	BERTHIN G FACILITY
22.	SOCIALIZATION OF MARITIME LAW	SOCIALIZATION	33.	FUEL FACILITIES	FUEL FACILITI ES
23.	MARITIME LAW ACCESS CAPABILITY	LAW ACCESS	34.	REPAIR FACILITIES	REPAIR FACILITI ES
24.	THE INVESTIGATING OFFICERS COURSE	SUSPAIDIKLA	35.	JURISTIC SUPPORT	JURISTIC SUPPOR T
25.	LEGAL STUDIES SCHOLARSHIP PROGRAM	SCHOLARSHIP	36.	INTELLIGENCE FUNCTION OPTIMIZATION	INTEL
26.	KRI CAPABILITY	KRI	37.	THE LEVEL OF OPERATION AREA VULNERABILITY	VULNER ABILITY
27.	NAVAL COMMAND CENTER CAPABILITY (EARLY DETECTION)	PUSKODAL	38.	THREATS / VIOLATIONS FORMS	VIOLATI ONS FORMS
28.	MPA OPTIMIZATION	MPA	39.	OPSKAMLA SOP	OPSKAM LA SOP
29.	SEAMAN PROFESSIONALISM	PROFESSIONALI SM	40.	LAW / GOVERNMENT REGULATION	GOVERN MENT REGULA TION

d. Convert Raw Causal Maps into Coded Causal Maps

The last step that is transcribed code that has been compiled in the previous step into the coded maps. Each basic phrases code in the variable is drawn into the node and connected by using the edge. The modeling with causal mapping is shown in Fig. 2.

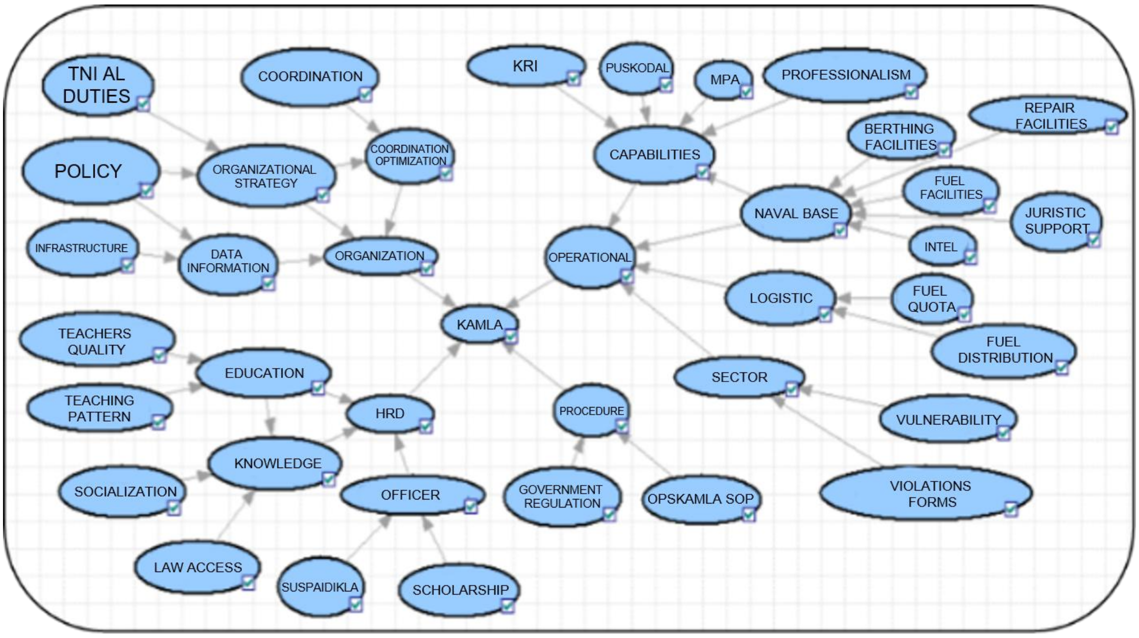

Fig.2. OPSKAMLA Causal Map

2.6.3 Modification of Causal Maps

In addition to completing encrypted causal maps, it is also necessary to modify a causal map to build a Bayesian network. In addition to example in Fig. 3 (Iqbal, et al., 2015).

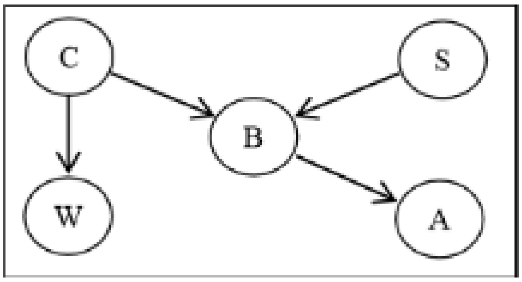

Fig. 3 Example of Bayesian network

C and S are the parents of B while A is the child of B. Similarly, W is the child of C. Furthermore, several independence statements can be observed amongst variables in BN. For instance, B creates conditionally dependency; otherwise C and S are independent from each other. Likewise, W and B become conditionally independent when C is given. Also, A is conditionally independent from its ancestors C and S if B is given.

To achieve Bayesian Network (Nadkarni & Shenoy, 2004) suggested to notice at four major problem in modification of the model, namely: conditional independencies, reasoning underlying the link between concepts, distinction between direct and indirect relations and eliminating circular relations. To resolve this the experts can be provided the concepts in the form of an adjacency matrix, where the rows represent causes and columns represent effects. The experts are asked to enter ‘0’(no relation), ‘+’ (positive relation) or ‘-’ (negative relation) in each cell to specify the relation between two concepts in the matrix as shown in Table 4.

Table 4. Matrix adjacency

Effects \ Causes	ORGANIZATIONAL STRATEGY	DATA INFORMATION	COORDINATION OPTIMIZATION	EDUCATION	OFFICER	KNOWLEDGE	CAPABILITIES	LOGISTIC	NAVAL BASE	SECTOR	COORDINATION	TNI AL DUTIES	POLICY	INFRASTRUCTURE	TEACHERS QUALITY	TEACHING PATTERN	SOCIALIZATION	LAW ACCESS	SCHOLAR SHIP	SUS PAIDIKLA	KRI	PUS KODAL	MPA	PROFES SIONALISM	FUEL QUOTA	FUEL DISTRIBUTION	BERTHING FACILITIES	FUEL FACILITIES	REPAIR FACILITIES	JURISTIC SUPPORT	INTEL	VULNER ABILITY	VIOLATIONS FORMS	OPS KAMLA SOP	GOVERNMENT REGULATION	PROCEDURE	OPERATIONAL	HRD	ORGANIZATION	KAMLA
ORGANIZATIONAL STRATEGY		0	+	0	0	0	0	0	0	0	0	+	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0
DATA INFORMATION	0		0	0	0	0	0	0	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0
COORDINATION OPTIMIZATION	+	+		0	0	0	0	0	0	0	+	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0
EDUCATION	0	0	0		0	+	0	0	0	0	0	0	0	0	+	+	0	0	+	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0
OFFICER	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	+	+	+	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0
KNOWLEDGE	0	0	0	+	+		0	0	0	0	0	0	0	0	+	0	+	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0
CAPABILITIES	0	0	0	0	0	0		0	+	0	0	0	0	0	0	0	0	0	0	0	+	+	+	+	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0	0
LOGISTIC	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	+	0	0	0	0	0	0	0	0	0	0	+	0	0	0
NAVAL BASE	0	0	0	0	0	0	+	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	+	+	+	+	0	0	0	0	0	+	0	0	0
SECTOR	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	+	+	0	0	0	+	0	0	0
COORDINATION	0	+	+	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0
TNI AL DUTIES	+	0	+	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0
POLICY	+	+	+	0	0	0	0	0	0	0	0	0		+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0
INFRASTRUCTURE	0	+	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0
TEACHERS QUALITY	0	0	0	+	0	+	0	0	0	0	0	0	0	0		+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0
TEACHING PATTERN	0	0	0	+	0	+	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0
SOCIALIZATION	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0
LAW ACCESS	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0
SCHOLARSHIP	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0
SUSPAIDIKLA	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0
KRI	0	+	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0	0
PUSKODAL	0	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0	0
MPA	0	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0	0
PROFESSIONALISM	0	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	+	0	0	0
FUEL QUOTA	0	0	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	+	0	0	0
FUEL DISTRIBUTION	0	0	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	+	0	0	0
BERTHING FACILITIES	0	0	0	0	0	0	+	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	+	0	0	0
FUEL FACILITIES	0	0	0	0	0	0	+	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	+	0	0	0
REPAIR FACILITIES	0	0	0	0	0	0	+	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	+	0	0	0
JURISTIC SUPPORT	0	0	0	0	0	0	+	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	+	0	0	0
INTEL	0	0	0	0	0	0	+	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	+	0	0	0
VULNERABILITY	0	0	0	0	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	+	0	0	0
VIOLATIONS FORMS	0	0	0	0	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	+	0	0	0
OPSKAMLA SOP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	+	0	0	0	0
GOVERNMENT REGULATION	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		+	0	0	0	0
PROCEDURE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	+		0	0	0	+
OPERATIONAL	0	0	0	0	0	0	+	+	+	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	+
HRD	0	0	0	+	+	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	+
ORGANIZATION	+	+	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		+
KAMLA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	+	+	+	

2.6.4 Derivation of Parameters of Bayesian Network

The final step in Modelling is create a Bayesian network parameter derivation. The focus of causal maps is to analyze the structure of the map using network analysis techniques (Knoke & Kuklisnki, 1982). Consequently, the uncertainty associated with the different variables in causal map is not captured by a causal map (Nadkarni & Shenoy, 2004). All variables assumed uncertainty on same level. In this research, state space associated with variables is based on the interpretation of experts in OPSKAMLA. Table 5 shows the state of each of the variables contained in the bayesian network model.

Tabel 5. Variable State

o	Concept	Description	States	No	Concept	Description	States
1.	Kamla	The OPSKAMLA performance implemented by TNI AL in the eastern region is influenced by organizational structure, human resources, operations and mechanisms /	Strong, Weak	12.	Capabilities	Quantity and ability of elements from technical, weaponry and censorship.	Strong, Weak

		procedures.					
2.	Organization	Structure Organizational that has been able to accommodate the task of law enforcement at sea and all the problems.	Good, Notgood	13.	Logistic	Ability to manage logistic support running smoothly, proportionally and timely in support of OPSKAMLA.	Good, Notgood
3.	HRD	The quality and professionalism of TNI AL personnel in the implementation of the task of opskamla primarily as an investigator.	Good, Notgood	14.	Naval Base	Ability to provide administrative and logistical support in order to secure the continuity of the operational of TNI AL elements / units.	Strong, Weak
4.	Operational	TNI AL capability in executing OPSKAMLA pattern in area aspect, element / unit deployment, Logistic usage and element / unit capability.	High, Low	15.	Sector	OPSKAMLA sector assignment based on consideration of threat and vulnerability level of the operating areas.	Good, Notgood
5.	Procedure	The procedures and mechanisms contained in the regulations, whether issued by the government or internal TNI AL in OPSKAMLA implementation.	Good, Notgood	16	Coordination	Procedures for improving coordination with other Maritime Security agencies so that OPSKAMLA can be effective.	Good, Notgood
6.	Organizational Strategy	the Organizational Structure improvement that can accommodate OPSKAMLA in TNI AL.	Good, Notgood	17.	TNI AL Duties	Duties implementation and TNI AL roles listed in Laws of the Republic of Indonesia number 34 of 2004 concerning Armed Foces.	Good, Notgood
7.	Data Information	The TNI AL ability to obtain data and	Good, Notgo	18.	Policy	Regulations made by the TNI leaders so that all	Good, Notgoo

		information using technology so as to facilitate law enforcement at sea	od			seaman can perform the task of TNI AL.	d
8.	Coordination Optimization	The TNI AL ability to establish communication and coordination with other agencies so as to facilitate law enforcement at sea.	Good, Notgood	19.	Infrastructure	The integrated ability of each Maritime Security agency to explores, processes and processing data / information and uses it, in current condition is working independently.	Good, Notgood
9.	Education	The TNI AL ability to organize learning about OPSKAMLA to support TNI AL personnel capabilities in OPSKAMLA implementation.	Good, Notgood	20.	Teachers Quality	Abilities / expertise from military teachers who master the material about OPSKAMLA.	Good, Notgood
10.	Knowledge	Ability to know the legislation by the TNI AL personnel so they can carry out OPSKAMLA according to procedure / SOP.	Good, Notgood	21.	Teaching Pattern	Presentation technique in learning OPSKAMLA materials so the goal in learning can be achieved	Good, Notgood
11.	Officer	Increased ability and amount of officers with investigator skills so they can implement investigations according to procedures / SOP.	Good, Notgood	22.	Socialization	Understanding and perceptions equating of the International Sea Law and Maritime law for TNI AL Officers.	Good, Notgood
23.	Law Access	The Navy ability to provide all actual maritime legislation and all derivative rules until their translation terms and procedures access to Navy Officers,	Good, Notgood	32.	Berthing Facility	The dock facility and its equipment are used to support all TNI AL warship activities and runways facility for take off and landing of Navy MPA.	Good, Notgood

24.	Suspaidikla	Courses that teach TNI AL officers to have qualifications as investigators of criminal cases at sea.	Good, notgood	33.	Fuel Facilities	The ability to facilitate the logistics required by elements / units implementing OPSKAMLA among others fuel, ammunition, personel logistic and other	Good, Notgood
25.	Scholarship	TNI AL ability in implementing educational scholarship program Faculty of law undergraduate, post graduade and doctoral.	Good, notgood	34.	Repair Facilities	Naval base facilities the serves as a maintenance and repair facility for TNI AL warships and MPA that are conducting OPSKAMLA	Good, Notgood
26.	KRI	KRI Quantity and ability from technical, weaponry and censorship.	Strong, Weak	35.	Juristic Support	The Naval Base capability to facilitating the judicial process of sea violatios	Good, Notgood
27.	Puskodal	Early detection capabilities possessed by TNI AL namely Integrated Maritime Surveillance System Radar (IMSS) operating system, WAN : Wide Area Network, Auto Position Monitoring System, Close Circuit Television (CCTV) and Web-based News Communications	Strong, Weak	36.	Intel	Intelligence function Naval Base to obtain valid information about the existence of a criminal action plan at sea because all criminal offenses are largely initiated planning from land-based.	Good, Notgood
28.	MPA	Naval MPA Quantity and ability in conducting maritime air patrol.	Good, Notgood	37.	Vulnerability	The frequency of occurrence of certain criminal cases at sea in certain operating areas.	High, Low
29.	Professionalism	TNI AL personel to work in accordance with their respective duties and	High, Low	38.	Violations Forms	Threats of certain criminal cases in the sea such as illegal fishing, illegal migrants, illegal logging,	Strong, Weak

		responsibilities on OPSKAMLA.				illegal mining and others.	
30.	Fuel Quota	Limitations on fuel usage to support OPSKAMALA for KRI and MPA	High, Low	39.	OPSKAMLA SOP	Procedures governing the Hot Pursuit process and rules in order to enforce the law and maintain security at sea	Good, Notgood
31.	Fuel Distribution	The distribution volume regulation in Main Command level adjusted proportionally.	Good, Notgood	40.	Government Regulation	The rules or norms established by the state that govern law enforcement and security at sea	Good, Notgood

3. Result And Discussion

3.1 Result

Following all the states are defined, then enter the state of each of the predefined variables into Genie 2.0 software presented in Figure 4.

3.2 Filling Prior Probability

Possible values are used to fill prior probability derived from the questionnaire which had been distributed to three experts. The filled probability value is the average of it. Table 6 shows each probability value which is the prior probability of each parent nodes.

The prior probability value according experts perception and existing condition. For example, the independent variable of KRI is quality and quantity condition of it. Presented in Table 6.

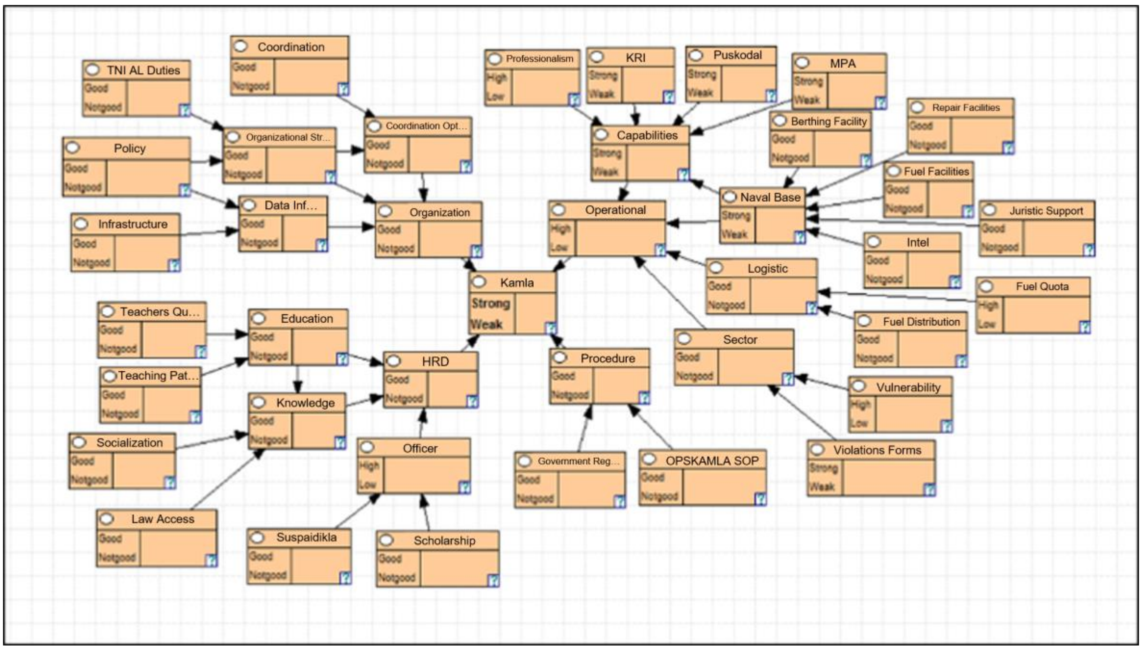

Fig.4. OPSKAMLA Performance Variable State

Table 6. Prior Probability for each Parent Nodes

NO	NODE NAME	PROBABILITY OF	EXPERT **1**	EXPERT **2**	EXPERT **3**	AVERAGE
1	COORDINATION	STATE 1	50%	35%	35%	40%
		STATE 2	50%	65%	65%	60%
2	TNI AL DUTIES	STATE 1	70%	60%	50%	60%
		STATE 2	30%	40%	50%	40%
3	POLICY	STATE 1	75%	70%	80%	75%
		STATE 2	25%	30%	20%	25%
4	INFRASTRUCTURE	STATE 1	40%	35%	60%	45%
		STATE 2	60%	65%	40%	55%
5	TEACHERS QUALITY	STATE 1	60%	50%	70%	60%
		STATE 2	40%	50%	30%	40%
6	TEACHING PATTERN	STATE 1	50%	65%	50%	55%
		STATE 2	50%	35%	50%	45%
7	SOCIALIZATION	STATE 1	45%	60%	75%	60%
		STATE 2	55%	40%	25%	40%
8	LAW ACCESS	STATE 1	60%	75%	75%	70%
		STATE 2	40%	25%	25%	30%
9	SUSPAIDIKLA	STATE 1	70%	80%	60%	70%
		STATE 2	30%	20%	40%	30%
10	SCHOLARSHIP	STATE 1	55%	75%	65%	65%
		STATE 2	45%	25%	35%	35%
11	PROFESSIONALISM	STATE 1	70%	80%	60%	70%
		STATE 2	30%	20%	40%	30%
12	KRI	STATE 1	60%	70%	65%	65%
		STATE 2	40%	30%	35%	35%
13	PUSKODAL	STATE 1	50%	35%	35%	40%
		STATE 2	50%	65%	65%	60%
14	MPA	STATE 1	55%	80%	60%	65%
		STATE 2	45%	20%	40%	35%
15	BERTHING FACILITY	STATE 1	50%	60%	70%	60%
		STATE 2	50%	40%	30%	40%
16	REPAIR FACILITIES	STATE 1	45%	60%	60%	55%
		STATE 2	55%	40%	40%	45%
17	FUEL FACILITIES	STATE 1	65%	60%	55%	60%
		STATE 2	35%	40%	45%	40%
18	JURISTIC SUPPORT	STATE 1	60%	65%	70%	65%
		STATE 2	40%	35%	30%	35%
19	INTEL	STATE 1	65%	60%	55%	65%

		STATE 2	35%	40%	45%	35%
20	FUEL QUOTA	STATE 1	50%	70%	75%	65%
		STATE 2	50%	30%	25%	35%
21	FUEL DISTRIBUTION	STATE 1	70%	60%	65%	65%
		STATE 2	30%	40%	35%	35%
22	VULNERABILITY	STATE 1	70%	65%	75%	70%
		STATE 2	30%	35%	25%	30%
23	VIOLATIONS FORMS	STATE 1	70%	85%	85%	80%
		STATE 2	30%	15%	15%	20%
24	OPSKAMLA SOP	STATE 1	75%	80%	85%	80%
		STATE 2	25%	20%	15%	20%
25	GOVERNMENT REGULATION	STATE 1	65%	60%	55%	60%
		STATE 2	35%	40%	45%	40%

3.3 Discussion

Following the model is validated by the experts, the next step is to implement data processing to achieve the desired objectives using Genie (General Network Interface) 2.0. The independent variable data is fed into each state of the independent variable as well as dependent variable data. From the software calculation, resulting OPSKAMLA performance implemented by TNI AL has a strength of 64% and 36% weakness. as shown in Fig. 5.

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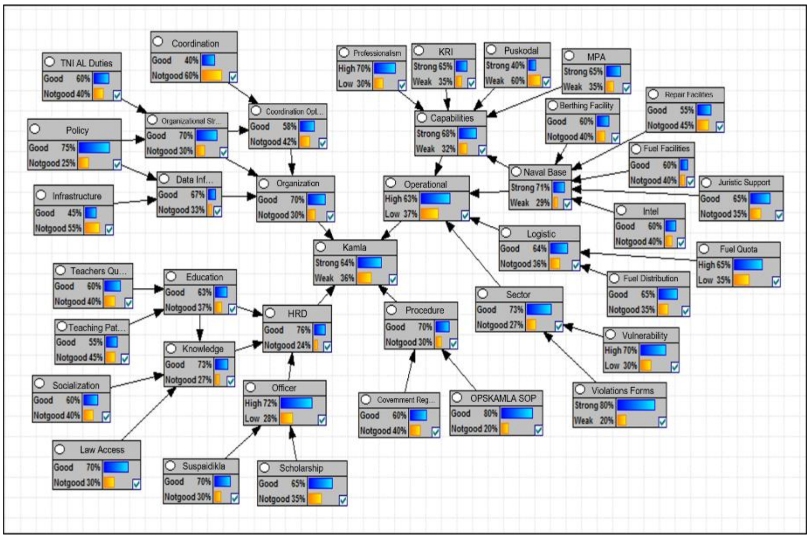

Fig.5. OPSKAMLA Performance Result

To determine whether the model is running in accordance with the desired, then carried out verification by putting hard evidence (100%) on variable Coordination, . as shown in Fig. 6.

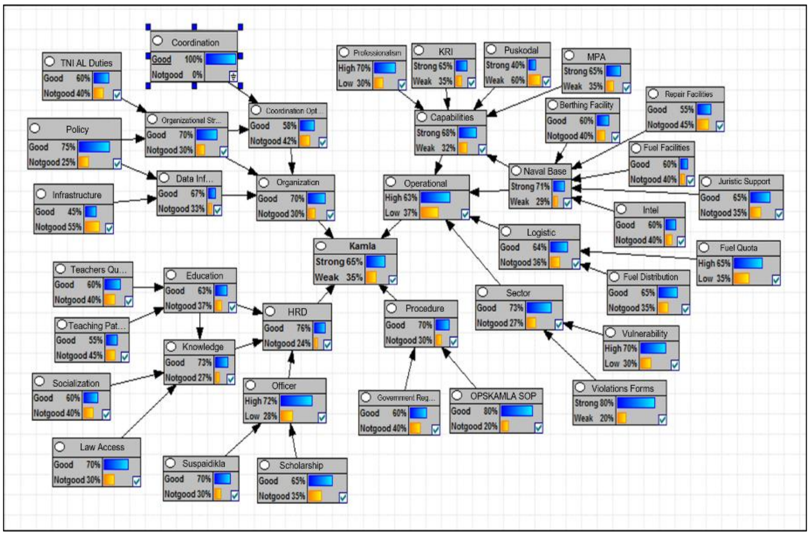

Fig. 6. OPSKAMLA Performance Modification

From Fig. 6, OPSKAMLA performance changes from 64% to 65% by changing the evidence level Caoordination variable with 100%. This proves that computer program can run in accordance as desired

3.4 Sensitivity Analysis

Sensitivity analysis is performed by changing the prior probability distribution of each node in the range of 0% - 100%. Through this experiment, will note where the biggest changes occurred in systems after the parameter is changed

a. Policy. This variable is chosen as the determining factor in Organization viewpoint because it has the highest sensitivity level. The prior probability changes generate posterior probability range between 58.90% to 65.10%. The sensitivity of Policy to Kamla is shown in Figure 7. From the graph can be seen a significant increase from the range prior probability 0% - 50% to the posterior probability value. While in the range prior probability 60% -100% increase in sensitivity decreased

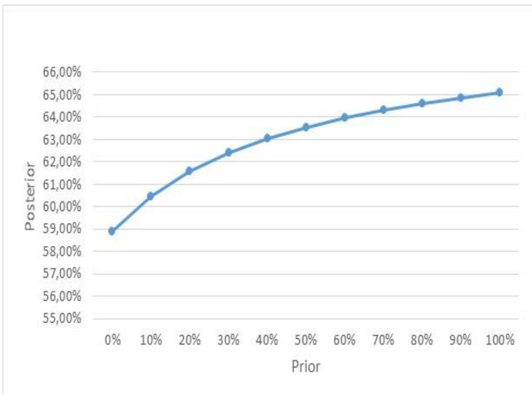

Fig.7. Policy Sensitivity Analysis

b. Teachers Quality. From the results of parameter change on determinant variable in HRD perspective, Teachers Quality ranked the highest with a posterior probability range between 60.82% to 65.37% as shown in Figure 8. From the graph, constant increase of prior probability value is followed by a constantly increasing tendency of sensitivity to the posterior probability value because the teachers always adjust to the technological development and dynamic situation.

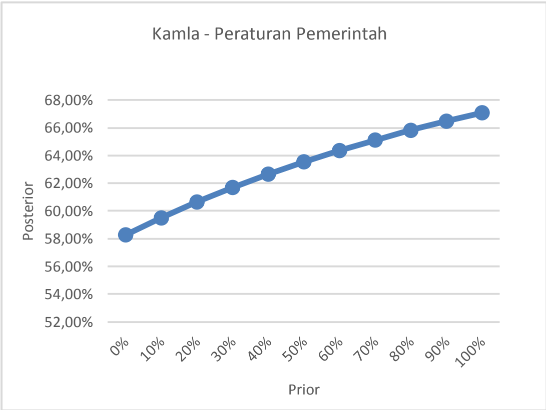

Fig. 8. Teachers Quality Sensitivity Analysis

c. Fuel Quota. Determinant variable in the Operational Viewpoint and has the highest ranking. Posterior probability range obtained between 61.28% s.d 64.77%. The sensitivity graph of the Fuel Quota for Kamla is shown in Figure 9. Increase in posterior probability value sensitivity from priority probability range 0% - 50% is significant, however in the range prior probability of 60% - 100% there is a decreased sensitivity. Due to nature of fuel is consumable, the higher of fuel usage then OPSKAMLA will be more efficiently and effectively.

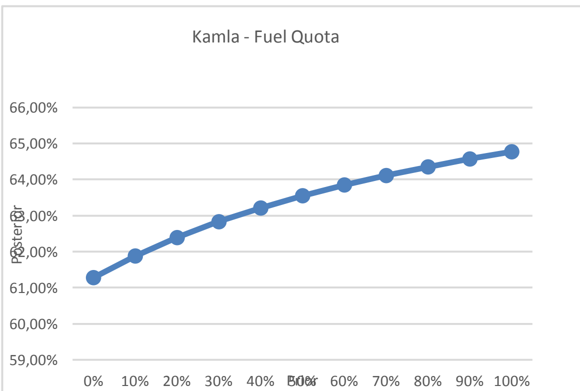

Fig.9. Fuel Quota Sensitivity Analysis

d. Government Regulation. Determinant variable and has the highest sensitivity level in Procedure viewpoint. Posterior probability range obtained between 58.28% s.d 67.09%. The sensitivity graph of the Government Regulation on OPSKAMLA performance is shown in Figure 10. It can be concluded that there is an increase in decreased sensitivity as Policy variable.

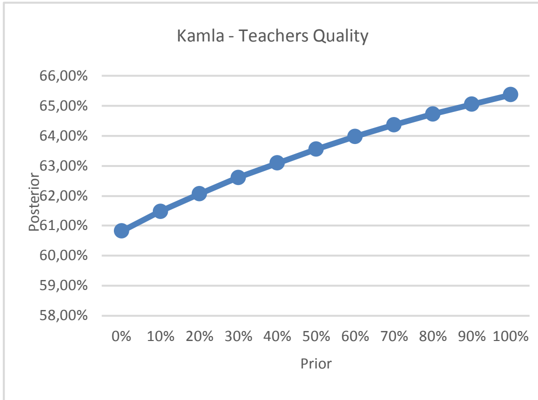

Fig. 10. Government Regulation Sensitivity Analysis

4. Conclusion

From the implementation of the study, it can be concluded :

a. TNI AL capability in implementing Opskamla in the eastern region has a performance of 64%. This needs to be improved and demands serious attention, especially in determining the strategies and policies terms and the improvement of each Opskamla performance variables.

b. This model consists of 25 independent variables and 15 dependent variables that construct OPSKAMLA performance. Through sensitivity analysis, there are 4 independent determinant variable which influence on OPSKAMLA performance model, Namely Policy with posterior probability range 58.90% - 65.10%, Teachers Quality posterior probability range 60.82% - 65.37%, Fuel Quota with posterior probability range 61.28% s.d 64.77% and Government Regulation with posterior probability range 58.28% s.d 67.09%. these four variables should be a point of concern for policy makers to improve OPSKAMLA performance in the eastern region.

REFERENCES

Ang, K. C., 2004. *Appliying Bayesian Belief Networkrs In Sun Tzu's Art Of War.* Monterrey: Thesis Naval Post Graduate School.

Asops, 2004. *Maritime Security Operations Guide Book.* Jakarta: Indonesian Navy Headquarter.

Asops, 2004. *Navy Operation Concept to enforce sovereignty and security at sea.* Surabaya: FPSO.

Borsuk, M. E., Stow, C. A. & Reckhow, K. H., 2003. *Journal : A Bayesian Network of Eutrophication Models of Synthesis Prediction and Uncertainty Analysis,.* USA: University of South Carolina.

Cain, J., 2001. *Guidelines for Using Bayesian Networks to Support The Planning and Management of Developement Programmes In The Water sector and Beyond.* Wallingford: Oxon.

Day, D., DeSarbo, W. & Oliva, T., 1987. Strategy maps: A spatial representation of. *Management Science,* pp. 33 (12), 1534-1551.

Goverment, 2004. *Laws of the Republic of Indonesia number 34 of 2004 concerning Armed Foces.* s.l.:Goverment.

Goverment, 2008. *Laws of the Republic of Indonesia number 17 of 2008 concerning Shipping.* s.l.:Goverment.

Hill, A. B., 1980. *The Environment and Disease : Asociation or Causation.* UK: Proceedings of The Royal Society of Medicine.

Hitchcock, J., 2001. *Effective Strong with Applications to Information and Complexity.* USA: University of Wyoming.

Iqbal, K. et al., 2015. An Overview of Bayesian Network Applications in Uncertain Domains. *International Journal of Computer Theory and Engineering,* Volume 7.

Kasal, 2011. *Principles of TNI AL Policy.* Jakarta: Indonesian Navy Headquarter.

Knoke, K. & Kuklisnki, J., 1982. *Network Analysis.* California: Sage.

Koarmatim, 2013. *Appreciation on the Optimization of Duties of the Navy in Order to Enforce Laws and Keep Security At Sea National Jurisdiction of Indonesia.* Surabaya: East Fleet Command.

Mabesal, 2002. *Maritime Security White Book.* Jakarta: Indonesian Navy Headquarter.

Mabesal, 2005. *Maritime Air Surveys Guide Book.* Jakarta: Indonesian Navy Headquarter.

Mabesal, 2009. *Navy Standard Operating Procedure for Law Enforcement and Maritime Security in National Jurisdiction Sea.* Jakarta: Indonesian Navy Headquarter.

Mabesal, 2011. *Principles of Maritme Security.* Jakarta: Indonesian Navy Headquarter.

Mabesal, 2011. *The Posture of the Navy until 2024.* Jakarta: Indonesian Navy Headquarter.

Nadkarni, S. & Shenoy, P. P., 2001. A Bayesian Network Approah to Making Inferences in Causal Maps. *European Journal Of Operation Research,* pp. 479-498.

Nadkarni, S. & Shenoy, P. P., 2004. A Causal maaping Approach To Constructing Bayesian Networks. *Decision Support System, Vol 38,* pp. 259-281.

NATIONS, U., 1982. *UNITED NATIONS CONVETION ON THE LAW OF THE SEA.* s.l.:UNITED NATIONS.

Neapolitan, R. E., 2004. *Learning Bayesian Network.* Chicago, Illionis: Peason Pentice Hall.

Neuman, W., 2000. *Social Research Methods : Qualitative and Quantitative Approaches, 4th ed.* Boston, USA: University of Winconsin.

Reilly, W. S. N. et al., 2004. *Journal : Modelling The Effect of Behaviour for Simulation Based Human FActors Design.* s.l.:Charles River Analytics.

Starr, C. & Shi, P., 2004. *Journal : An Introduction to Bayesian Belief Networks and their Applications to Land Operations Departement of Defence.* s.l.:Australia Departement of Defence.

Tsaridas, A. & amd Margaritis, K., 1997. Cognitive Mapping and Certainty Neuron Cognitive. *Information Science,* pp. 109-130.

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ANALYSIS OF HEALTHCARE SERVICES QUALITY IN NAVAL HOSPITAL DR.RAMELAN USING SERVQUAL - FUZZY METHOD

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ABSTRACT

Service Quality is a very important concept that must be understood if the company wants to remain competitive and evolving. Quality of service in hospitals should be directed to patient satisfaction, it is to maintain patient loyalty. With the development of business competition, it is important to make health care providers improving their service qualities. Customer satisfaction is an important key to service quality management. from the initial sampling, obtained the data of customer dissatisfaction in Dr.Ramelan hospital by 41.47%. It is necessary to do research to determine the cause of this customer dissatisfaction. The purpose of this research is to identify the gap between perception and expectation of customer to health service at inpatient unit of Dr.Ramelan hospital. This paper used servqual method which was integrated with fuzzy method. Based on the results of this study, it was showed that the attributes of X_5 (bathroom hygiene and clean water availability) had the greatest gap of 25 health service attributes identified at the Dr.Ramelan hospital, with gap score -0,0433. The second on attribute X_{18} (The availability of doctors and nurses at the time of patient need) with a gap score of -0,0364. And the third on attribute X_{10} (Fast, accurate examination, treatment and treatment services) with a gap score of -0,0354. Based on the results of this paper, it could be concluded that the results could assist the management of the hospital in determining the policy strategy by prioritizing attributes that have a big gap to improve the quality of its services.

KEYWORD : Service quality, fuzzy, Health care.

1. INTRODUCTION

One of the important concepts in management and business is service quality. Service quality is a very important concepts that companies must understand if they want to remain competitive and evolving. Service quality becomes increasingly important for today's business, particularly in high-customer involvement industries such as healthcare services (Punnakitikashem, et al., 2012). Health care service providers should disseminate correct information from time to time as more quality information leads to patient awareness and satisfaction (Dave & Dave, 2014). Service quality in hospitals should be directed towards the satisfaction of patients (Rafidah, et al., 2016). Service quality and customer satisfaction have been recognized as the main preserve of curtomer loyalty (Anderson & Mittal, 2000).

With the development of business competition, it is important to make health care providers improving their service qualities. Customer satisfaction is an important key to service quality management. from the initial sampling, obtained the data of customer dissatisfaction in Dr.Ramelan hospital by 41.47%. it is necessary to do research to determine the cause of this customer dissatisfaction. This research is to analyze how the quality of health service in inpatient unit of Dr.ramelan Surabaya hospital. Based on the results of this study, it could be conclude that it can assist the management of the hospital in determining the policy setrategy by prioritizing attributes that have a big gap to improve the quality of its services.

The purpose of this paper was to identify the gaps between customer expectations of a service and their perceptions of service at Dr.Ramelan hospital, particularly in inpatient units. This paper used a Servqual approach that was integrated with the fuzzy method to gain a gap between the perceptions and expectations of consumers. This approach had been used extensively to assess the quality of private sector services, but there was little application to public services (Munhurrun, et al., 2010).

This paper had many literature to support the research, for example paper titled “A Conceptual Model of Service Quality and Its Implications for Future Research” (Parasuraman, et al., 1985) and other research such as SERVQUAL : A Multiple-Item Scale for Measuring Consumer Perseptions of Service Quality (Parasuraman, et al., 1988). Five Imperatives for Improving Service Quality (Parasuraman, et al., 1990). Health Care Service Quality: Case Example of a Hospital with Lean Implementation (Punnakitikashem, et al., 2012). A study on Service quality and customer satisfaction of selected Private hospitals of Vadodara City (Dave & Dave, 2014). Service Quality and Determinants Of Customer Satisfaction In Hospitals: Turkish Experience (Zaim, et al., 2010). A Comparative Study of Service Quality on Patient Satisfaction Between Public Hospital in Johor Bahru (Rafidah, et al., 2016). Impact of Service Quality on Customers’ Satisfaction (Bharwana, et al., 2013). Essentials for improving service quality in cancer care (Berrya & Mate, 2016). A Review on Dimensions of Service Quality Models (Yarimoglu, 2014). Service Quality in the Public Service (Munhurrun, et al., 2010).

The other literature supporting this paper was Measuring Consumer Satisfaction in Healthcare Sectore : The Applicability of Servqual (Chakraborty & Majumdar, 2011). The Dimensions of Service Quality for Hospital (Duffy, et al., 2001). Factors influencing healthcare service quality (Mosadeghrad, 2014). Hospital Service Quality and its Effect on Patient Satisfaction and Behavioural Intention (Amin & Nasharuddin, 2013). The Assessment of Perceived Service Quality of Public Health Care Services in Romania Using the SERVQUAL Scale (Lorin, et al., 2013). SERVQUAL: Measuring higher education service quality in Thailand (Yousapronpaiboon, 2014). Service quality assessment in health care sector: the case of Durres public hospital (Kalaja, et al., 2016). Assessing Obstetrics Perceived Service Quality at a Public Hospital (Martins, et al., 2015). (Lowrie, et al., 2015)

The results of this study can be used by the management of the hospital as a material consideration in determining the policy strategy to improve the quality of service. This paper was organized as follows. Section 1 is Introduction. Section 2 is about Material and Methodology. Section 3 is result and discussion of the research. Finally, in section 5 presents conclusion of this paper.

2. MATERIALS AND METHODOLOGY

2.1. Service Quality

The first is that customers are the sole judge of service quality. Customers assess service by comparing the service they receive (perceptions) with the service they desire (expectations) (Parasuraman, et al., 1990). Majority of research pertaining to service quality has focused on the measurement of service quality based on the functional dimension (James & Kang, 2004). The techniques of measuring service quality and service quality dimensions have become a major area in marketing literature during the past few decades (Yarimoglu, 2014).

Service quality is identified into ten dimensions, which the customer uses to evaluate the service quality. They are reliability, responsiveness, competence, access, courtesy, communication, credibility, security, understanding/knowing the customer, and tangibles (Parasuraman, et al., 1985). Thus, Servqual is developed from a modification of ten dimensions to five principal dimensions customers, which are tangibles, reliability, responsiveness, assurance and empathy (Parasuraman, et al., 1990). The instrument in servqual is summarized in five dimensions called service quality model (The Gaps Models). Service Quality Model is a model that can analyze the gap between two main variables, the services expected by the customers (expectation) and services they receive (perception) (fig.1)

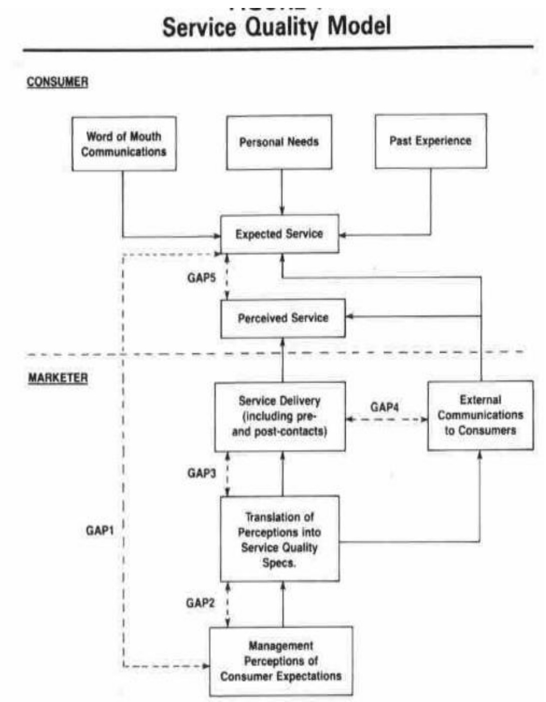

Fig 1. Service Quality Model

(Parasuraman, et al., 1985)

2.2. Fuzzy

Generally, the fuzzy set is an extension of the crisp set, the set that divides a group of individuals into two categories, namely members and non-members (Rose, et al., 2004). Fuzzy number is a special fuzzy set F = {(x,$\mu_F(x)$), x € R} where x where x is the values that lie on the line of real numbers. R^1 ; -∞< x < +∞ R :1 and μ_F is a continuous mapping of R^1 into the closed interval [0, 1] (Chan, et al., 1999). Fuzzy number is used to describe non-precise numerical concepts. A triangular fuzzy number (TFN), expressed by M = (a,b,c), where a<b<c, is a special fuzzy number and has the following type triangular membership function (Zadeh, 1965):

$$\mu_M(x) = \begin{cases} 0, & \text{if } x \leq a \\ (x-a)/(u-a), & \text{if } a < x \leq u \\ (x-b)/(u-b), & \text{if } u < x \leq b \\ 0, & \text{if } x \geq b \end{cases} \qquad (1)$$

2.3. Methodology of Research

The methodology of this research is described as follows:

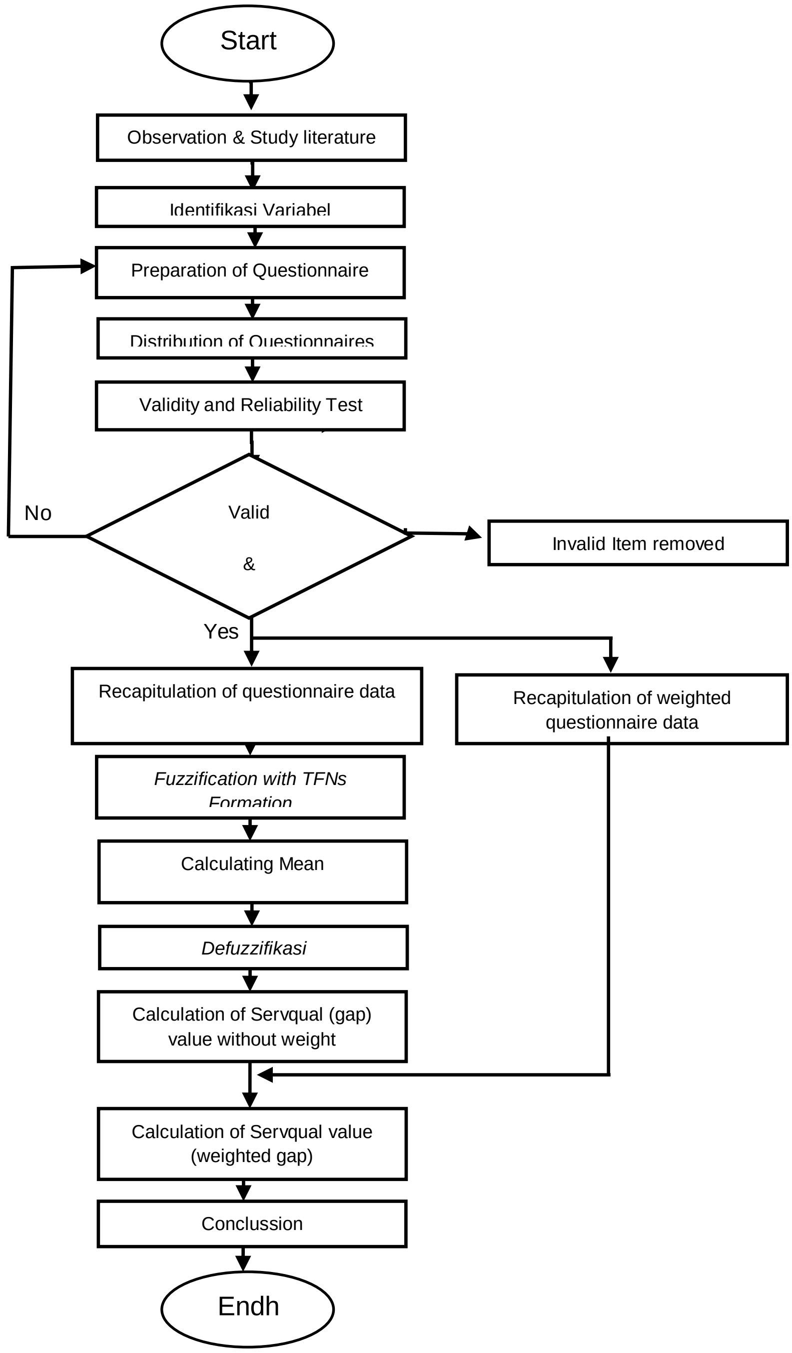

Fig 2. Flowchart of the research

The stages of this research were data collection, validity and reliability test, fuzzyfication, calculation of mean value, defuzzyfication, calculation of servqual value without weight, calculation of weight of each variable, calculation of weighted servqual value. The stage of data collection in this study was performed to identify the attributes of health services, preparation of questionnaire, and distribute the questionnaire to the respondents. Respondents used in this research were patient or family of patient in Dr.Ramelan hospital, especially in inpatient units In this research, a total amount of 25 attributes of health services had been identified to be assessed by the respondents, such attributes were:

Table.1 Attribute of health services

Tangibles	(X_1)	Convenient to Inpatient unit location
	(X_2)	Cleanliness, tidiness and comfort of the bedroom
	(X_3)	lighting and bedroom ventilation
	(X_4)	completeness of bedroom facilities
	(X_5)	Cleanliness of the bathroom and availability of clean water
	(X_6)	The availability of medication required by the patient
	(X_7)	Completeness, readiness and cleanliness of medical devices used
	(X_8)	Neatness and cleanliness of the appearance of doctors and nurses
	(X_9)	Taste and variety of food menu served
reliability	(X_{10})	Fast, accurate examination, treatment and treatment services
	(X_{11})	The patient's examination schedule is performed appropriately
	(X_{12})	The service procedure is not complicated
	(X_{13})	easy to contact the hospital staff
responsiveness	(X_{14})	The nurse's alertness when the patient needs help
	(X_{15})	The ability of doctors and nurses to resolve patient complaints
	(X_{16})	Doctors and nurses provide a clear and understandable information
assurance	(X_{17})	Attention to patients who need service
	(X_{18})	The availability of doctors and nurses at the time of patient need
	(X_{19})	The ability of doctors to analyze the disease
	(X_{20})	The accuracy of the medical team handles the patient
empathy	(X_{21})	Patience of nurses in caring for patients
	(X_{22})	Courtesy and hospitality of nurses and doctors
	(X_{23})	patient easy complaint submission

	(X_{24})	The ability of doctors and nurses to provide moral support to patients
	(X_{25})	Service to all patients regardless of social status

3. RESULT AND DISCUSSION

3.1. Result.

In this study, Likert scale was used as measuring tools in the questionnaire. Questionnaires were distributed to 98 respondents randomly at the inpatient unit of the Dr.ramelan hospital. The test validity and reliability from the results of the questionnaire were performed with SPSS 17.0 software.

Fuzzification of respondent's data (perception and expectation) was done by changing the result of respondent appraisal (in likert scale) to form fuzzy number with formation TFN_s (Triangular Fuzzy Number).

Table. 2 fuzzyfication perception for attributes X_1

Res pon den.	Atribut X1				Res pon den.	Atribut X1				Res pon den.	Atribut X1			
	Nil ai	Fuzzy				Nil ai	Fuzzy				Nil ai	Fuzzy		
		Low	Crisp	Upp			Low	Crisp	Upp			Low	Crisp	Upp
1	3	2	3	4	34	4	3	4	5	67	2	1	2	3
2	3	2	3	4	35	4	3	4	5	68	4	3	4	5
3	3	2	3	4	36	3	2	3	4	69	4	3	4	5
4	3	2	3	4	37	3	2	3	4	70	4	3	4	5
5	5	4	5	6	38	4	3	4	5	71	4	3	4	5
6	4	3	4	5	39	3	2	3	4	72	5	4	5	6
7	5	4	5	6	40	4	3	4	5	73	5	4	5	6
8	3	2	3	4	41	3	2	3	4	74	4	3	4	5
9	3	2	3	4	42	2	1	2	3	75	4	3	4	5
10	3	2	3	4	43	3	2	3	4	76	5	4	5	6
11	3	2	3	4	44	3	2	3	4	77	4	3	4	5
12	4	3	4	5	45	5	4	5	6	78	3	2	3	4
13	3	2	3	4	46	4	3	4	5	79	3	2	3	4
14	3	2	3	4	47	4	3	4	5	80	4	3	4	5
15	3	2	3	4	48	3	2	3	4	81	5	4	5	6
16	4	3	4	5	49	4	3	4	5	82	3	2	3	4

17	3	2	3	4	50	4	3	4	5	83	3	2	3	4
18	5	4	5	6	51	3	2	3	4	84	3	2	3	4
19	5	4	5	6	52	3	2	3	4	85	4	3	4	5
20	3	2	3	4	53	2	1	2	3	86	3	2	3	4
21	5	4	5	6	54	3	2	3	4	87	3	2	3	4
22	3	2	3	4	55	4	3	4	5	88	3	2	3	4
23	5	4	5	6	56	4	3	4	5	89	3	2	3	4
24	4	3	4	5	57	5	4	5	6	90	4	3	4	5
25	3	2	3	4	58	3	2	3	4	91	4	3	4	5
26	4	3	4	5	59	4	3	4	5	92	4	3	4	5
27	4	3	4	5	60	4	3	4	5	93	3	2	3	4
28	2	1	2	3	61	3	2	3	4	94	4	3	4	5
29	5	4	5	6	62	3	2	3	4	95	4	3	4	5
30	3	2	3	4	63	3	2	3	4	96	4	3	4	5
31	4	3	4	5	64	4	3	4	5	97	3	2	3	4
32	3	2	3	4	65	4	3	4	5	98	3	2	3	4
33	3	2	3	4	66	3	2	3	4					

After all the fuzzification results obtained in each attribute, then the average (perceptions and expectations of respondents) from each attribute was calculated, and the defuzzification stage was subsequently performed.

Table. 3 Mean Perceptions of Respondents (Fuzzy) and Defuzzyfication

Attribute	Fuzzy			Defuzzyfication	Attribute				Defuzzyfication
	Low	Crisp	Upp			Low	Crisp	Upp	
X_1	2.59	3.59	4.59	3.50	X_{14}	2.87	3.87	4.87	3.78
X_2	2.58	3.58	4.58	3.49	X_{15}	2.85	3.85	4.85	3.76
X_3	2.82	3.82	4.82	3.73	X_{16}	2.79	3.79	4.79	3.70
X_4	2.60	3.60	4.60	3.51	X_{17}	2.86	3.86	4.86	3.77
X_5	2.31	3.31	4.31	3.20	X_{18}	2.73	3.73	4.73	3.64

X_6	2.70	3.70	4.70	3.61	X_{19}	2.68	3.68	4.68	3.59
X_7	2.65	3.65	4.65	3.56	X_{20}	2.88	3.88	4.88	3.79
X_8	2.97	3.97	4.97	3.88	X_{21}	2.70	3.70	4.70	3.61
X_9	2.39	3.39	4.39	3.29	X_{22}	2.94	3.94	4.94	3.85
X_{10}	2.64	3.64	4.64	3.55	X_{23}	2.72	3.72	4.72	3.63
X_{11}	2.68	3.68	4.68	3.59	X_{24}	2.68	3.68	4.68	3.59
X_{12}	2.62	3.62	4.62	3.53	X_{25}	2.72	3.72	4.72	3.63
X_{13}	2.59	3.59	4.59	3.50					

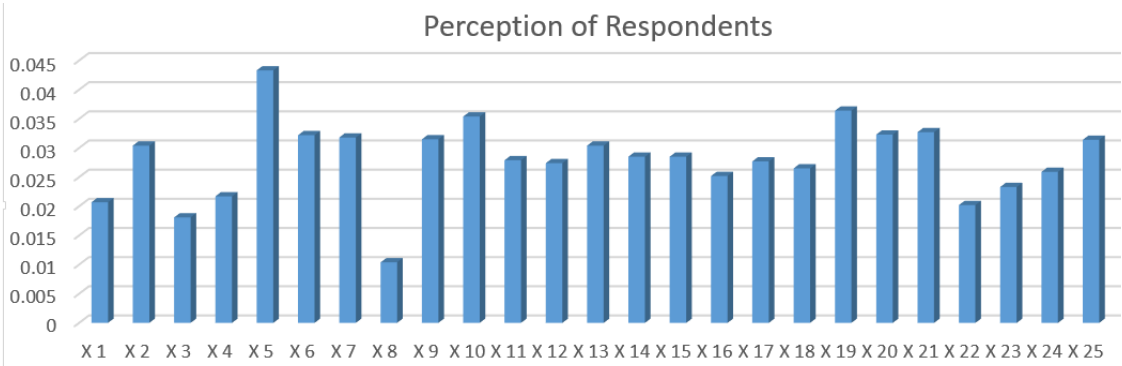

Fig 3. Perception of Respondents

Table. 4 Mean Expectation of Respondents (Fuzzy) and Defuzzyfication

Attribute	Fuzzy			Defuzzyfication	Attribute				Defuzzyfication
	Low	Crisp	Upp			Low	Crisp	Upp	
X_1	3.16	4.16	5.16	4.08	X_{14}	3.54	4.54	5.54	4.47
X_2	3.34	4.34	5.34	4.26	X_{15}	3.45	4.45	5.45	4.37
X_3	3.29	4.29	5.29	4.21	X_{16}	3.44	4.44	5.44	4.36
X_4	3.17	4.17	5.17	4.09	X_{17}	3.48	4.48	5.48	4.40
X_5	3.40	4.40	5.40	4.32	X_{18}	3.44	4.44	5.44	4.36
X_6	3.47	4.47	5.47	4.39	X_{19}	3.54	4.54	5.54	4.47
X_7	3.41	4.41	5.41	4.33	X_{20}	3.58	4.58	5.58	4.51
X_8	3.23	4.23	5.23	4.15	X_{21}	3.48	4.48	5.48	4.40
X_9	3.27	4.27	5.27	4.19	X_{22}	3.44	4.44	5.44	4.36

X_{10}	3.45	4.45	5.45	4.37		X_{23}	3.31	4.31	5.31	4.23
X_{11}	3.36	4.36	5.36	4.28		X_{24}	3.34	4.34	5.34	4.26
X_{12}	3.32	4.32	5.32	4.24		X_{25}	3.47	4.47	5.47	4.39
X_{13}	3.35	4.35	5.35	4.27						

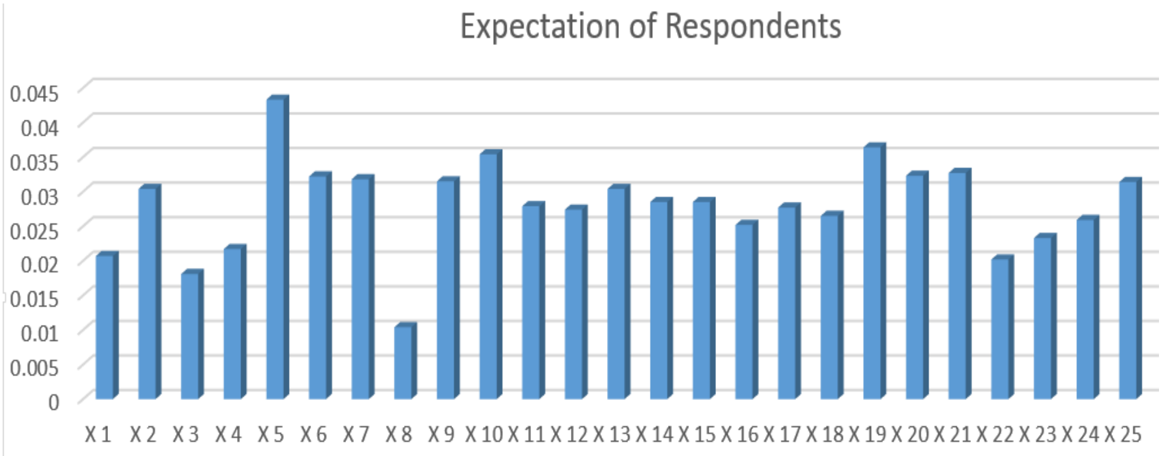

Fig 4. Expectation of Respondents

The next stage was the calculation of servqual value (gap) without weight (Table 5).

Servqual Value (gap score) = Mean of Perception - Mean of Expectation

Table. 5 Servqual value (gap score) without weight

attribute	Perception	Expectation	Gap score		attribute	Perception	Expectation	Gap score
X_1	3.50	4.08	-0.59		X_{14}	3.78	4.47	-0.69
X_2	3.49	4.26	-0.77		X_{15}	3.76	4.37	-0.61
X_3	3.73	4.21	-0.48		X_{16}	3.70	4.36	-0.67
X_4	3.51	4.09	-0.59		X_{17}	3.77	4.40	-0.64
X_5	3.20	4.32	-1.12		X_{18}	3.64	4.36	-0.72
X_6	3.61	4.39	-0.78		X_{19}	3.59	4.47	-0.88
X_7	3.56	4.33	-0.77		X_{20}	3.79	4.51	-0.72
X_8	3.88	4.15	-0.27		X_{21}	3.61	4.40	-0.79

X_9	3.29	4.19	-0.90		X_{22}	3.85	4.36	-0.51
X_{10}	3.55	4.37	-0.82		X_{23}	3.63	4.23	-0.59
X_{11}	3.59	4.28	-0.69		X_{24}	3.59	4.26	-0.67
X_{12}	3.53	4.24	-0.71		X_{25}	3.63	4.39	-0.76
X_{13}	3.50	4.27	-0.77					

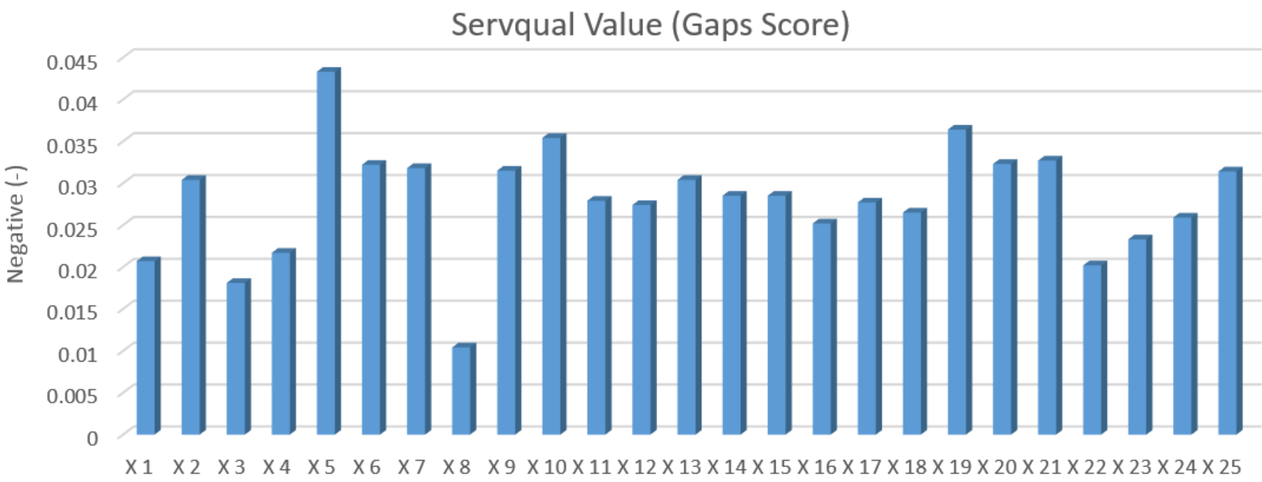

Fig 5. Servqual value (gap score) without weight

The next step after the obtained of servqual value without weight performed was the weighting of each attribute. In this study, the weighing of the attribute was performed by calculating the value average of each service quality attribute given by the respondent. Weighted questionnaires were distributed to experts in the health sector, in this case the staff of Dr.Ramelan hospital as many as 10 respondents. Based on the distributed questionnaire data, the results of weighting each attribute were obtained as follows (Table 6):

Table. 6 Weight value of attribute

No	Attribute	Weight		No	Attribute	Weight
1	X_1	0.0350		14	X_{14}	0.0413
2	X_2	0.0395		15	X_{15}	0.0413
3	X_3	0.0377		16	X_{16}	0.0413

4	X_4	0.0368		17	X_{17}	0.0413
5	X_5	0.0386		18	X_{18}	0.0422
6	X_6	0.0413		19	X_{19}	0.0413
7	X_7	0.0413		20	X_{20}	0.0449
8	X_8	0.0386		21	X_{21}	0.0413
9	X_9	0.0350		22	X_{22}	0.0395
10	X_{10}	0.0431		23	X_{23}	0.0395
11	X_{11}	0.0404		24	X_{24}	0.0386
12	X_{12}	0.0386		25	X_{25}	0.0413
13	X_{13}	0.0395				

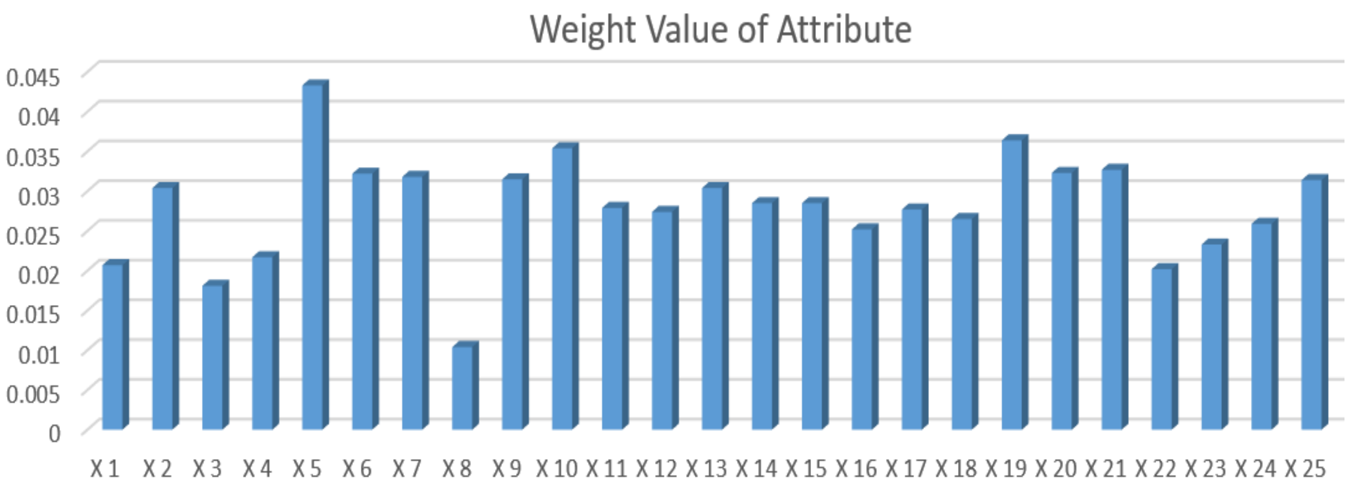

Fig 6. Weight value of attribute

After the result of weighting each attribute were obtained, servqual weighted value was subsequently counted by multiplying servqual value without weight with weight value of each attribute (Table.7).

Table. 7 Result of final Servqual value (gap score)

No	Attribute	Servqual without weight	Weight	Gap score		No	Attribute	Servqual without weight	Weight	Gap score
1	X_1	-0.59	0.0350	-0.0207		14	X_{14}	-0.69	0.0413	-0.0285
2	X_2	-0.77	0.0395	-0.0304		15	X_{15}	-0.61	0.0413	-0.0285
3	X_3	-0.48	0.0377	-0.0181		16	X_{16}	-0.67	0.0413	-0.0252
4	X_4	-0.59	0.0368	-0.0217		17	X_{17}	-0.64	0.0413	-0.0277
5	X_5	-1.12	0.0386	-0.0433		18	X_{18}	-0.72	0.0422	-0.0265
6	X_6	-0.78	0.0413	-0.0322		19	X_{19}	-0.88	0.0413	-0.0364
7	X_7	-0.77	0.0413	-0.0318		20	X_{20}	-0.72	0.0449	-0.0323
8	X_8	-0.27	0.0386	-0.0104		21	X_{21}	-0.79	0.0413	-0.0327
9	X_9	-0.90	0.0350	-0.0315		22	X_{22}	-0.51	0.0395	-0.0202
10	X_{10}	-0.82	0.0431	-0.0354		23	X_{23}	-0.59	0.0395	-0.0233
11	X_{11}	-0.69	0.0404	-0.0279		24	X_{24}	-0.67	0.0386	-0.0259
12	X_{12}	-0.71	0.0386	-0.0274		25	X_{25}	-0.76	0.0413	-0.0314
13	X_{13}	-0.77	0.0395	-0.0304						

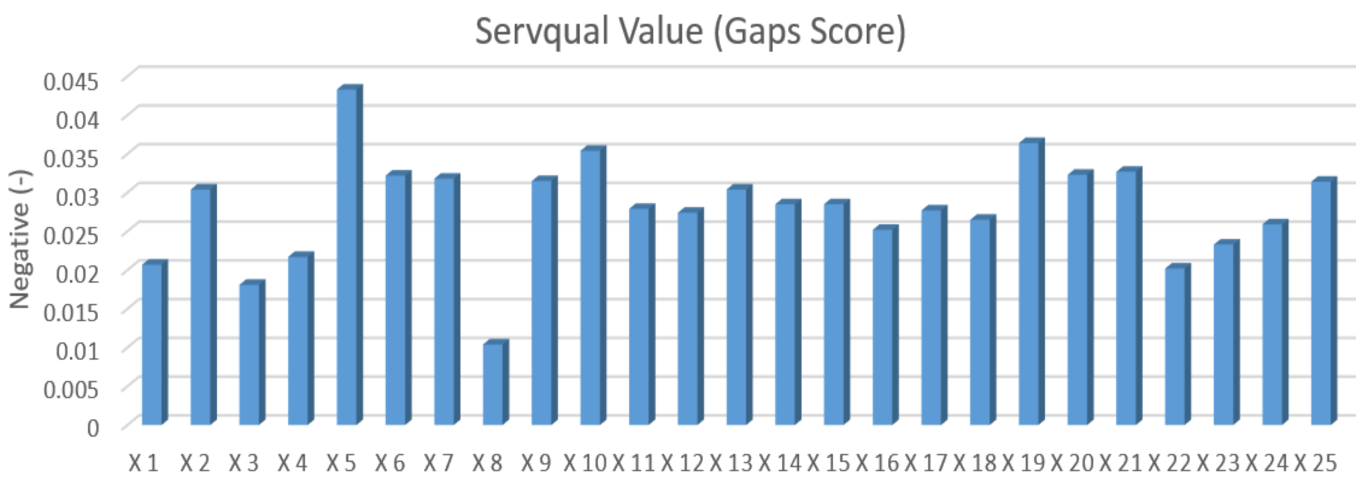

Fig 7. Final of Servqual value (gap score)

3.2. Discussion

The respondent's perception value indicated the level of service quality received by the patient during the use of health services at Dr. Ramelan hospital. Based on the average value of respondent perception, attribute X5 (Cleanliness of the bathroom and availability of clean water) had the lowest value, while the attribute X8 (Neatness and cleanliness of the appearance of doctors and nurses) had the highest value. The expectation value of the respondent showed the respondent's willingness to the quality of service that should be given by Dr. Ramelan hospital. The highest expectation value was the attribute of doctors' ability to analyze the disease (X_{19}). Whereas the smallest expectation value was the attribute of X_1 (Convenient to Inpatient unit location).

The analysis of servqual without weight was performed to find out how big the gap between perception and expectation of respondent to health service in Dr. Ramelan hospital. Based on the results of this calculation, the attribute X_5 (Cleanliness of the bathroom and availability of clean water) had the largest gap, this showed the biggest gap between the perception and expectations of respondents to this attribute. While the smallest gap value was the attribute of Neatness and cleanliness of the appearance of doctors and nurses (X_8).

From the weighting of each attribute by the hospital management, the highest value of weight on attribute X_{19} (The ability of doctors to analyze the disease) was obtained. While the lowest weight value was in the Convenient to Inpatient unit location (X_1) attribute. In the final result, a weighted servqual value with the highest gap was obtained in the attribute of Cleanliness of the bathroom and availability of clean water (X_5) with a score of -0,0433, The availability of doctors and nurses at the time of patient need (X_{18}) with a score of -0,0364, and attribute of Fast, accurate examination, treatment and treatment services (X_{10}) with a score of -0,0354. this indicated that these attributes should be a prioritized to improve service quality.

4. CONCLUSION

Based on the results and discussion above, the policy strategy that can be taken by hospital management to improve the quality of service was prioritizing service quality improvement, the first on attribute X_5 (Cleanliness of the bathroom and availability of clean water) with a gap score of -0,0433. The second on attribute X_{18} (The availability of doctors and nurses at the time of patient need) with a gap score of -0,0364 and the third on attribute X_{10} (Fast, accurate examination, treatment and treatment services) with a gap score of -0,0354. Attributes these services were assessed by customers was the least quality.

5. REFERENCES

AMIN, M. & NASHARUDDIN, S. Z., 2013. HOSPITAL SERVICE QUALITY AND ITS EFFECT ON PATIENT SATISFACTION AND BEHAVIOURAL INTENTION. *CLINICAL GOVERNANCE : AN INTERNATIONAL JOURNAL,* VOLUME 18 NO 3, PP. 238-254.

Anderson, E. W. & Mittal, V., 2000. Strengthening the satisfaction - profit chain. *Journal of Service Research,* Volume 3 No 2, pp. 107-120.

Berrya, L. L. & Mate, K. S., 2016. Essentials for improving service quality in cancer care. *Healthcare,* Volume 4, pp. 312-316.

Bharwana, T. K., Bashir, D. M. & Mohsin, M., 2013. Impact of Service Quality on Customers' Satisfaction. *International Journal of Scientific and Research Publications,* 3(5).

Chakraborty, D. R. & Majumdar, A., 2011. Measuring Consumer Satisfaction in Healthcare

Sectore : The Applicability of Servqual. *Journal of Arts, Science & Commerce,* II(4), p. 149.

Dave, D. D. R. & Dave, R., 2014. A study on Service quality and customer satisfaction of selected Private hospitals of Vadodara City. *Pacific Business Review International,* 6(11).

Duffy, J. et al., 2001. The Dimensions of Service Quality for Hospital. *Healthcare Management Review,* Volume 26, pp. 47-59.

James, J. & Kang, G.-D., 2004. Service quality dimensions: an examination of Gronroos's service quality model. *Managing Service Quality ,* Volume 14, pp. 266-277.

Kalaja, R., Myshketa, R. & Scalera, F., 2016. Service quality assessment in health care sector: the case of Durres public hospital. *Procedia - Social and Behavioural Sciences ,* Volume 235, pp. 557-565.

Lorin, V., Gheorghe, L. R. & Petrescu, C. M., 2013. The Assessment of Perceived Service Quality of Public Health Care Services in Romania Using the SERVQUAL Scale. *Procedia Economics and Finance,* Volume 6, pp. 573-585.

Lowrie, D. B., Li, M., Huang, C. Y. & Lu, X. C., 2015. Evaluating Patients Perception of Service Quality at Hospital in Nine Chinese Cities by use of the Servqual Scale. *Asian Pacific Journal of Tropical Biomedicine,* Volume 5 No 6, pp. 497-504.

Martins, A. L., Carvalho, J. C. d., Ramos, T. & Fael, J., 2015. Assessing Obstetrics Perceived Service Quality at a Public Hospital. *Procedia - Social and Behavioural Sciences ,* Volume 181, pp. 414-422.

Mosadeghrad, A. M., 2014. Factors influencing healthcare service quality. *International Journal of Health Policy and Management,* Volume 3 No 2, pp. 77-89.

Munhurrun, P. R., Bhiwajee, S. D. L. & Naidoo, P., 2010. Service Quality in The Public Service. *International Journal of Management And Marketing Research,* Volume 3 no 1.

Parasuraman, A., Berry, L. L. & Duke, V. A. Z., 1990. Five Imperatives for Improving Service Quality. *Sloan Management Review,* Volume 31 no 4, pp. 29-38.

Parasuraman, A., Zeithaml, V. A. & Berry, L. L., 1985. A Conceptual Model of Service Quality and Its Implications for Future Research. *Journal of Marketing,* Volume 49, pp. 41-50.

Parasuraman, A., Zeithaml, V. A. & Berry, L. L., 1988. SERVQUAL : A Multiple-Item Scale for Measuring Consumer Perseptions of Service Quality. *Journal of Retailing,* Volume 64 No 1.

Punnakitikashem, P., Buavaraporn, N., Maluesri, P. & Leelartapin, K., 2012. *Health Care Service Quality: Case Example of a Hospital with Lean Implementation.* Chicago, POM Journal.

Rafidah, A., Nurulhuda, A. & Suhaila, Y., 2016. A Comparative Study of Service Quality on Patient Satisfaction Between Public Hospital in Johor Bahru. *SCIREA Journal of Agriculture ,* 1(2).

Yarimoglu, E. K., 2014. A Review on Dimensions of Service Quality Models. *Journal of Marketing Management ,* Volume 2, pp. 79-93.

Yousapronpaiboon, K., 2014. SERVQUAL: Measuring higher education service quality in Thailand. *Procedia - Social and Behavioural Sciences,* Volume 116, pp. 1088-1095.

Zadeh, L. A., 1965. Fuzzy Sets. *Information and Control,* Volume 8, pp. 338-353.

Zaim, H., Bayyurt, N. & Zaim, S., 2010. Service Quality And Determinants Of Customer Satisfaction In Hospitals: Turkish Experience. *International Business & Economics Research Journal,* Volume 9 No 5.

Indonesian Naval Technology College
Postgraduate International Conference, Vol. 1, No. 1, pp. 120-127
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DETERMINE OPTIMUM AMPHIBIOUS RAID TARGET IN AMPHIBIOUS OPERATION USING PROMETHEE ANALYSIS

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ABSTRACT

Indonesia as one of world archipelagic country has larger water area than its land area. It has unrestricted sea access to the main shoreline and generated threat to Indonesian territorial sovereignty. An amphibious operation is a sea to land war operation and it most suitable for Indonesian geographic. Amphibious raid can be combined with amphibious assault in Amphibious operation. The aim of the paper is determining the optimum amphibious raid target that gives best impact and effectivity. Promethee analysis approach compares alternatives target based on 6 criteria. Criteria used for determining landing point are the value of the target, time to reach the target area, obstacle of the lane, a risk of detected, vehicles availability and withdrawal support. From 3 alternatives given by data simulation, the best alternative has 3 benefits from given 6 criteria.

KEYWORDS : Amphibious operation, Amphibious raid, Promethee.

1. INTRODUCTION

Indonesia that located in south-east Asia has coverage of area approximately 7,9 million square kilometers, is one of world archipelagic country (Persoon & Weerd, 2006). It has 13.466 named islands stretched in equatorial, which 5 main islands are Sumatra, Java, Borneo, Celebes and Papua (Tumonggor & et. al., 2013). It gets to benefit from the geographical position as central to cross line Asia and Australia Continent and Indian and Pacific Ocean (Manurung, 2016). The changed of goods delivery method from land transportation route (silk road) to ocean shipping transportation made Indonesia become connector of Eurasian Blue Belt that gives them great strategical value (Habova, 2015).

Indonesian people blessed with larger water coverage compared to their land area, approximately 63% (Hutomo & Moosa, 2005). Plenty of natural resources especially mining resources and the fishing product must be managed well to increase people prosperity (Subekti, 2013). Indonesia has lots of volcanoes from Aceh in the north of Sumatra stretched until Moluccas (Rinard Hinga, 2015). High rainfall rate and soil fertility as the effect of volcanoes eruption create large of rainforest area in Indonesia. The most important of all, Indonesia has 3 world shipping line: ALKI 1, ALKI 2 and ALKI 3 (Vantier, et al., 2005).

In another hand, this geographical benefit gives weaknesses in the transportation sector. They found difficulties for their transportation as land transport vehicles cannot reach all the landscape (Ralahatu & Jinca, 2013). This situation creates centralized of developing in Java Island. Indonesia needs good water transportation facilities to support the movement of humans, goods, and technology to the rest of the country (Georgescu, 2014). The structure of Indonesian islands composition and unrestricted access from the sea in lots of shorelines increase maritime vulnerability (Bakir, 2007). The government needs to assure national security and unity of Indonesian territory. Defense Ministry gets this role, and it executes by Indonesian Armed Force (TNI) (Indonesia, 2004).

Indonesia embraces active defensive defense principal (Indonesia, 2015). It’s mean that Indonesia will avoid expansion to another nation, but will be ready to eliminate every threat from outside. This principal need responsive defense system. It affected in last 10 years defense posture development be the main priority of Defense Ministry that booked in Indonesian Minimum Essential Force (MEF) (Piesse, 2015). This military policy made an extension of the dynamic changes of military power in South East Asia and Pacific region (Shekhar, 2013).

Java Island as the center of Indonesian government and economics activities in Indonesia. This circumstance followed by military power concentrated in Java. Defense elements composition in islands other than Java are adequate, create susceptible areas especially in nation borders (Guild & Carrera, 2013). This situation can increase eagerness of invasion to Indonesia territory.

An amphibious operation is war operation that most suited for enemy’s beach area assault. The amphibious operation generally described as troops attack movement from sea to beach foundation area using amphibious vehicles. Amphibious operation initially with battleship maneuver in the sea to deploy amphibious vehicles. Amphibious operation arranged by a good collaboration of communication and water movement between the battleship and amphibious landing unit. The accuracy of deciding beach foundation area that giving advantageous needed to ensure amphibious operation well executed (Navy, 2014).

Amphibious Surveillance Unit is an elite troop of Indonesian Marine Corps. It has best known in special military operation. Speed, secret and deadly ability are the main characteristic of this unit. All that descriptions make Amphibious Surveillance Unit especially used as a beach spies mission and amphibious raid (TNI AL, 2003).

One of the main war principal said that war must be finished in the shortest period (Tzu & Hou, 2003). This principle requires strategy developing from usual strategies. Shock factor in a battle can decide the result of war (Clausewitz & Gatzke, 1942). Technology and knowledge development make basic and plot strategies can learn handily. It became a vulnerable side to anticipate and exploited by enemies. Amphibious raid implementation concept planned an attack from the unpredicted side can boost chaos effect for enemies.

The aim of this paper is giving optimum amphibious raid target as an early part of amphibious operation using Promethee. Promethee used for determining best amphibious raid target option from available given alternatives.

Promethee developed by French professor Jean-Pierre Brans, is an abbreviation of Preference Ranking Organization Method for Enrichment of Evaluations (Figueira, et al., 2005). It calculates suitable alternatives for purpose and integrated problem understanding. Promethee determines decision problem rational and comprehensive, grouped action, identify and quantified conflict and synergy, and giving alternatives for a structured reason (Behzadian, et al., 2010).

The inscriptive benefit from this paper in giving academic contribution in amphibious operation which referenced to improving Indonesian national defense.

2. MATERIALS/METHODOLOGY

2.1. Promethee

Multi-criteria analysis help managers and leaders in the decision making of decision alternatives compared with some criteria (Department for Communities and Local Government, 2009). One of multi-criteria analysis methods popularly use is Promethee. Promethee generally used in one by one comparison based on criteria. This approach mostly applied to environmental management, business management, logistics and distribution, and factory production and assembly.

Promethee used to give a solution in:

a. Alternative decision-making
b. Priority decision making
c. Resources allocation
d. Ranking
e. Conflict resolution

Promethee process consists of:

a. Threshold value calculation
b. Preference degree value calculation
c. Preference index value calculation
d. Preference direction calculation

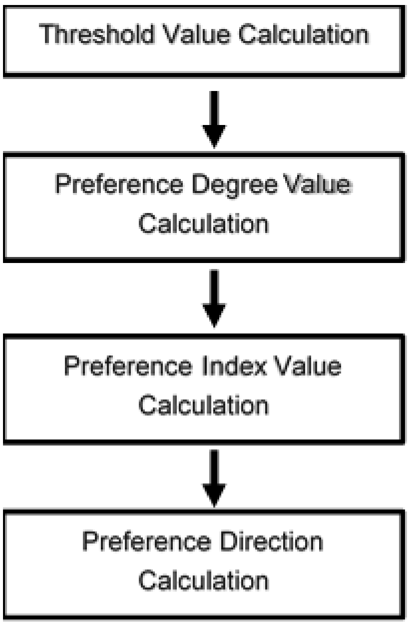

Fig. 1 Flowchart

Preference Value

Calculate preference value between alternatives using preference function

$$\mathrm{H(d)} = \begin{cases} 0 & \mathrm{d} \leq 0 \\ 1 & \mathrm{d} > 0 \end{cases} \quad \text{...(1)}$$

H(d) = criteria margin function

d = margin of first criteria and second criteria

Preference Index

Preference index is intensity of decision maker preference that stating first alternative is better than second alternative. Its considered simultaneously from all of criteria.

$$\varphi(\mathrm{a,b}) = \sum_{i=1}^{n} \pi_i P_i(\mathrm{a,b}) : \forall \mathrm{a,b} \in \mathrm{A} \quad \text{..........(2)}$$

$\varphi(\mathrm{a,b}) = 1$; strong preference a than b

$\varphi(\mathrm{a,b}) = 0$; weak preference a than b

Leaving flow

Leaving flow is node lead away from a point, for example point a.

$$\emptyset^{+}(\mathrm{a,x}) = \frac{1}{n-1} \sum_{X \in A} \varphi(\mathrm{a,x}) \quad \text{.........................(3)}$$

$\varphi(\mathrm{a,x})$ =alternative preference of a better than x

n = total value

Entering flow

Entering flow is node inside to a point, for example point a.

$$\emptyset^{-}(\mathrm{a,x}) = \frac{1}{n-1} \sum_{X \in A} \varphi(\mathrm{a,x}) \quad \text{.......................(4)}$$

$\varphi(\mathrm{a,x})$ = alternative preference of a better than x

n = total value

Net flow

Net flow is margin between leaving flow and entering flow

$$\emptyset = \emptyset^{+}(\mathrm{a}) - \emptyset^{-}(\mathrm{a}) \quad \text{......................................(5)}$$

2.2. Amphibious Operation

First amphibious operation performed by Continental Navy and Continental Marines in 1776 for Nassau War (Nassau Assault) in the Bahamas. The objectives of this attack are to capture Britain gunpowder storage, arms, and munitions. It engages 210 marines and 50 sailors utilize ships (Anderson, 1962). Based on usage, amphibious operation classified in 5 types (Navy, 2014):

a. Amphibious Raid
b. Amphibious Demonstration
c. Amphibious Assault
d. Amphibious withdrawal

e. Other Operations such as conflict prevention and disaster mitigation.

5 important phases of amphibious operation:

a. Planning; using backward planning start from landing vehicles maneuver.

b. Embarkation; prepare every material used to perform an amphibious operation.

c. Rehearsal; make sure every unit mastering their assignment.

d. Moving; consist of sea maneuver and preparation to debark amphibious vehicles into several phases.

e. Action; is projection amphibious operation to the land.

Amphibious operation planning conducted based on land movement to avoid miscommunication and allow good coordination when personal carrier vehicles reach beach foundation area.

2.3. Amphibious Raid

Amphibious raid is quick executed amphibious assault with a planned withdrawal. There are 3 main aspects of Amphibious Raid:

a. Speed

b. Stealthiness

c. Support

Speed is related to time needed to reach target area and obstacles in the lane. Stealthiness mean a risk of being detected by enemies from every movement we made. Support is a combination of landing vehicles availability and withdrawal plan support. Amphibious raid main task is to create destruction, secure the information, divide enemy's concentration and search and rescue personnel/material duty. Amphibious raid involves small unit and operated before or simultaneous with an amphibious assault.

Amphibious raid landing location criteria need to consider 3 main aspects above. Each criterion will be assessed using rating 1-5 depend on an advantage of each criterion refer to operation achievement :

a. 1 is a high disadvantage

b. 2 is a low disadvantage

c. 3 is neutral

d. 4 is a low benefit

e. 5 is a high benefit

Amphibious raid landing location criteria in this analysis determined as:

a. Value of target

b. Time to reach target area

c. The obstacle in the lane

d. Risk of detected

e. Landing Vehicles availability

f. Withdrawal support

Table 1. Criteria

Code	Criteria
C1	Value of target
C2	Time to reach target area
C3	Obstacle of the lane
C4	Risk of detected
C5	Landing vehicles availability
C6	Withdrawal support

Measurement score of every criterion are:

a. Value of target measured by the importance of each target for enemy side.

b. Time to reach target area measured by the time needed to reach each target.

c. Obstacle of the lane measured by difficulties on approach road to each target.

d. Risk of detected measured by enemy detection possibilities caused by raid amphibious movement.

e. Landing vehicles availability measured vehicles action complexity to approach each target.

f. Withdrawal support measured by difficulty for withdrawal movement.

2.4. Target

The target of analysis in this paper is giving an optimal target for amphibious raid based on criteria decided.

3. RESULT AND DISCUSSION

Given 3 alternative targets based on intelligent data simulation. Promethee analysis given by:

Table 2. Alternative targets

Target	A	B	C
C1	Communication center	Gunnery	Port
C2	80 minutes	60 minutes	40 minutes
C3	Hillside	Plain surface	Beach area
C4	Minimal risk	Considerable risk	Medium risk
C5	Difficult access	Accessible	Accessible
C6	Open withdrawal spot	Close withdrawal spot	Open withdrawal spot

Table 3. Scoring Table

	A	B	C
C1	5	4	3
C2	3	3	5
C3	2	4	3
C4	5	4	2
C5	1	4	4
C6	5	2	4

Table 4. Preference value

Criteria	(A,B)		(A,C)		(B,A)		(B,C)		(C,A)		(C,B)	
	d	H(d)	d	H(d)	d	H(d)	d	H(d)	d	H(d)	d	H(d)
C1	1	1	2	1	-1	0	1	1	-2	0	-1	0
C2	0	0	-2	0	0	0	-2	0	2	1	2	1

C3	-1	0	-1	0	2	1	1	1	1	1	-1	0
C4	1	1	3	1	-1	0	2	1	-3	0	-2	0
C5	-3	0	-3	0	3	1	0	0	3	1	0	0
C6	3	1	1	1	-3	0	-2	0	-1	0	2	1

Preference index

Multi criteria preference index result

(A,B) = $^{1}/_{6}$ (1+0+0+1+0+1) = 0.50

(A,C) = $^{1}/_{6}$ (1+0+0+1+0+1) = 0.50

(B,A) = $^{1}/_{6}$ (0+0+1+0+1+0) = 0.33

(B,C) = $^{1}/_{6}$ (1+0+1+1+0+0) = 0.50

(C,A) = $^{1}/_{6}$ (0+1+1+0+1+0) = 0.50

(C,B) = $^{1}/_{6}$ (0+1+0+0+0+1) = 0.33

Table 5. Preference index

	A	**B**	**C**
A	-	0.50	0.50
B	0.33	-	0.50
C	0.50	0.33	-

Leaving flow result for each alternative

A = 1/(3-1) (0.50+0.50) = 0.50

B = 1/(3-1) (0.33+0.50) = 0.417

C = 1/(3-1) (0.50+0.50) = 0.417

Entering flow result for each alternative

A = 1/(3-1) (0.50+0.50) = 0.417

B = 1/(3-1) (0.50+0.50) = 0.417

C = 1/(3-1) (0.50+0.25) = 0.50

Net flow as result of Promethee analysis

A = 0.50 – 0.417 = 0.083

B = 0.417 – 0.417 = 0

C = 0.417 – 0.50 = - 0.083

Promethee analysis for amphibious raid target selection based on criteria determined are:

Table 6. Overview result of Promethee

Alternative	Leaving flow	Entering flow	Net flow	Ranking
A	0.50	0.417	0.083	1
B	0.417	0.417	0	2
C	0.417	0.50	-0.083	3

4. CONCLUSION

From this paper analysis provide result:

a. Amphibious raid target selection evaluated with 6 criteria; Value of target, Time to reach target area, Obstacle of the lane, Risk of detected, Landing vehicles availability, and Withdrawal support.

b. Each alternative target based on intelligent data simulation has specific situation and analyzed using Promethee method.

c. Alternative A gives 3 benefits and 2 disadvantages. Alternative B gives 4 benefits and 1 disadvantages. Alternative C gives 3 benefits and 1 disadvantage.

d. Alternative A receives highest Net Flow score; 0,083 compared to 0 for alternative B and -0.083 for alternative C.

5. REFERENCES

Anderson, B., 1962. *By Sea and by Rier: The Naval History of the Civil War.* Massachusetts: Da Capo Press.

Bakir, N. O., 2007. *A Brief Analysis of Threats and Vulnerabilities in the Maritime Domain,* Los Angeles: Center for Risk and Economic Analysis of Terrorism Events (CREATE).

Behzadian, M., Kazemzadeh, R. B., Albadvi, A. & Aghdasi, M., 2010. PROMETHEE: A comprehensive literature review on methodologies and applications. *European Journal of Operational Research,* 200(1), pp. 198-215.

Clausewitz, C. v. & Gatzke, H. W., 1942. *Principles of War.* Pennsylvania: The Military Service Publishing Company.

Department for Communities and Local Government, 2009. *Multi-criteria analysis: a manual.* London: Department for Communities and Local Government.

Figueira, J., Greco, S. & Ehrgott, M., 2005. *Multiple Criteria Decision Analysis: State of the Art Surveys.* Berlin: Springer Verlag.

Georgescu, C., 2014. The Role of Maritime Transport in the Development of World Economy. *Knowloedge Horizon - Economics,* Volume 6, pp. 177-184.

Guild, E. & Carrera, S., 2013. *EU Border and Their Controls.* Brussels: CEPS Essay.

Habova, A., 2015. Silk Road economic belt: China's Marshall plan, pivot to Eurasia or China's way of foreign policy. *Knowledge Society Institute Journal,* Volume VIII.

Hutomo, M. & Moosa, M. K., 2005. Indonesian Marine and Coastal Biodiversity: Present Status. *Indian Journal of Marine Sciences,* 34(1), pp. 88-97.

Indonesia, D. M. o. T. R. o., 2015. *Defence White Paper.* Jakarta: Defence Ministry of The Republic of Indonesia.

Indonesia, P. R., 2004. *UNDANG-UNDANG REPUBLIK INDONESIA NOMOR 34 TAHUN 2004.* Jakarta: Kementerian Pertahanan.

Manurung, H., 2016. The Impacts of Indonesia and Russia Trade Relations on Indonesia's Maritime Security. *Journal of International Studies,* pp. 1-17.

Navy, U., 2014. *Joint Publication 3-02 Amphibious Operations.* Virginia: Joint Education and Doctrine.

Persoon, G. A. & Weerd, M. v., 2006. Biodiversity and Natural Resource Management in Insular Southeast Asia. *Island Studies Journal,* 1(1), pp. 81-108.

Piesse, M., 2015. *The Indonesian Maritime Doctrine: Realising the Potential of the Ocean,* Dakeith: Future Directions International Pty Ltd..

Ralahatu, K. A. & Jinca, M. Y., 2013. The Development of Indonesian Archipelago Transportation. *International Refereed Journal of Engineering and Science.*

Rinard Hinga, B. D., 2015. *Ring of Fire: An Encyclopedia of the Pacific Rim's Earthquakes, Tsunamis, and Volcanoes: An Encyclopedia of the Pacific Rim's Earthquakes, Tsunamis, and Volcanoes.* California: ABC-CLIO.

Shekhar, V., 2013. *Indonesia's Military Modernisation.* New Delhi: Indian Council of World Affairs.

Subekti, I., 2013. Implications of Marine Fisheries Resource Management in Indonesia Based on the Code of Conduct for Responsible Fisheries (CCRF). *Scientific Journal of Legal Studies QISTI.*

TNI AL, 2003. *Pemberian Status Pasukan Khusus kepada Intai Amfibi Korps Marinir.* SK Kasal No. Skep/1857/XI/2003 ed. Jakarta: Setumal.

Tumonggor, M. K. & et. al., 2013. The Indonesian archipelago: an ancient genetic highway linking Asia and the Pacific. *Journal of Human Genetics,* Volume 58, p. 165–173.

Tzu, S. & Hou, W. C., 2003. *Art of War.* Singapore: Pearson Education Asia.

Vantier, L., Wilkinson, C. & Lawrence, D., 2005. *Indonesian Seas, GIWA Regional assessment 57,* Kalmar: University of Kalmar.

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Postgraduate International Conference, Vol. 1, No. 1, pp. 128-142
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MENTAL WORKLOAD ANALYSIS OF CADET NAVAL ACADEMY WITH SUBJECTIVE WORKLOAD ASSESSMENT TECHNIQUE

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ABSTRACT

There are plentiful activities conducted by the Cadets in order to hold educational process at the Naval Academy. These activities are particularly vulnerable to physical and psychological friction, especially in routine and nurturing activities, where activities in this phase are thought to cause the Cadets to experience excessive mental workloads which may result in the Cadets being unable to continue their education. Therefore, this research would identify one of the factors that were suspected to be the cause of the problem which was psychological factor or mental workload on the Academy of Naval using Subjective Workload Asesessment Technique (SWAT) method. SWAT method was chosen because it was easier to apply and had some advantages in terms of results validity and accuracy, so that the performance of Cadets expected by Institution were: Tanggap, Tanggon and Trengginas. The results of this study indicated that there was a high mental workload for some sub activities at some level. The highest mental workload in level I is 69,0 (RPS activity), in level II is 83,4 (senior junior development), in level III is 77,6 (senior junior development). Besides this research also showed that the mental workload between the four levels of Level I, II, III and IV had a significant difference in mental workload in carrying out every activity at the Academy.

KEYWORODS : Subjective Workload Assessment Technique (SWAT), Mental workload, Cadets

1. INTRODUCTION

The education methods applied in the Naval Academy are teaching, training and nurturing methods (Yudhoyono & Jalal, 2009/2010). The aims of the methods are described as follows: Teaching method aims to equip Cadets with general science and basic profession as marine warriors. The training method aims to equip the Cadets with the basic skills of the profession as well as the special profession of each corps. Nurturing aims to shape, nurture and solidify the personality of Cadets and the spirit of true warrior (W.Masland & Radway, 2015).

Various activities are conducted by the Cadets in the education process in Naval Academy. Each Cadets activity will provide workload in the form of physical workload or mental workload. The most dominant workload wich has a high stress buren is the mental workload, thus the metal workload must be considered. In addition, the activities of Cadets are very susceptible to physical and psychological friction, especially in routine and nurturing activities, where activities in this phase are expected to cause the Cadets to experience excessive mental workload which may cause the Cadets to not continue their education. Based on data obtained from the Cadets Regiment recorded during the period of 6 years (2008-2013), there were 17 Cadets expelled, whether it was due to mental factors or due to other factors.

Based on those data, it can be said that there are still very serious problems in the educational environment, why is that? In an education, the number of incoming education will be equal to the number that graduated, because the Cadets who follow the education are those who have been through a variety of selection that is so tight both at the regional and central levels. Among thousands of people who register, the number of people accepted are only ± 100 people each generation or ± 1:20 in each enrollment, meaning that the person accepted is a person who has qualified both physically and psychologically/mentally for the education. Therefore, when 1 person of each force is expelled from education for any reason then it can be said that the institution has not succeeded in implementing the ideal education system.

The research that discusses about the SWAT application are research conducted by Rubio et al. the title Evaluation of Subjective Mental Workload: A Comparison of SWAT, Nasa TLX and Workload Profile. In that study, the results of the ANOVAs performed showed that there are no differences with regard to the three instruments' intrusiveness,and that among the three subjective workload instruments WP has an outstanding sensitivity to the different task manipulations (Rubio, et al., 2004).

Another research conducted by Widyanti et al that they adaptation of rating scale mental effort for use in Indonesia (Widyanti, et al., 2013). This study attempts to apply rsme searching task in experiments. 80 people were asked to fill in the questionnaires NASA TLX and RSME. And the result shows that RSME in line with NASA TLX.

Next research conducted by Waard about driving a vehicle, it may seem to be a fairly simple task (Waard, 1996). After some initial training many people are able to handle a car safely. Nevertheless, accidents do occur and the majority of these accidents can be attributed to human failure. At present there are factors that may even lead to increased human failure in traffic. So the author disscussed about measurement mental workload drivers.

In the study by Battiste and Bortolussi. This research was a part of study which investigated workload measures for aircraft certification. No significant main effects were found for any performance- based measures of workload. Both SWAT and NASA-TLX were sensitive to differences between high and low workload flights and to differences among flight segments (Battiste & Bortolussi, 1988).

The Study of Sirevaag et al. This research see claims through the process of two places format different communication, digitally and verbal, in a simulated high and the higher multi-function helicopter (Sirevaag, et al., 2010). The discussed in terms of structural and capacity communication systems suit filed for the advancement of multi-function helicopter.

Some of these studies showed that the Subjective Workload Assessment Technique method could be used to analyze the level of mental workload in various fields (Eggemeier, et al., 1982) (Nygren, 1985).

Therefore, this study would identify one of the factors that were suspected to be the cause of the Cadets problem, namely psychological factors or mental workload in Cadets level I, level II, level III and level IV while undergoing education at Naval Academy using SWAT method. SWAT method was chosen because it was easier to apply and had several advantages in terms of validity and accuracy of the results, so that the performance of Cadets expected by the institution could be obtained, namely: Tanggap, Tanggon and Trengginas and at the same time could be a recommendation for the institution in taking policy.

2. MATERIAL AND METHODOLOGY

2.1 Workload

Working loads experienced by a worker/employee are physical workload, mental and psychological workload arising from the work environment (Moray, 1982). Workload is designed in accordance with the capabilities and limitations of both physical and mental workers. Therefore, information on workloads obtained through measurement becomes important. The basic concept of mental workload leads to the difference between the processing resources available to the operator and the resource requirements needed in the task (Vidulich & P.S.Tsang, 2007).

Basically, the workload explains the interaction between an operator performing the task and the task itself. In other words, the term workload illustrates the difference between the capacities of a human information processing system that is expected to satisfy the expected performance and that capacity is available for actual performance (Hancock & N.Meshkati, 1988). Henry R. Jex defined the mental workload as "the operator's evaluation of the attentional load margin (between their motivated capacity and the current task demands) while achieving adequate task performance in a mission-relevant context" (Derrick & Wickens, 1984).

2.2 SWAT (Subjective Workload Assessment Technique)

The SWAT Method (Subjective Workload Assessment Tehnique) is one of the way to measure the mental workload developed by Harry G. Armstrong, the Aerospace Medical Research Laboratory, Wright-Petterson Air Force Base, Ohio, USA to answer the question of how to measure mental workload in real environment (Real World Environtment) naturally and objectively from qualitative data sources (Reid & Nygren, 1988). SWAT was divided into 2 steps (R.S.Bridger, 1995) namely:

a. Scale Development

In the scale development, subjects are required to conduct a card ordering of 27 (twenty seven) combination cards from the lowest workload sequence to the highest workload, according to the perceptions of each person.

b. Event Scoring

In the scoring event, the tried person (subject) is asked his SWAT rating from each task, then SWAT rating, calculated by using SWAT program inside the computer to know the workload score of each combination

Based on SWAT model, human work performances are divided into 3 workload dimensions, namely: Time Load (T), Mental Effort Load (E), dan Psychological Stress Load (S) (Waard, 1996) (Moray, 1982).

a. Time Load (T)

The time load dimension depends on the availability of time and the ability to step over (overlap) in an activity. This is closely related to timeliness analysis which is the primary method to find out if the subject can complete the task within the specified time range. This time load consists of three rating categories: Low Time Load, Moderate Load, High Time Load. As for the understanding of each rating according to SWAT levels, it would be described below:

1) Low Time Load. It always has excess time. The interruption and work simultaneously (overlap) between activities never happened or rarely happened.
2) Moderate Time Load. It sometimes has excess time. The interruption and work simultaneously (overlap) between activities often happended.
3) High Time Load. It has no excess time. The interruption and work simultaneously (overlap) between activities often happened or always happened.

b. Mental Effort Load (E)

The mental effort load is an indicator of the mental needed and attention required to complete an activity, it was independent of the number of sub-jobs or time constraints (Jung & Jung, 2001). With a low mental effort workload, the concentration and attention required to perform low activity and performance tend to be automated. As these loads increase, the concentration and attention required would also increase. In general, this is related to the level of complexity of work and the amount of information that must be processed by the subject to carry out his work well.

High mental effort requires overall concentration and attention according to the complexity of the work or the amount of information to be processed (Sekker, 2014). Activities such as calculation, decision making, remembering information and problem solving are examples of mental effort. Mental effort load consists of three categories of rating : Low Mental Effort Load, Moderate Mental Effort Load, High Mental Effor Load (YM & ZM, 2005). As for the meaning of each rating according to SWAT levels, it would be described bellow:

1) Low Mental Effort Load. The need for concentration and conscious mental effort is very small. Activities performed almost automatically and do not need attention.
2) Moderate Mental Effort Load. Concentration needs and moderate conscious mental effort. The complexity of moderate to high activity is consistent with uncertainty, predictive disability, and unfamiliarity. Additional attention is required.
3) High Mental Effort Load. The need for concentration and conscious mental effort is enormous. Job activities are so complex that they require more attention.

c. Psychological Stress Load (S)

The workload of psychological distress relates to conditions that can lead to confusion, frustration, and fear during work, thereby causing work resolution to be more difficult than it really is (Sirevaag, et al., 2010).

People tend to relax at low stress level. Along with the increase of stress, there is confusion concentration to the relevant aspects of a job that is more caused by individual factors of the subject. These factors include: motivation, fatigue, fear, skill level, temperature, noise, vibration, and comfort. Most of these factors affect the performance of the subject directly if they arrive at a high level. Albeit small, these factors woulb be taken into account in SWAT if it interferes and causes the individual to exclude his ability to prevent the job from being affected (Sheridan, 1980).

Psychological Pressure Load consists of three rating categories: Low Psychological Pressure Load, Moderate Psychological Pressure Load and High Psychological Pressure Load. As for the meaning of each rating according to SWAT levels, it would be described below (Eggemeier & Stadler, 1984):

1) Low Psychological Load. Confusion, risk, frustration or anxiety can be overcome easily.
2) Moderate Psychological Load. The stress that arises and deals with confusion, frustration and anxiety adds to the existing workload. Additional compositions are necessary to maintain the performance of the subjects.
3) High Psychological Load. There is high stress associated with confusion, frustration and anxiety. At this level, it requires great self-control.

Each of these dimensions consists of three rating categories with workload intervals as follows (Sirevaag, et al., 2010) (Luximon & Goonetilleke, 2001) :

1) Lower Load if the final scale is 0–40
2) Medium Load if the final scale is 41–60
3) Over Load if the final scale is 61-100

2.3. Methodology

This research was qualitative research where the data was taken directly from the respondents which was Cadets by distributing 27 SWAT cards to be sorted starting from the lowest and highest mental workload and filling in the questionnaire related to Education at Naval Academy 2012/2013. The sampling method was taken randomly. The samples required for the adequacy of the data in this study were as many as 120 samples, consisting of 30 people in Level IV, 30 people of Level III, 30 people of Level II 30 people of Level I. It was obtained with experiment design with anova nested anova method without interaction.

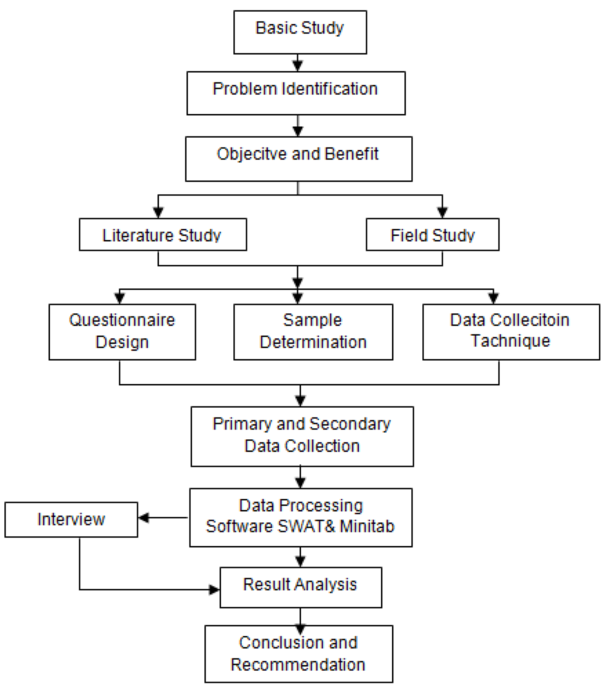


Fig. 1 Research Process Steps/flowchart

2.4. Data Collection

The data collection using SWAT method was by scale development. The Cadets was asked to sort the cards of 27 combined cards from the lowest workload sequence to the highest workload based on correspondent (Cadet)'s perspective. In the ordering of the card, there is no rule which was right or wrong. The ordering of cards was done according to the perceptions of each correspondent. In addition to sorting 27 SWAT cards, Cadets filled out a questionnaire about the workload of the activities it undertook. In the questionnaire, cadets were also asked to rate the workload experienced by the activities.

2.5. Data Processing

After collecting data from 27 SWAT cards according to the order from the lowest to the highest based to the perception of each correspondent, then the results of this card sorting were recorded and downloaded on the computer to interpret the dimension scale into the SWAT (Scaling Solution) scale. In addition, the results of filling out questionnaires on activities carried out by Cadets were transformed into Event Scoring. From the result of conversion between SWAT scale to SWAT rating, the work load of each Cadets could be known.

Finally, to test and compare the mental workload of the four levels with each of the 30 Cadets Per levels and 4 activities with 25 sub-activities performed, the Nested Anova test was used with the help of Minitab 16 software.

3. RESULT AND DISCUSSION

In this study Cadets was asked to provide an assessment of the workload consisting of time load (T), mental effort load (E) and psychological pressure load (S). The activities of Cadets divided into 4 groups. The group activities were: routine activities, parenting activities, teaching activities and training activities as shown in Table 1.

Table.1 The Cadet's Activity Group

Activities	No	Sub Activities
Routine	1	Waking Up
	2	Morning Training
	3	Breakfast
	4	Morning Roll Call
	5	Noon Roll Call
	6	Lunch
	7	Dinner
	8	Evening Study Session
	9	Evening Roll CAll
Nurturing	10	Ceremony
	11	Exercise
	12	Inspection
	13	Karate
Teaching	14	Physical Training
	15	Proffesion Learning
	16	Non-profession Learning
	17	Examination
	18	Military Gymnastic
	19	Basic Military Rule
	20	Agile Field
	21	Military Fighting
	22	Military Swimming
	23	RPS
	24	Fielding, Maping, and Compass Knowledge
	25	Grenades Throwing

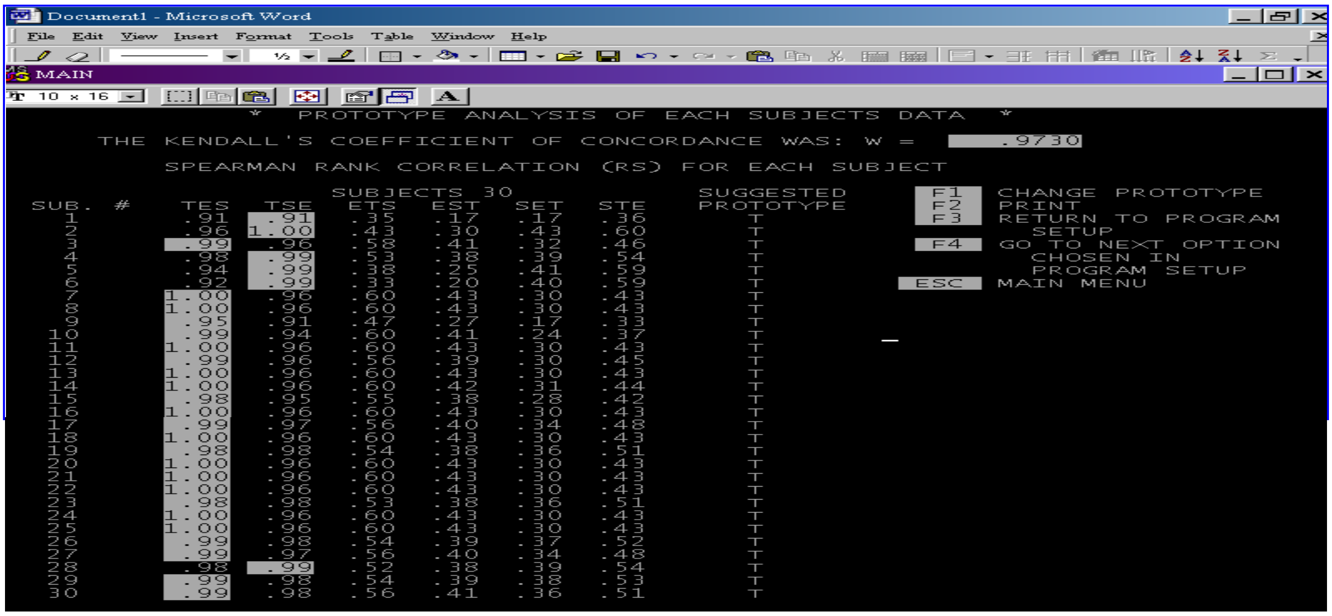
3.1. Card Arranging Analysis and Scale Development

Based on the data processing, if Kendall coefficient showed value more than 0.75 then the scale that could be used here was group scaling solution). This groups were described as follows :

a. Level IV of Cadets

After the data processing was performed, the coefficient of kendall could be obtained and it was 0,9730 as shown in

Figure 2 Cadets Level IV prefered time factor in completing each job, in addition to having a high effort workload (effort), while for the business of stress (stress) in this group was not really needed. The relative importance of each factor was 68.50%, the time factor indicating that the Level IV tuna collectively prefers the time factor (T). The second factor was the Mental Effort (E) with a percentage of 21.77% and the last dimension was the dimension of Stress (S) with a percentage of 9.73%.



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MAIN

* PROTOTYPE ANALYSIS OF EACH SUBJECTS DATA *

THE KENDALL'S COEFFICIENT OF CONCORDANCE WAS: W = .9730

SPEARMAN RANK CORRELATION (RS) FOR EACH SUBJECT

SUBJECTS 30

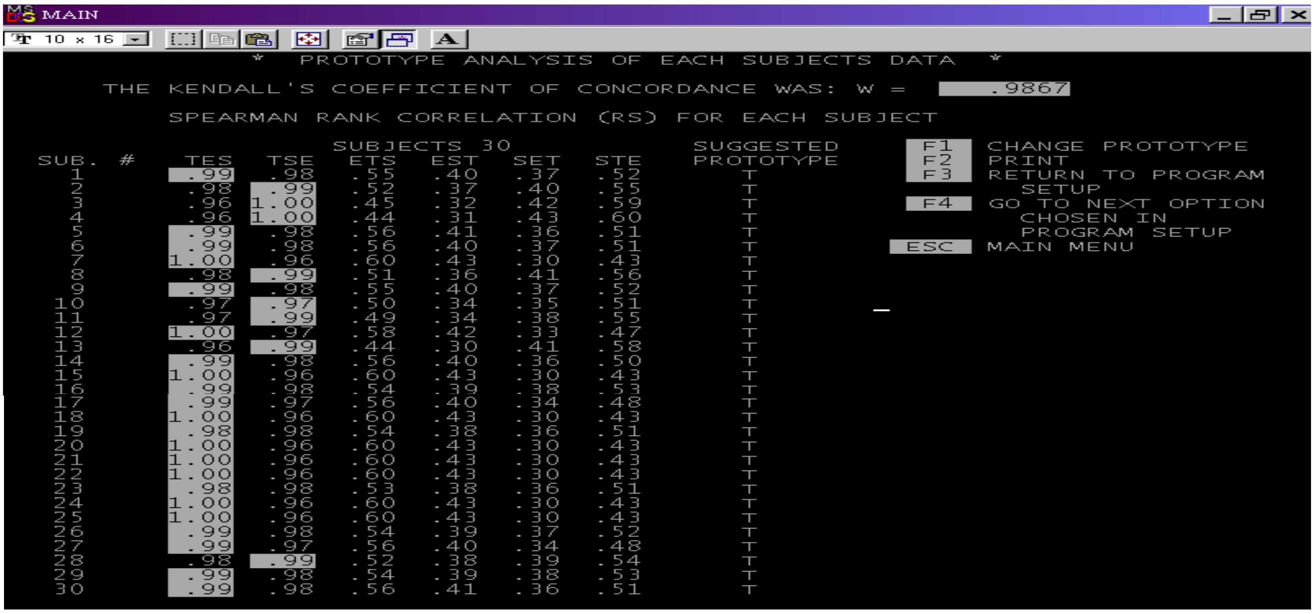
SUB. #	TES	TSE	ETS	EST	SET	STE	SUGGESTED PROTOTYPE
1	.91	.91	.35	.17	.17	.36	T
2	.96	1.00	.43	.30	.43	.60	T
3	.99	.96	.58	.41	.32	.46	T
4	.98	.99	.53	.38	.39	.54	T
5	.94	.99	.38	.25	.41	.59	T
6	.92	.99	.33	.20	.40	.59	T
7	1.00	.96	.60	.43	.30	.43	T
8	1.00	.96	.60	.43	.30	.43	T
9	.95	.91	.47	.27	.17	.33	T
10	.99	.94	.60	.41	.24	.37	T
11	1.00	.96	.60	.43	.30	.43	T
12	.99	.96	.56	.39	.30	.45	T
13	1.00	.96	.60	.43	.30	.43	T
14	1.00	.96	.60	.42	.31	.44	T
15	.98	.95	.55	.38	.28	.42	T
16	1.00	.96	.60	.43	.30	.43	T
17	.99	.97	.56	.40	.34	.48	T
18	1.00	.96	.60	.43	.30	.43	T
19	.98	.98	.54	.38	.36	.51	T
20	1.00	.96	.60	.43	.30	.43	T
21	1.00	.96	.60	.43	.30	.43	T
22	1.00	.96	.60	.43	.30	.43	T
23	.98	.98	.53	.38	.36	.51	T
24	1.00	.96	.60	.43	.30	.43	T
25	1.00	.96	.60	.43	.30	.43	T
26	.99	.98	.54	.39	.37	.52	T
27	.99	.97	.56	.40	.34	.48	T
28	.98	.99	.52	.38	.39	.54	T
29	.99	.98	.54	.39	.38	.53	T
30	.99	.98	.56	.41	.36	.51	T

F1 CHANGE PROTOTYPE
F2 PRINT
F3 RETURN TO PROGRAM SETUP
F4 GO TO NEXT OPTION CHOSEN IN PROGRAM SETUP
ESC MAIN MENU

Fig. 2 Result Kendal's Coefficient Level IV of Cadets

b. Level III of Cadets

The kendall coefficient value was obtained at 0.9867 as shown in Figure 3. Cadets Level III prefered the time factor in completing each job, in addition to having a similar amount of mental effort and stress workload. The relative importance of each factor was 67.50%. The time factor indicating that Level III collectively prefered the time factor (T). The second factor was the mental effort dimension factor (E) with the percentage of 20.00% and the last dimension was stress (S) with a percentage of 12.50%.



MAIN

* PROTOTYPE ANALYSIS OF EACH SUBJECTS DATA *

THE KENDALL'S COEFFICIENT OF CONCORDANCE WAS: W = .9867

SPEARMAN RANK CORRELATION (RS) FOR EACH SUBJECT

SUBJECTS 30

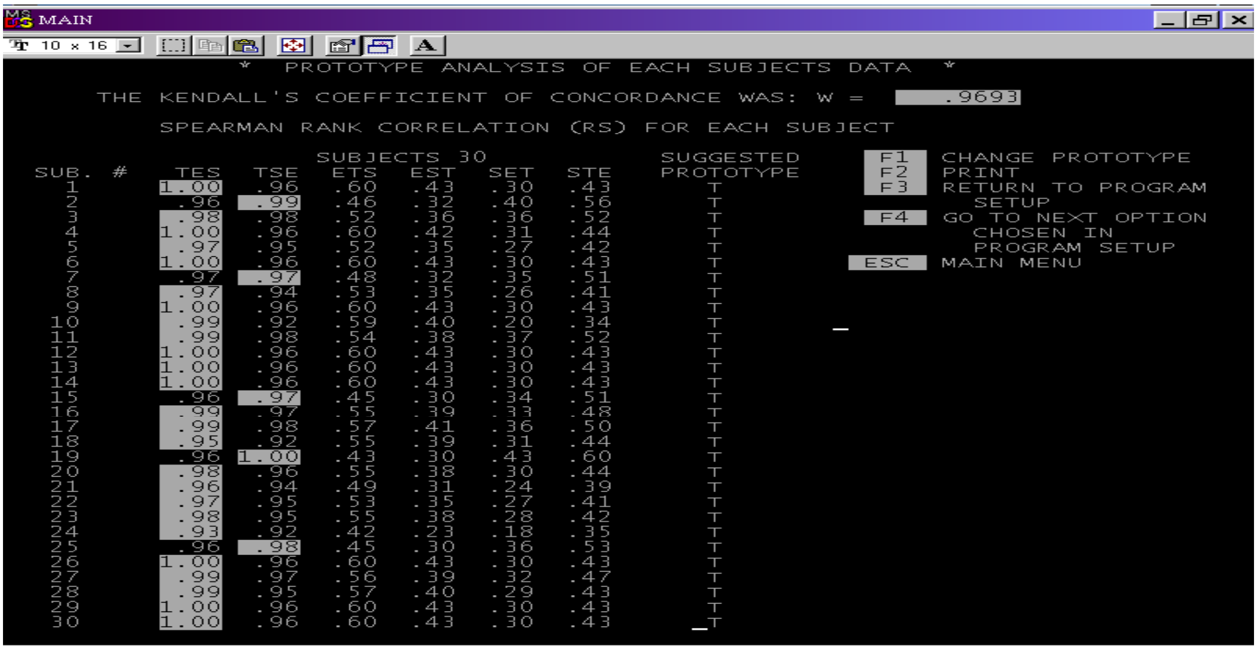
SUB. #	TES	TSE	ETS	EST	SET	STE	SUGGESTED PROTOTYPE
1	.99	.98	.55	.40	.37	.52	T
2	.98	.99	.52	.37	.40	.55	T
3	.96	1.00	.45	.32	.42	.59	T
4	.96	1.00	.44	.31	.43	.60	T
5	.99	.98	.56	.41	.36	.51	T
6	.99	.98	.56	.40	.37	.51	T
7	1.00	.96	.60	.43	.30	.43	T
8	.98	.99	.51	.36	.41	.56	T
9	.99	.98	.55	.40	.37	.52	T
10	.97	.97	.50	.34	.35	.51	T
11	.97	.99	.49	.34	.38	.55	T
12	1.00	.97	.58	.42	.33	.47	T
13	.96	.99	.44	.30	.41	.58	T
14	.99	.98	.56	.40	.36	.50	T
15	1.00	.96	.60	.43	.30	.43	T
16	.99	.98	.54	.39	.38	.53	T
17	.99	.97	.56	.40	.34	.48	T
18	1.00	.96	.60	.43	.30	.43	T
19	.98	.98	.54	.38	.36	.51	T
20	1.00	.96	.60	.43	.30	.43	T
21	1.00	.96	.60	.43	.30	.43	T
22	1.00	.96	.60	.43	.30	.43	T
23	.98	.98	.53	.38	.36	.51	T
24	1.00	.96	.60	.43	.30	.43	T
25	1.00	.96	.60	.43	.30	.43	T
26	.99	.98	.54	.39	.37	.52	T
27	.99	.97	.56	.40	.34	.48	T
28	.98	.99	.52	.38	.39	.54	T
29	.99	.98	.54	.39	.38	.53	T
30	.99	.98	.56	.41	.36	.51	T

F1 CHANGE PROTOTYPE
F2 PRINT
F3 RETURN TO PROGRAM SETUP
F4 GO TO NEXT OPTION CHOSEN IN PROGRAM SETUP
ESC MAIN MENU

Fig. 3 Result Kendal's Coefficient Level III of Cadets

c. Level II of Cadets

The kendall coefficient value was obtained at 0.9693 as shown in Figure 4. Cadets Level II prefered the time factor in completing each job, in addition to have a high stress workload yet low mental effort load. The relative importance of each factor was 68.50%. The time factor indicating that Level II collectively prefered the time factor (T). The second factor was the mental effort dimension factor (E) with the percentage of 21.78% and the last dimension was stress (S) with a percentage of 9.73%.



MAIN

* PROTOTYPE ANALYSIS OF EACH SUBJECTS DATA *

THE KENDALL'S COEFFICIENT OF CONCORDANCE WAS: W = .9693

SPEARMAN RANK CORRELATION (RS) FOR EACH SUBJECT

SUBJECTS 30

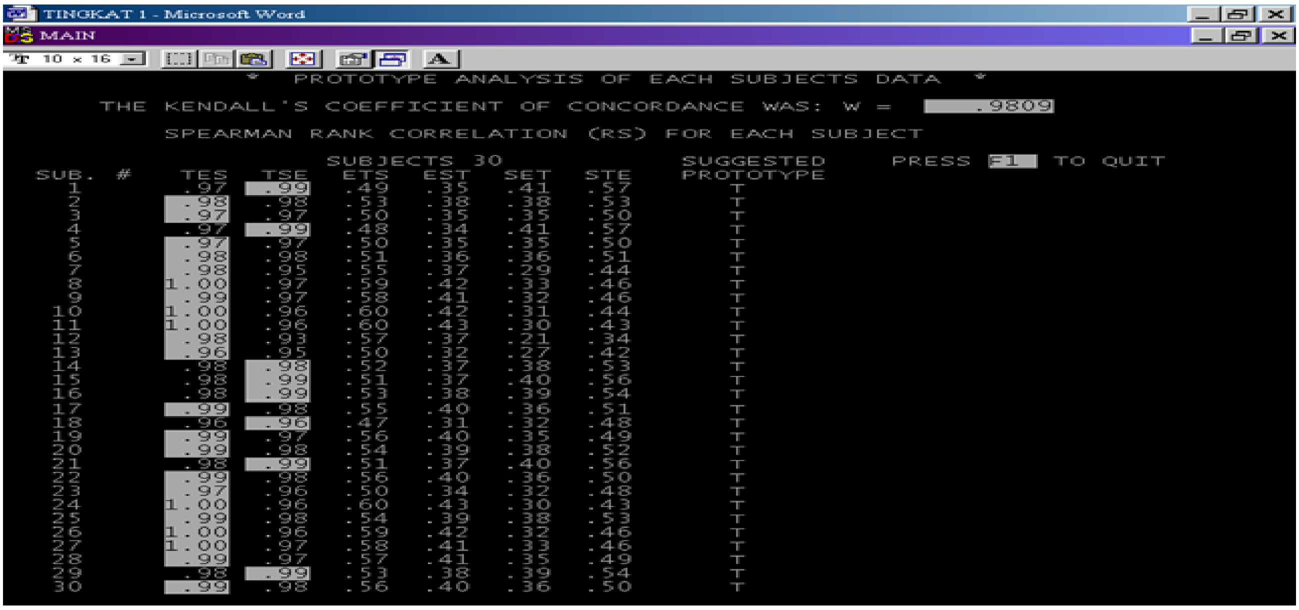
SUB. #	TES	TSE	ETS	EST	SET	STE	SUGGESTED PROTOTYPE
1	1.00	.96	.60	.43	.30	.43	T
2	.96	.99	.46	.32	.40	.56	T
3	.98	.98	.52	.36	.36	.52	T
4	1.00	.96	.60	.42	.31	.44	T
5	.97	.95	.52	.35	.27	.42	T
6	1.00	.96	.60	.43	.30	.43	T
7	.97	.97	.48	.32	.35	.51	T
8	.97	.94	.53	.35	.26	.41	T
9	1.00	.96	.60	.43	.30	.43	T
10	.99	.92	.59	.40	.20	.34	T
11	.99	.98	.54	.38	.37	.52	T
12	1.00	.96	.60	.43	.30	.43	T
13	1.00	.96	.60	.43	.30	.43	T
14	1.00	.96	.60	.43	.30	.43	T
15	.96	.97	.45	.30	.34	.51	T
16	.99	.97	.55	.39	.33	.48	T
17	.99	.98	.57	.41	.36	.50	T
18	.95	.92	.55	.39	.31	.44	T
19	.96	1.00	.43	.30	.43	.60	T
20	.98	.96	.55	.38	.30	.44	T
21	.96	.94	.49	.31	.24	.39	T
22	.97	.95	.53	.35	.27	.41	T
23	.98	.95	.55	.38	.28	.42	T
24	.93	.92	.42	.23	.18	.35	T
25	.96	.98	.45	.30	.36	.53	T
26	1.00	.96	.60	.43	.30	.43	T
27	.99	.97	.56	.39	.32	.47	T
28	.99	.95	.57	.40	.29	.43	T
29	1.00	.96	.60	.43	.30	.43	T
30	1.00	.96	.60	.43	.30	.43	T

F1 CHANGE PROTOTYPE
F2 PRINT
F3 RETURN TO PROGRAM SETUP
F4 GO TO NEXT OPTION CHOSEN IN PROGRAM SETUP
ESC MAIN MENU

Fig. 4 Result Kendal’s Coefficient Level III of Cadets

d. Level I of Cadets

The kendall coefficient value was obtained at 0. 9809 as shown in Figure 5. Cadets Level I prefered the time factor in completing each job, in addition to having a similar amount of mental effort and stress workload. The relative importance of each factor was 67.50%. The time factor indicating that Level I collectively prefered the time factor (T). The second factor was the mental effort dimension factor (E) with the percentage of 18.10% and the last dimension was stress (S) with a percentage of 14.10%.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* PROTOTYPE ANALYSIS OF EACH SUBJECTS DATA *

THE KENDALL'S COEFFICIENT OF CONCORDANCE WAS: W = .9809

SPEARMAN RANK CORRELATION (RS) FOR EACH SUBJECT

SUBJECTS 30 PRESS F1 TO QUIT

SUB. #	TES	TSE	ETS	EST	SET	STE	SUGGESTED PROTOTYPE
1	.97	.99	.49	.35	.41	.57	T
2	.98	.98	.53	.38	.38	.53	T
3	.97	.97	.50	.35	.35	.50	T
4	.97	.99	.48	.34	.41	.57	T
5	.97	.97	.50	.35	.35	.50	T
6	.98	.98	.51	.36	.36	.51	T
7	.98	.95	.55	.37	.29	.44	T
8	1.00	.97	.59	.42	.33	.46	T
9	.99	.97	.58	.41	.32	.46	T
10	1.00	.96	.60	.42	.31	.44	T
11	1.00	.96	.60	.43	.30	.43	T
12	.98	.93	.57	.37	.21	.34	T
13	.96	.95	.50	.32	.27	.42	T
14	.98	.98	.52	.37	.38	.53	T
15	.98	.99	.51	.37	.40	.56	T
16	.98	.99	.53	.38	.39	.54	T
17	.99	.98	.55	.40	.36	.51	T
18	.96	.96	.47	.31	.32	.48	T
19	.99	.97	.56	.40	.35	.49	T
20	.99	.98	.54	.39	.38	.52	T
21	.98	.99	.51	.37	.40	.56	T
22	.99	.98	.56	.40	.36	.50	T
23	.97	.96	.50	.34	.32	.48	T
24	1.00	.96	.60	.43	.30	.43	T
25	.99	.98	.54	.39	.38	.53	T
26	1.00	.96	.59	.42	.32	.46	T
27	1.00	.97	.58	.41	.33	.46	T
28	.99	.97	.57	.41	.35	.49	T
29	.98	.99	.53	.38	.39	.54	T
30	.99	.98	.56	.40	.36	.50	T

Fig. 5 Result Kendal’s Coefficient Level III of Cadets

Based on the data processing, it could be seen that each level of Level IV, Level III, Level II and Level I indicated group-based data processing, which was indicated from the acquisition of the coefficient of kendall. The results of group-based data processing showed that it was related to the pattern of life in the military. Military life had a tendency to always be in groups and always maintain the group, ranging from groups of squads, platoon, company, batalioon up to the Brigade or the army itself.

3.1 Respective Workload Analysis on Activity in Each Level

In each level there are many activity and average level as shown in Table 2.

Table. 2 Result of each activity and average level

NO	SUB ACTIVITIES LEV I	AVERAGE LEVEL I	SUB ACTIVITIES LEV II	AVERAGE LEVEL II	SUB ACTIVITIES LEV III	AVERAGE LEVEL III	SUB ACTIVITIES LEV IV	AVERAGE LEVEL IV
1	Waking Up	26,5	Waking Up	57,8	Waking Up	54,2	Waking Up	42,3
2	Morning Training	26,4	Morning Training	59,9	Morning Training	50,6	Morning Training	36,6
3	Breakfast	15,1	Breakfast	61,5	Breakfast	46,4	Breakfast	16,0
4	Morning Roll Call	25,3	Morning Roll Call	58,2	Morning Roll Call	53,1	Morning Roll Call	19,0
5	Noon Roll Call	51,5	Noon Roll Call	70,8	Noon Roll Call	44,3	Noon Roll Call	12,7
6	Lunch	45,1	Lunch	75,1	Lunch	63,6	Lunch	8,6
7	Dinner	28,8	Dinner	64,4	Dinner	38,2	Dinner	8,0
8	Evening Study	29,6	Evening Study	43,2	Evening Study	22,5	Evening Study	8,6
9	Evening Roll Call	56,0	Evening Roll Call	82,6	Evening Roll Call	52,3	Evening Roll Call	4,5
10	Ceremony	38,0	traditional Roll Call	82,6	traditional Roll Call	69,8	traditional Roll Call	5,9
11	Exercise	32,2	Exercise Roll Call	47,2	Exercise Roll Call	36,6	Exercise Roll Call	10,6
12	Inspection	34,9	Exercise time	43,8	Exercise time	30,2	Exercise time	12,4
13	Karate	37,8	GS Training	81,4	GS Training	76,3	GS Training	17,8
14	Phsyical Training	42,9	Karate	55,4	Karate	29,1	Karate	8,0
15	Proffesion Learning	26,1	On Duty	67,2	On Duty	51,3	On Duty	21,6
16	Non-Proffesion Learn	32,9	Senior junior developme	83,4	Senior junior develop	77,6	Senior junior develop	5,4
17	Examination	41,1	Physical Training	63,6	Physical Training	56,4	Physical Training	50,0
18	Military Gym	41,1	Profession learning	44,6	Profession learning	53,5	Profession learning	27,1
19	Basic Military Rule	34,5	Non-Proffesion Learn	36,9	Non-Proffesion Learn	19,0	Non-Proffesion Learn	8,5
20	Agile Field	53,0	Theory Exam	50,7	Theory Exam	44,3	Theory Exam	38,5
21	Military Fighting	38,3	Practical Exam	49,5	Practical Exam	56,8	Practical Exam	31,9
22	Military Swimming	36,3	Jalasesya sailing	47,8	Shooting	24,5	Jala Yuda	35,9
23	RPS	69,0	Sea survival	45,7	Scuba	43,7	Swimming	17,4
24	Mapping n Compass	54,2	Pek Nubika	44,4	Latek Profesi	53,1	Latsitardanus	3,7
25	Grenades Throwing	41,0	Swimming	55,5	Swimming	54,6	Profesional Training	16,3

At this analysis stage, the sub activities that would be discussed on each level had SWAT score above 61 (61-100). According to SWAT method, it was considered as high load work category (high load). If we see in Figure 6 Level IV there wasn't any high mental workload. Based on Interviews with some respondents, Cadets level IV and Cadet's Mentoring, it was found that it was due to the the state of Cadets level IV. Cadets level IV was the most senior Cadets at the Academy so that in the implementation of activities, they could carry out well without pressure from anywhere.

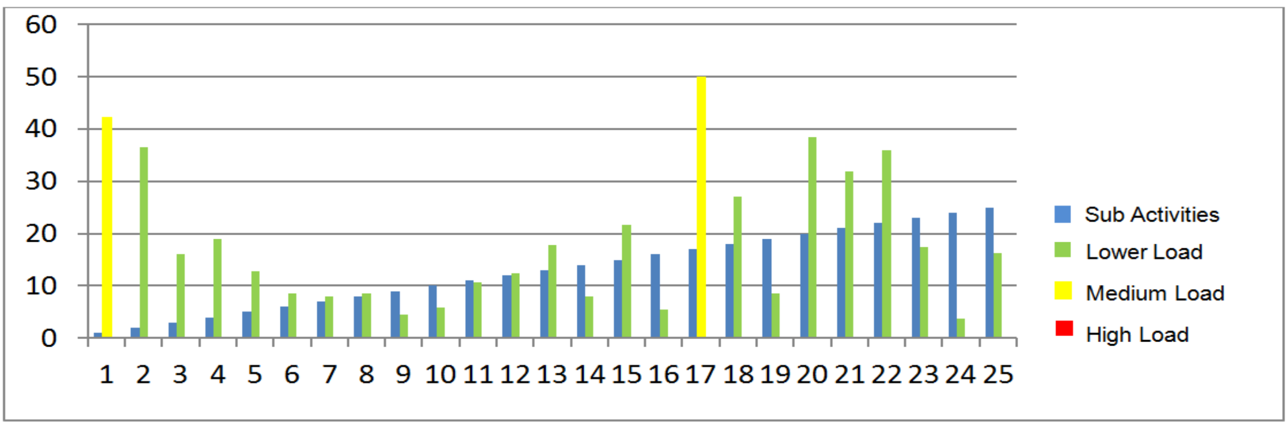

Fig. 6 Graph of Level IV Cadets Based on SWAT Scale

In Figure 7 the Level III of Cadets group, there were several sub activities that had a high mental workload, from 25 sub activities there were 4 sub-activities included in the category of high mental workload. The sub activities would be described bellow:

a. Lunch

Lunch was held jointly between level II, III, and IV in one table, lunch started at 12:45 to 13:00. This sub activity had mental load average of 63,3 which according to SWAT included in high load category.

b. Traditional Roll Call

It was the Cadets Corp Regiment Assembly which was held on Saturday Morning. This activity was taken over by Cadets Corps officials. It was held at 07.00-finish, the mental workload on this sub activity was 69.8. In this activity the junior Cadets will be checked for the neatness of personnel and material, ranging from shoe, clothes, hair neatness and others. If there were deficiencies or violation, they would get disciplinary punishment.

c. Drum Flute Training(GS)

Drum Band Training was held 3 times a week in the morning and evening. The value of mental workload on this activity was equal to 76.3. This was because the level of difficulty and compactness in training was high enough to force them to practice hard, along with the pressure of senior Cadets punishment in case of errors in the exercise so that the mental workload of the Cadets was higher.

d. Senior Junior Development

This activity was anything related to senior Cadets coached against junior Cadets about the life of the Cadets Corps Regiment. Senior were allowed to impose a proportional penalty against any wrongdoing by junior Cadets.

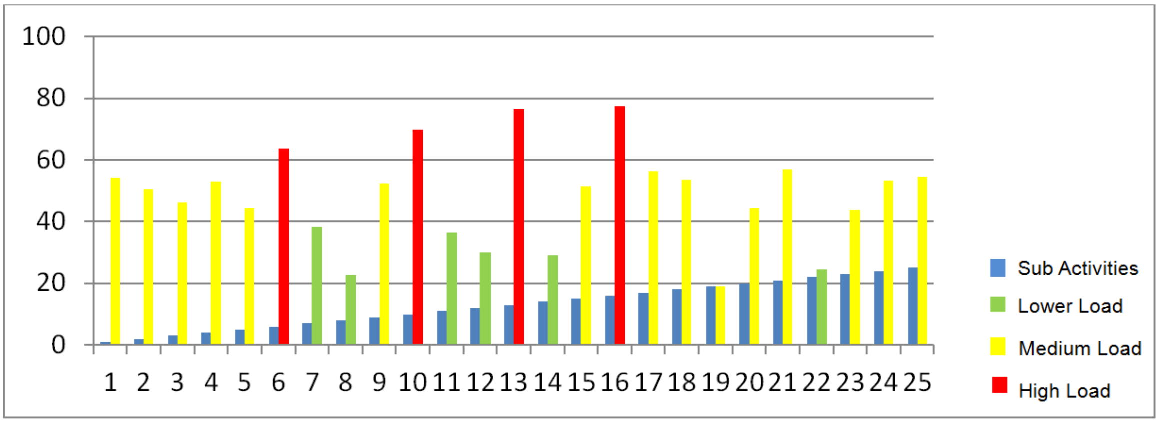

Fig. 7 Graph of Level III Cadets Based on SWAT Scale

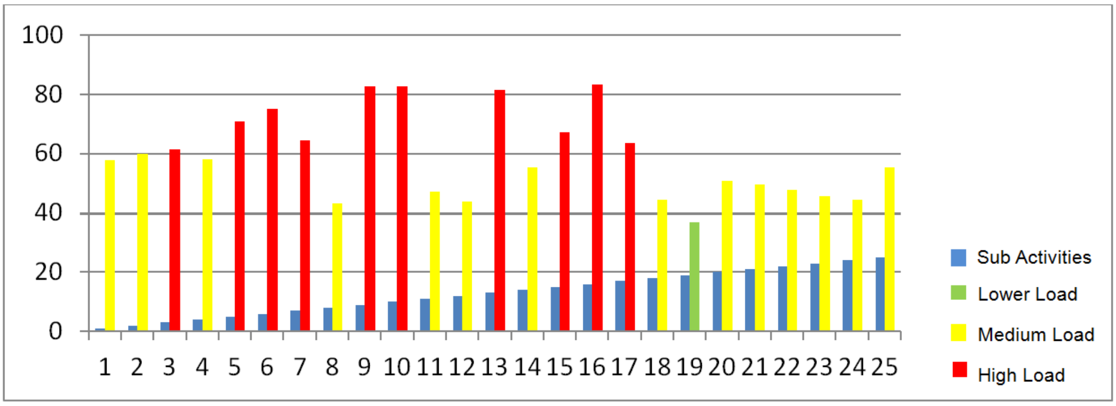

Fig. 8 Graph of Level II Cadets Based on SWAT Scale

Based on the graphic figure 8 of Load Workload Level **II**, there were some sub activities that had a high mental workload, from 25 sub activities there were 10 sub-activities included in the category of high mental workload. The sub activities were described bellow:

a. Breakfast with an average mental load value of 61.5.

b. Noon Roll Call with an average mental load value of 70.8.

c. Lunch with an average mental load score of 75.1

d. Dinner with an average mental workload of 64.3.

e. Night Roll Call with an average mental load value of 82.6.

f. Tradition Roll Call with an average mental load value of 69.8.

g. Drum Flute Training (GS) with an average mental load value of 81.4.

h. On Duty with an average mental load value of 67.2.

i. Senior Junior Development with an average mental load score of 83.3.

j. Physical Training with the average mental load value of 63.6,

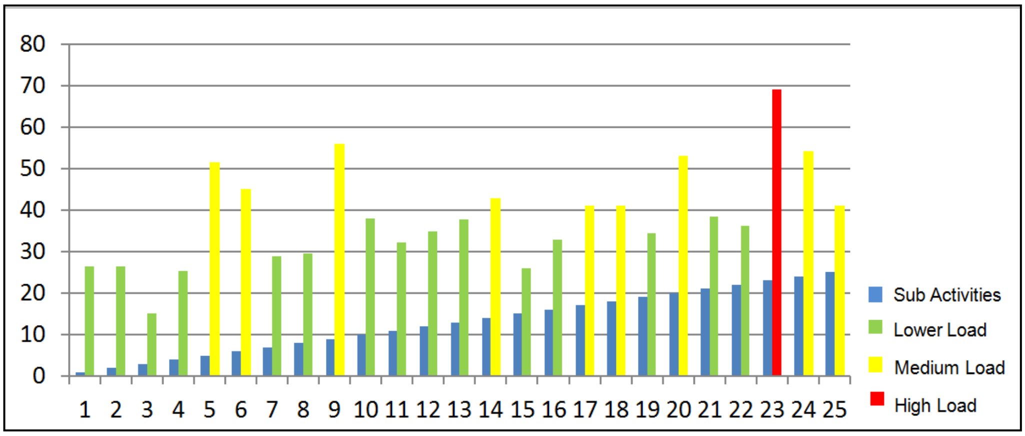

Fig. 9 Graph of Level **I** Cadets Based on SWAT Scale.

In Figure 9, the Level I Cadets, there were several sub activities that had high mental workload. From 25 sub activities, there wass only 1 sub activity that included in the category of high mental workload. That sub activity was Route Commander Soedirman (RPS). It was a Long March activity to commemorate the Commander Soedirman's struggling for independence. The distance traveled was long and hard so that the Cadets Level I felt burdened with this sub-activity. Other than that, the weather at that time was bad and made their shoes wet and sore, also they had to carry the goods in a bag of hinges that contains logistics inventory for 3 days. It made their burden getting heavy. Some respondents also said that the lack of exercise factor was also the cause of the weight in this activity. The mean mental load of this activity was 69.0

3.2 Data Test Analysis with ANOVA

Anova testing was intended to test the uniformity of the population and compare it. The population was consisted of Level I, Level II, Level III, and Level IV. The thing that we wanted to know was whether there was a significant difference in the mental workload between the four levels and the significant differences in each activity.

The results of the test with Nested anova showed that the four levels of Level I, Level II, Level III, and Level IV Cadets had a significant difference in mental workload between each other, as well as the activities performed. There was a very significant difference in each activity at each level. This was in accordance with the initial hypothesis that there wass indeed a difference between the 4 (four) levels and the activities.

3.3 Recommendation

Based on observations, interviews and data analysis, the recommendations could be given to activities which had been considered having a high workload so that expectations of these activities could run well without changing the essence of the activity itself. Here were suggestions for improving sub activities.

a. Dine Activity

The supervision of Officers and Commisioned Officer must be further tightened to avoid the disproportionate actions or penalties from the senior Cadets to the junior in the dining room. Disciplinary punishment must be performed to the senior Cadets who was caught performing dishonest acts in the dining room.

b. Traditional Roll Call

The seniors should set a good example for the junior Cadets and need proper supervision from the Commisioned Officer to avoid the disproportionate actions of the senior to the Junior Cadets.

c. Genderang Suling Training (GS)

It was necessary to teach theories about musical instruments by music experts, so that when exercised the Cadets understand with the musical instrument he holds, this was to avoid mistakes in the practice that led to more penalties than the exercise itself. Although at the time the fully responsible practice was the GS Caregiver, but other caregivers should keep an eye on the exercise.

d. Senior-Junior Development

The need for supervision of all activities in buildings and rooms and the provision of disciplinary punishments provided by senior

Cadets should be educational and not excessive.

4. CONCLUSION

4.1. In general, based on the interviews, observations and in-depth analysis, the mental workload of Level IV Cadets did not contain a high mental workload as they are the most senior Cadets in the Academy. They do not feel pressured in carrying out any activities. As for Level III, they had a high workload in four activities: Lunch (63,6), traditional Roll Call (69,8), GS Training (76,3) and Senior Junior Development (77,6). Meanwhile, while Level II Cadets had more mental workload among these activities: Breakfast (61,5), Lunch (70,8), Noon Roll Call (70,8), Lunch (75,1), Dinner (64,4), Evening Roll Call (82,6), Traditional Roll Call (82,6), GS Training (81,4), Duty (67,2), Senior Junior Development (83,4), and Physical Training (63,6). Finally, the activity with the most mental workload for Level I was RPS (Rute Panglima Sudirman /Panglima Sudirman Route) which is score is 69,0..

4.2. The result of ANOVA test showed that the four level workloads that were Level IV, Level III, Level II and Level I were not identical. It means that there wes a very significant difference between each level as well as all of the activities that had been performed. Anova testing results showed that the four activities had a very significant difference.

4.3. Most Cadets Juniors had a high mental workload due to the pressures of the senior Cadets, this was ilustrated in the results of the data. The smaller the level the greater the mental workload was perceived. However, this condition did not occur in Level I Cadets because they were in Magelang and not directly related to their senior. It means that the senior-junior direct interaction in the Academy greatly affected the mental workload for the Cadets, especially the Junior Cadets.

5. REFERENCES

Battiste, V. & Bortolussi, M., 1988. *Transport pilot workload: A comparison of two subjective techniques..* Santa Monica, Human Factor Society.

Derrick, W. & Wickens, C., 1984. *A multiple processing resource explanation of the subjective dimensions of operator workload.* Champaign: Univercity of Illinois, Engineering Psychology Laboratory.

Eggemeier, F., Crabtree, M. & Reid, G., 1982. *Subjective workload assessment in a memory update task.* Santa Monica, Human Factor Society.

Eggemeier, F. & Stadler, M., 1984. *Subjective workload assessment in a spatial memory task.* Santa Monica, Human Factor Society.

HAncock & N.Meshkati, 1988. *Human Mental Workload.* New York: North Holland.

Jung, H. S. & Jung, h. S., 2001. Establishment of overall Workload Assessment Technique for Various Tasks and Workplaces. *International Journal of Industrial Ergonomics,* 28(6), pp. 341-353.

Luximon, A. & Goonetilleke, R. S., 2001. Simplified subjective workload assessment technique. *Ergonomics,* 44(3), pp. 229-243.

Moray, N., 1982. Subjective mental workload. *Human Factors,* Volume 24, pp. 25-40.

Nygren, T., 1985a. *Axiomatic and numeric conjoint measurement: A comparison of three methods for obtaining subjective workload (SWAT) rankings.* New York, Institute of Electrical and Electronics Engineers.

R.S.Bridger, 1995. *Introduction to Ergonomics.* Singapura: McGraw-Hill.

Reid, G. B. & Nygren, T. E., 1988. The Subjective Workload Assessment Technique : A Scalling Procedure for Measuring Mental Workload. *Advances in Psychology,* Volume 52, pp. 185-218.

Rubio, S., Diaz, E., Martin, J. & Puente, J. M., 2004. Evaluation of Subjective Mental Workload: A Comparison of SWAT, NASA TLX and Workload Profile Methods. *Applied Psychology,* 53(1), pp. 61-86.

Sekker, A., 2014. Using Outputs of Nasa TLX for buiding a mental workload expert system. *Journal of Science,* 27(4), pp. 1131-1142.

Sheridan, T., 1980. Mental workload—What is it? Why bother with it?. *Human Factor Society Bulletin,* 23(2), pp. 1-2.

Sirevaag, E. J. et al., 2010. Assessment of Pilot Performance and mental Workload in Rotary Wing Aircraft. *Ergonomics,* Volume 36, pp. 1121-1140.

Vidulich, M. & P.S.Tsang, 2007. Techniques of subjective workload assessment : a comparison of SWAT and the NASA-Bipolar methods. *Ergonomics,* Volume 29, pp. 1385-1398.

W.Masland, J. & Radway, L. I., 2015. *Soldiers and Scholars : Military Education and National Policy.* s.l.:Princeton University Press.

Waard, D. d., 1996. *The measurement of Drivers Mental Workload.* Netherlands: The Traffic Research Centre VSC, Univercity og Groningen.

Widyanti, A., Jhonson, A. & Waard, D. D., 2013. Adaptation of Rating Scale Mental Effort for use in Indonesia. *International Journal of Industrial Ergonomics,* Volume 43, pp. 70-76.

YM, X. & ZM, W., 2005. The Appraisal of Reliability and Validity of Subjective Workload Assessment Technique and NASA-task load index. *Europe PMC,* 23(3), pp. 178-181.

yudhoyono, A. & Jalal, m. A., 2009/2010. Stronger Militaries through the Transformation of Military Education. *Kennedy School Review Cambridge,* Volume 10, pp. 109-113.

FIELD II
LOGISTICS MANAGEMENT

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THE IMPLEMENTATION OF SIMPLE ADDITIVE WEIGHTING (SAW) METHOD AS A DECISION SUPPORT SYSTEM TO REDUCE BAD CREDIT IN PT. CENTRAL SANTOSA FINANCE BANYUWANGI

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ABSTRACT

PT. Central Santosa Finance is a motorcycle financing company. PT Central Santosa Finance was established to become the preferred financing institution for financing motorcycle ownership loans. Through the Ministry of Finance's permit KEP-523 / KM.10 / 2010 which was issued on September 3, 2010 and operates since September 17, 2010, then as part of the largest private bank group in Indonesia, namely BCA Bank, the company continues to expand its business unit by continuing to create competitive advantage so that it can provide the best solutions and benefits to consumers. However, over time PT. Central Santosa Finance is experiencing bad credit. In the period of January to May 2017, especially for two-wheeled vehicles Honda brand experienced bad credit of 15.03% of new customers as much as 1377 and bad credit as much as 207 customers. They can directly give credit without knowing closely how and who the prospective customers who will be financed. In this case, with the analysis of 5C decisions (character, capacity, capital, collateral, and condition) using simple additive weighting method (SAW) can attempt to eliminate the old habits of credit marketing staff who casually give credit and also the company can control and maintain quality of the consumer so that no bad credit that can harm the company PT Central Sentosa Finance Banyuwangi.

Keywords: SAW, 5C, Credit

1. INTRODUCTION.

1.1. The Background

In general, the purchase of motorcycles can be seen in two ways those are cash and credit. While Leasing is one of the credit sales systems by a lot of companies that do not have enough funds to buy a motor vehicle in cash, or prospective buyers of the vehicle is intentionally buying on credit the vehicle that they want to buy with the certain aim through some special conditions that must be complemented by prospective customers who deserve a credit. According to PERPRES no. 09 in 2009 concerning financing institutions in the form of provision of capital goods by way of factoring, venture capital, leases with leased capital, or lease with an operating lease to be used by a lessee for a specified period based on the gradual payment of each month. PT. Central Santosa Finance established in automotive industry regulations in Indonesia, especially in the two-wheeler industry, and as part of the largest private bank group in Indonesia that is Bank Central Asia through the Ministry of Finance's permit. KEP-523 / KM.10 / 2010 which was published on September 3, 2010 and operates since September 17, 2010, PT Central Santosa Finance is one of the financing institutions of the people's choice to feel the help with this Leasing implementation. Financing company can continue its activities in the field of financing services then the company needs to keep the company's performance to stay healthy, ranging from credit application procedures, decision making creditworthiness. There are some assessment criteria that must be done to get really beneficial customer which is done by using 5C analysis using simple additive weighting (SAW) method to reduce the occurrence of bad credit. The credits with a 5C assessment contain character, capacity, capital, collateral, and condition. This analysis has aims to eliminate the old habits of credit marketing staff who usually only rely on proximity to the sales dealers only. They can directly give credit without knowing closely how and who the prospective customers who will be financed, because of that it raises the occurrence of bad credit, especially two-wheeler Honda vehicles in the period January to May 2017.

Table. 1 The Percentage of Bad Credit

Month	New Customer	Bad Credit	Percent
January	107	41	38,31%
February	245	40	16,32%
March	313	42	13.41%
April	340	44	12.94%
May	372	40	10,75%
Total	**1.377**	**207**	**15.03%**

In this case with the analysis of the 5C decision using the simple additive weighting method (SAW) can attempt to eliminate the old habits of credit marketing staff who arbitrarily give credit and also the company can control and maintain the quality of the consumer so that no bad credit that can harm the company of PT Central Sentosa Finance Banyuwangi.

1.2. Problem Identification

Based on the background that has been described above, the authors can convey the identification of the problem as follows:

a. How to apply simple additive weighting method (SAW) as decision support system to Reduce bad credit in prospective customers PT. Central Santosa Finance Banyuwangi?
b. What are the recommended improvements to overcome bad credit?

1.3. The Objective of the Research

Based on the problem identification above, the research objectives that have to be achieved are as follows:

a. To know the apply simple additive weighting method (SAW) as decision support system to Reduce bad credit in prospective customers PT. Central Santosa Finance Banyuwangi and implementation of the provision of vehicle loans at PT. Central Santosa Finance.
b. To provide recommendation of system improvement to reduce the occurrence of bad debts with the analysis of creditworthiness decision making by using simple additive weighting (SAW) method.

1.4. The Problem Limitation

In order for this research more focused, the researcher limits it only on the matters relating to the internal control in credit application procedures and crediting process at PT. Central Santosa Finance.

a. Bad Credit to customers of two-wheeled vehicles Honda brand.
b. The customer data used in the period from January to September 2017

1.5. Benefits of The Research

This research is expected to provide the following benefits:

a. Can increase knowledge about financing institutions, leasing system, and understanding in the submission of motor vehicle loans conducted at PT. Central Santosa Finance.
b. It is expected that this research can be useful for future researcher as a reference or as a comparison and study for research conducted.

2. MATERIALS/METHODOLOGY; EXPERIMENTAL PROCEDURE.

2.1 Financing Institution

In Indonesia, although there has been a channeling of funds provided by bank and non-bank financial institutions, institutionally began officially recognized after the government issued Presidential Decree No. 61 in 1988 on Financing Institutions, which was then followed up by Decree of the Minister of Finance of the Republic of Indonesia No. 1251 /KMK.013/1988 concerning in Provisions and Procedures for Implementation of Financing Institutions, which has been amended the latest by Decree of the Minister of Finance of the Republic of Indonesia No. 448 / KMK.017 / 2000 concerning in Financing Company. The meaning of the Financing Institution according to Article 1 point (2) of Presidential Decree Number 61 Year 1988 regarding Financing Institution, namely: Financing Institution is a business entity that performs financing activities in the form of provision of funds or capital goods by not drawing funds directly from the community .

2.2 The Understanding of Credit

According to the Banking Act Number 10 of 1998 credit is the provision of money or bills that can be equivalent to it, based on a loan agreement or agreement between the bank and another party requiring the borrower to repay his debt after a certain period of time with the giving of interest. In a broad sense credit is defined as trust. Likewise in the Latin language credit means "credere" means to believe. The intention of trusting for the lender is that he trusts the recipient that the credits he or she distributes will be returned according to the agreement. As for the recipient of credit is the acceptance of trust that has the obligation to pay in accordance with the term (Kasmir 2009).

2.3 The Understanding of Sample

Sample is part of the population that represents all the characteristics of the population. A population with a large quantity can be taken partly by the quality of the sample representing exactly the quality of the population with a representative word. The number of samples is not always large and also not always small, it depends on the representation of characters from the sample. For example in the study of blood type, of course no need to put all blood from someone into laboratory because 2 ml of blood is enough to be used to know blood group that exist in leg, head or hand of patient. In some forms of research the possibility of numbers should be met so that there is a standard rule of drinking samples to be taken in a study. This is done with consideration of the quality of the samples taken. For example, a study of purchasing power in Gowa district. Taking five sample people as representatives of the population is not enough to represent the entire population. Apart from quality, in a study requiring inference statistics, the minimum sample size should be adjusted to the type of statistical analysis used primarily for the distribution of data from the sample.

2.3.1 Determining Number of Samples by Slovin Method

One method used to determine the number of samples is to use the Slovin formula (Sevilla, et al 1960), as follows:

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

Where:
n: the amount of sample
N: the amount of population
e: error tolerance

2.4 Simple Additive Weighting (SAW) Method

Simple Additive Weighting (SAW) method is a method used to find the optimal alternative from a number of alternatives with certain criteria. The essence of Simple Additive Weighting (SAW) is to determine the weight value for each attribute, then proceed with the ranking process that will select the alternatives already given. Basically, there are 3 approaches to finding attribute weight value that is subjective approach, objective approach and approach of integration between subjective & objective. Each approach has its advantages and disadvantages. In a subjective approach, the weighted value is determined by the subjectivity of the decision-makers, so that several factors in the alternative ranking process can be determined freely. Whereas in the objective approach, the weight value is calculated mathematically so that it ignores the subjectivity of the decision maker (Kusumadewi, et al, 2006).

The steps in using Simple Additive Weighting (SAW) method according to (Kusumadewi 2006) are:

a. Determine the alternative (candidate), ie Ai.
b. Determining the criteria that will be used as a reference in decision making, namely Cj.
c. Provide an alternative match rating on each criterion.
d. Determine the importance level weight (W) of each criterion.
   W = [W1, W2, W3, …. , Wj]
e. Create a match rating table of each alternative on each criteria.
f. Create a decision X matrix constructed from the match rating table of each alternative on each criterion. The value of x each alternative (Ai) on each criterion (Cj) has been determined, where, i = 1,2, ... m and j = 1,2, ... n.

$$x = \begin{pmatrix} x_{11} & \dots & x_{1j} \\ \dots & \dots & \dots \\ x_{i1} & \dots & x_{ij} \end{pmatrix}$$

g. Performing normalization of decision X matrix by calculating the value of performance normalized rating (rij) from alternative Ai on criterion Cj.

$$\text{Rij} = \frac{\frac{x_{ij}}{Max_i\ (Xij)}}{\frac{Min_i\ (Xij)}{X_{ij}}}$$

If i is the benefit criterion and If j is the cost criterion

The Information:

1) It says the profit criterion if the value of xij provides benefits to the decision maker, otherwise the cost criterion if xij raises the cost of decision makers.
2) If it is a profit criterion, the xij value is divided by the value of Maxi (xij) of each column, while for the cost criterion, the Mini (xij) value of each column is divided by the xij value

h. The result of the value of the normalized performance rating (rij) forms a normalized matrix (R)

$$R = \begin{pmatrix} r11 & \cdots & r1j \\ \vdots & \ddots & \vdots \\ ri1 & \cdots & rij \end{pmatrix}$$

i. The result of the preference value (Vi) is derived from the sum of the multiplication of the normalized row matrix element (R) with the corresponding weight of preference (W) of the matrix column column (W).
j. The benefits of Simple Additive Weighting (SAW)

There are some advantages of Simple Additive Weighting (SAW) according to (Kusrini, 2007):

1) Simple Additive Weighting (SAW) provides a model that is easy to understand, flexible for a variety of unstructured issues.
2) Simple Additive Weighting (SAW) reflects a natural way of thinking to sort elements of a system into different levels and group similar elements in each level.
3) Simple Additive Weighting (SAW) provides a measurement scale and provides a method for setting priorities.
4) Simple Additive Weighting (SAW) provides an assessment of the logical consistency of

the considerations used in determining priorities.

5) Simple Additive Weighting (SAW) leads to a comprehensive view of emerging alternatives to the problems at hand.
6) Simple Additive Weighting (SAW) provides a means for non-coerced assessments but is an appropriate assessment of their respective views.
7) Simple Additive Weighting (SAW) allows every person or group to sharpen their logic and intuition skills on matters mapped through Simple Additive Weighting (SAW)

2.5 The Framework

The framework of the analysis process in this research can be described as follows:

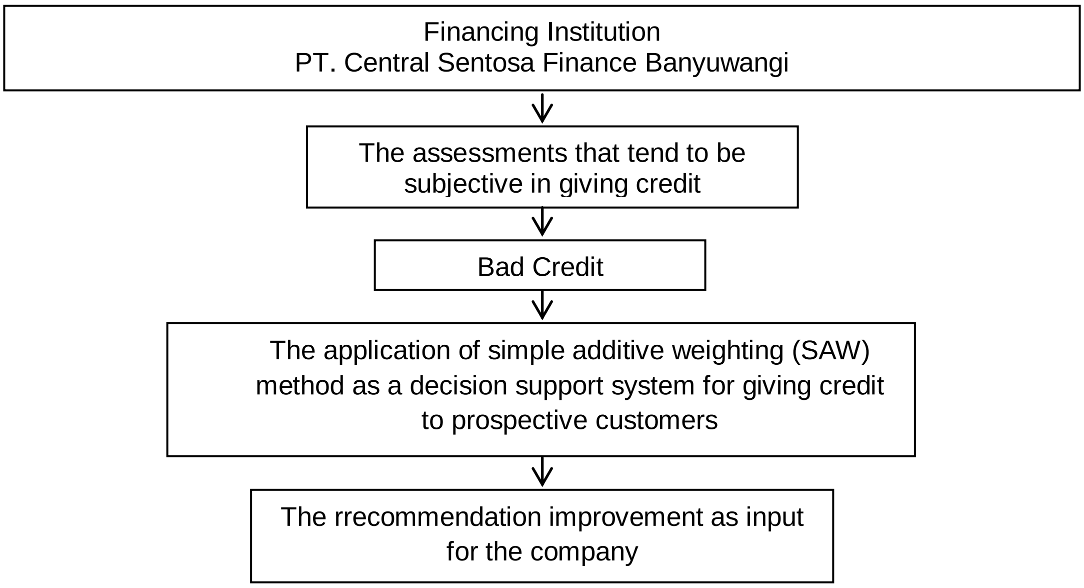


Fig. 1 The Framework

2.6 Material or Research Instrument

The main material or instrument in this research is observation about the observation of Credit Applying procedure and analysis of supporting system The decision of credit giving to prospective customers of PT. Central Santosa Finance Branch Banyuwangi. Simple Additive Weighting (SAW) is a process of analyzing learning which is done by giving score of weight criteria to each character through 5C namely: character, capacity, capital, collateral, and condition.

2.7 Data Collection Method

Methods of data collection in this study include:

a. Observation,
Technique of data collecting through direct observation and indirectly to object of research (Umar 2002).
b. Interview
The most sociological research technique because of its form comes from the verbal interaction between the researcher and the respondent and also the best way to determine why a person behaves, by asking directly (Black & Champion, 1992).
c. Documentation
By conducting data collection and company documents relevant to this research. In this study, the document that became the object of research data is the document used that is

produced related to motorcycle credit at PT. Central Santosa Finance Banyuwangi.

d. Field Studies

Collecting data directly to the field using data collection techniques.

e. Literature Review

Collecting data by taking literature or books related to the object of research as the foundation material theory and the foundation of the analysis.

2.8 The Data Analysis Method

Data analysis technique is the process of organizing and arranging systematically data into patterns, categories, and units of basic descriptions so that it can find the theme and work hypothesis as suggested data, and to increase the understanding of these materials to be presented to others (Moleong, 2004).

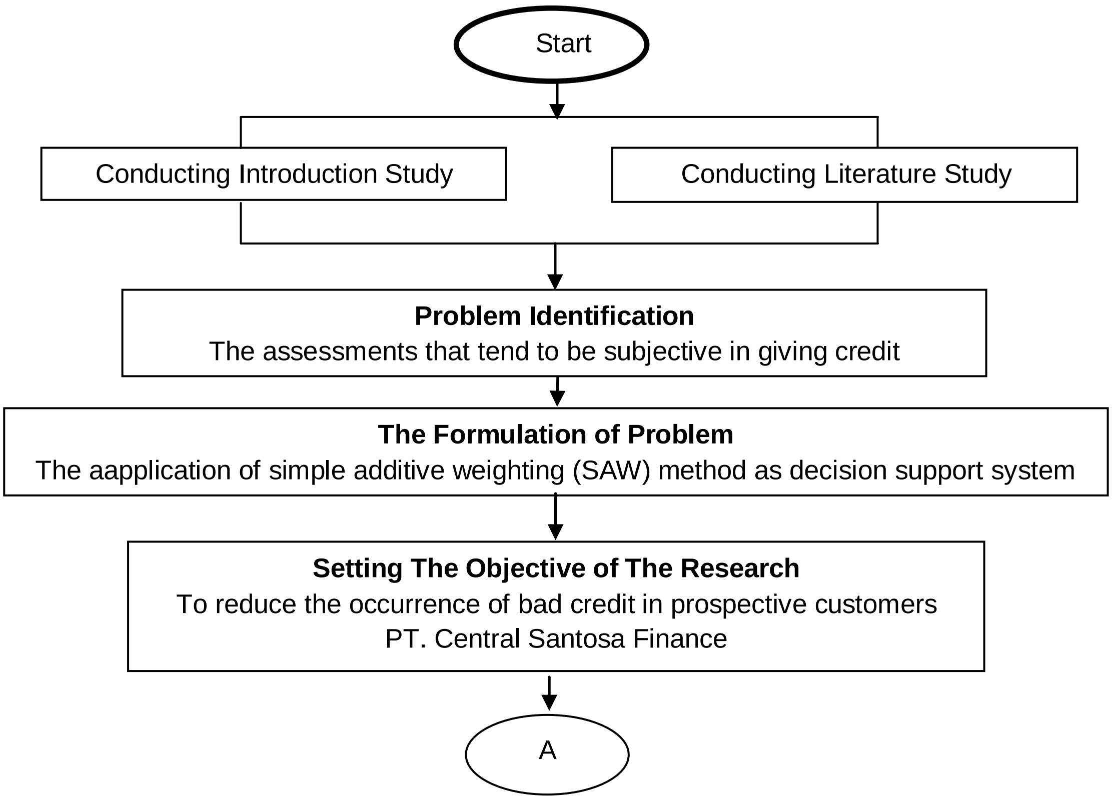
2.8.1 Determine The Sample Size

Determining the sample size is the first thing to do. The selection of samples using appropriate methods can accurately describe actual population conditions. One method used to determine the number of samples is to use the Slovin formula (Sevilla, et al 1960).

2.8.2 The Stage of Analyze Data and Result Analysis

The first step of the Simple Additive Weighting (SAW) method is the weighting of each applicant criteria. Then assign the crips value on each criterion based on the alternatives that have been specified into the crips value of 5C namely: character, capacity, capital, collateral, and condition. After that calculate each value using simple additive weighting (SAW) method. From the calculation results can be determined that prospective customers who apply for credit is worthy or not to be given a credit.

2.9 The Flow Chart of Study



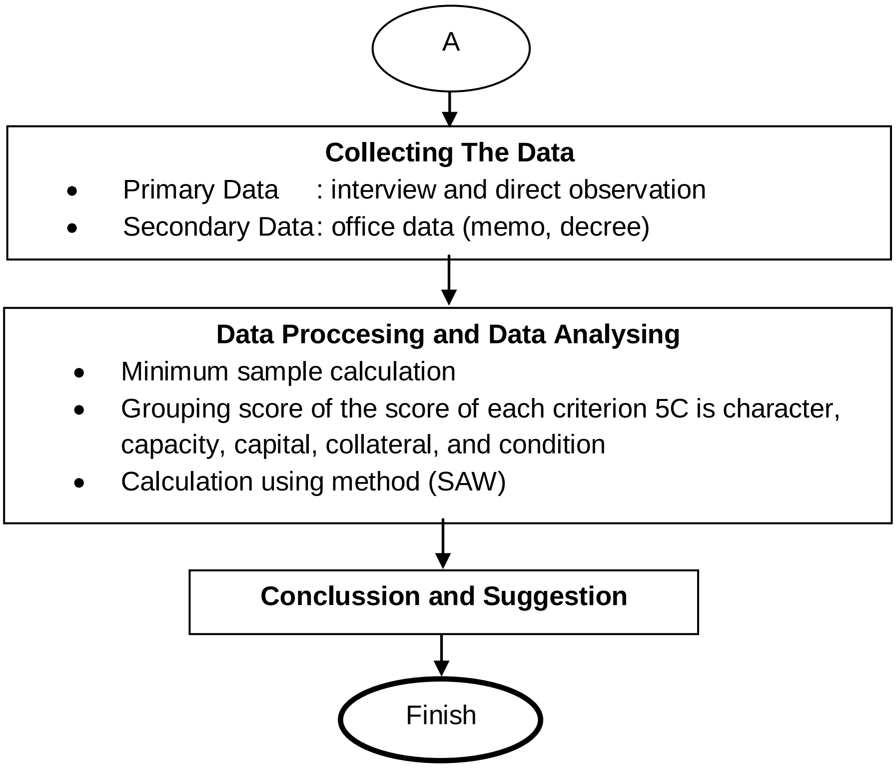


Fig. 2 Research Flow chart

3. RESULT AND DISCUSSION.

3.1 Collecting Data

Research data collection should not be done carelessly. The purpose of this data collection step and data collection techniques is to obtain valid data, so the results and conclusions of the study will not be doubted the truth. Data can be differentiated into several categories based on how to acquiring it.

a. Data Primer

The results of direct observation of customers who will apply for credit at PT. Central Santosa Finance Banyuwangi with direct interviews and field check activities in the neighborhood of potential customers.

b. Secondary Data

Data obtained from PT. Central Santosa Finance Banyuwangi in form of directors decree, internal memo office and data customer PT. Central Santosa Finance Banyuwangi.

3.2 Data Processing and Analysis

3.2.1 Minimum Sample Calculation

Determining the sample size is the right thing to do and selecting the sample using the right method can accurately describe the actual population condition. Slovin formula to determine the number of research samples. From the data of prospective customers who will take credit at PT. Central Santosa Finance Banyuwangi is amounts to 474 prospective customers who take Honda motorcycle credit for the period of September 2017.

$$n = \frac{\mathrm{N}}{1 + \mathrm{N}e^2}$$

$$n = \frac{474}{1 + 474 \text{ x } 0.15^2}$$

$n = \frac{474}{11,67}$

$n = 40,61$

3.2.2 Grouping of The Value Score of Each Criterion 5C

In the determination of credit provision can be determined group classification, and score in accordance with the conditions of prospective borrowers who apply for credit based on indicators owned. Scoring varies depending on the options of each question. Here are the criteria of crediting with 5C. The assessment of credit by the method of analysis 5C (Kasmir 2008), namely:

a. Character

The nature or character of the persons who will be given a credit must be credible as reflected in the background of the customer in both personal and work-related backgrounds such as his or her lifestyle or lifestyle, family circumstances, hobbies and social standing. Character is a measure to assess the willingness of customers to pay their credit. According to Dendawijaya (2005) information about prospective borrowers can be obtained by working with banks and other business circles. Information from banks is obtained through correspondence or correspondence between banks known as an information bank, including an official request to Bank Indonesia (BI) to obtain information about prospective borrowers, whether about their personal or company or business owned.

b. Capacity

To see the ability of prospective customers in paying credit associated with the ability to manage the business and the ability to make a profit. So it will be seen their ability to restore the credit disbursed.

c. Capital

The effective use of capital can be seen from the financial statements (balance sheet and income statement) by measuring such as in terms of liquidity, solvency, rentability and other measures. Capital is to know the sources of financing the customer has for the business to be financed by the bank.

d. Collateral

It is a guarantee given by the prospective customer both physical and non physical. Guarantee should exceed the amount of credit granted. Guarantees should also be checked for validity so that if a problem occurs, the deposited guarantee will be used as soon as possible.

e. Condition

The economic conditions of the present and the future should be judged in accordance with their respective sectors. Business prospects from the sector run by customers should also be assessed. Assessment of the prospects of the business sector financed should have good prospects, so the possibility of such credit has problem is relatively small.

The first step of the Simple Additive Weighting method is the weighting of each applicant criteria of credit.

Table 2. Giving Weight Criteria

Criteria Name	Weight Score
Character	25
Capital	15
Capacity	35
Collateral	10
Condition	15

From the criteria above, a degree of criterion is made based on a predetermined alternative to the value of the crips. The rating of each alternative matches on each criterion like the following table:

Table 3. Criteria Crips Score Character

Criteria	Applicant Criteria	Score
Character	Very Less	20
	Less	40
	Enought	60
	Good	80
	Very Good	100

Table 4. Criteria Crips Score Capital

Criteria	Aplicant Criteria	Score
Capital	DP <15% of the price	20
	DP 16-20% of the price	40
	DP 21-25% of the price	60
	DP 26-30% of the price	80
	DP >30% of the price	100

Tabel 5. Criteria Crips Score Capacity

Criteria	Aplicant Criteria	Score
Capacity	Very Less	20
	Less	40
	Enought	60
	Good	80
	Very Good	100

Tabel 6. Criteria Crips Score Collateral

Criteria	Applicant Criteria	Score
Collateral	BPKB motor	100

Tabel 7. Criteria Crips Score Condition

Criteria	Applicant Criteria	Score
Condition	Very Less	20
	Less	40
	Enought	60
	Good	80
	Very Good	100

3.2.3 Calculating Using Simple Additive Weighting

Based on the criteria and rating of each alternate match on any predetermined criteria, further elaboration of each criterion alternatives. Taken several samples of prospective customers credit applicants with the following data:

Table 8. The Data of Prospective Clients for The Period of September 2017

No	Cust. Name	Brand	Object Price	Down Pyment	Installment	Top
1	Ririn Agustina	Vario 125 CBS	19.215.000	3.300.000	667.000	36
2	Dias Fajar Pranata	Vario 125 CBS	19.215.000	5.900.000	560.000	36
3	Ponidi	Beat FI ISS	16.940.000	1.900.000	630.000	36
4	Iriyanto	Vario 125 CBS	19.215.000	5.800.000	743.000	24
5	Much. Fadlilah	Beat CBS FI	16.740.000	3.000.000	575.000	36
6	Supiyanto	Beat FI ISS	16.940.000	1.800.000	634.000	36
7	Buhani	Vario 125 ISS	19.510.000	4.400.000	635.000	36
8	Endri Pujianto	Vario 110 CW	17.410.000	1.800.000	653.000	36
9	Susanto	CBR 150 R	35.385.000	6.700.000	1.590.000	24
10	Tri Kusdiantoro	Vario 125 ISS	19.510.000	6.000.000	765.000	24
11	Rosida Himawati	Vario 150 Exc	22.400.000	7.100.000	863.000	24
12	Belly Dani	Vario 125 CBS	19.215.000	2.100.000	944.000	24
13	Alpan	Beat CBS FI	16.740.000	1.700.000	659.000	34
14	Wakiah	Vario 125 CBS	19.215.000	5.100.000	794.000	24
15	Suryadi	Vario 125 CBS	19.215.000	3.600.000	656.000	36
16	Saiman Hadi	Vario 125 CBS	19.215.000	10.200.000	650.000	18
17	Muhammad Riza	Vario 110 CW	17.410.000	1.800.000	654.000	36
18	Ari Setijorini	Vario 125ISS	19.510.000	2.000.000	733.000	36
19	Muawanah	Beat FI ISS	16.940.000	1.700.000	638.000	36
20	Yohana Novita	Vario 150 Exc	22.400.000	2.300.000	1.940.000	12
21	Agus Suhairi AH	Vario 125 CBS	19.215.000	3.500.000	660.000	36
22	Suryati	Vario 125 CBS	19.215.000	2.000.000	720.000	36
23	Jumadi	Vario 150 Exc	22.400.000	4.400.000	757.000	36
24	Ribut Hadi	Beat CBS FI	16.740.000	1.700.000	629.000	36

No	Cust. Name	Brand	Object Price	Down Pyment	Installment	Top
25	Moh. Nurkholiq	Vario 125 ISS	19.510.000	7.700.000	500.000	36
26	Hartoyo	Beat FI ISS	16.940.000	1.760.000	635.000	36
27	M Ali Mustofa	Vario 125 CBS	19.215.000	2.100.000	1.745.000	12
28	Marbani	Beat FI ISS	16.940.000	1.700.000	638.000	36
29	Abdolah	Beat FI ISS	16.940.000	1.800.000	659.000	34
30	Tri Yuda Jhesy Eri	Beat CBS FI	16.740.000	1.700.000	654.000	34
31	Ernawati	Vario 125 CBS	19.215.000	2.000.000	949.000	24
32	Solikhah	Beat FI ISS	16.940.000	1.700.000	638.000	36
33	Gatot Supriyo	Beat FI ISS	16.940.000	1.700.000	638.000	36
34	Sulastri	Vario 125 ISS	20.140.000	2.100.000	755.000	36
35	Ahmd Rudi Fathoni	Vario 125 CBS	19.215.000	10.200.000	650.000	18
36	Suwali	Vario 110 CW	17.410.000	6.300.000	618.000	24
37	Didik Nurhadi	Vario 125 ISS	19.510.000	3.500.000	672.000	36
38	Susilowati	Beat FI ISS	16.940.000	1.700.000	638.000	36
39	Sundari	Vario 125 CBS	19.215.000	6.400.000	729.000	24
40	Tyas Adi Wibowo	Vario 125 CBS	19.215.000	2.500.000	700.000	36
41	Sarji	Vario 125 ISS	19.510.000	6.800.000	599.000	30

1. Prospective Clients named Ririn Agustin

Table. 9 : Sample table of Applicant Criteria

Criteria	Alternatif		
	Bad Criteria	Ririn Agustina	Current Criteria
Character (C1)	Good	Good	Very Good
Capital (C2)	<DP 15%	DP 17%	DP >30%
Capacity (C3)	Enough	Enough	Very Good
Collateral (C4)	BPKB motor	BPKB Motor	BPKB Motor
Condition (C5)	Enough	Good	Very Good

Table. 10 : Appropriate Adjusting Criteria of Applicant Samples table

	C1	C2	C3	C4	C5
Bad	80	20	60	100	60
Ririn Agustina	80	40	60	100	80
Current	100	100	100	100	100

Make the X decision matrix, created from the match table

$$X = \begin{bmatrix} 80 & 20 & 60 & 100 & 60 \\ 80 & 40 & 60 & 100 & 80 \\ 100 & 100 & 100 & 100 & 100 \end{bmatrix}$$

Perform normalized matrices by calculating the normalized performance rating (rij) value of the Ai attribute on the Cj attribute based on the equation adjusted to the attribute type (attribute benefit = Maximum or cost attribute = Minimum).

Calculation :

R11 = $\frac{80}{\max(80,80,100)} = \frac{80}{100}$ = 0,8

R12 = $\frac{20}{\max(20,40,100)} = \frac{20}{100}$ = 0,2

R13 = $\frac{60}{\max(60,60,100)} = \frac{60}{100}$ = 0,6

R14 = $\frac{100}{\max(100,100,100)} = \frac{100}{100}$ = 1

R15 = $\frac{60}{\max(60,80,100)} = \frac{60}{100}$ = 0,6

R21 = $\frac{80}{\max(80,80,100)} = \frac{80}{100}$ = 0,8

R22 = $\frac{40}{\max(20,40,100)} = \frac{40}{100}$ = 0,4

R23 = $\frac{60}{\max(60,60,100)} = \frac{60}{100}$ = 0,6

R24 = $\frac{100}{\max(100,100,100)} = \frac{100}{100}$ = 1

R25 = $\frac{80}{\max(60,80,100)} = \frac{80}{100}$ = 0,8

R31 = $\frac{100}{\max(80,80,100)} = \frac{100}{100}$ = 1

R32 = $\frac{100}{\max(20,40,100)} = \frac{100}{100}$ = 1

R33 = $\frac{100}{\max(60,60,100)} = \frac{100}{100}$ = 1

R34 = $\frac{100}{\max(100,100,100)} = \frac{100}{100}$ = 1

R35 = $\frac{100}{\max(60,80,100)} = \frac{100}{100}$ = 1

Perform the assessment process by multiplying the normalized matrix (R) with the weight value (W).

$$R = \begin{bmatrix} 0{,}8 & 0{,}2 & 0{,}6 & 1 & 0{,}6 \\ 0{,}8 & 0{,}4 & 0{,}6 & 1 & 0{,}8 \\ 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

The last, summing the product between a normalized matrix (R) with a weighted value (W). Weight criteria are: Character = 25%, Capital = 15%, Capacity = 35%; Collateral = 10%, and Condition = 15%, then the solution is as follows

Vector weight [W] = {25,15,35,10,15}

V1=(25)(0,8)+(15)(0,2)+(35)(0,6)+(10)(1)+ (15)(0,6) = 63

V2=(25)(0,8)+(15)(0,4)+(35)(0,6)+(10)(1)+ (15)(0,8) = 69

V3=(25)(1)+(15)(1)+(35)(1)+(10)(1)+(15)(1)= 100

From the calculation, it can be concluded that the value of V1 and V3 is a static value that changes only if the criteria weight is changed, while the value of V2 is the value of the credit applicant. Value V1 is the minimum value at which bad credit may occur and V3 is the maximum value at which credit runs smoothly. In this case, the eligibility value is 63 - 100. So Ririn Agustina is declared eligible to receive credit with value 69.

4. CONCLUSION.

4.1 Conclusion

The conclusion that can be given after doing the research:

a. With the implementation of the 5C decision analysis using the simple additive weighting (SAW) method can attempt to eliminate the old habits of credit marketing staff who arbitrarily provide credit with subjective judgment without knowing the prospective customers who take credit.
b. With this Simple Additive Weighting (SAW) Method to determine the feasibility of providing motorcycles credit of PT Central Santosa Finance Banyuwangi will assist in providing recommendations and considerations in credit decision making.

4.2 Suggestion

The suggestion that can be given after doing the research:

a. Improving credit quality by making improvements in credit decision making and also running good and correct credit procedures in accordance with applicable regulations.
b. Fixed the credit submission system for the better so that no action that could harm the company.

5. REFERENCES

Afriyanti, M, (2013), *Decision Support System Determination Bonus And Increase Employee Salary At PT. Priz Travel with Simple Additive Weighting Method (SAW)*, Central Library STTI, Tanjung Pinang.

Ariyanto, (2012), *Decision Support System of Best Employee Selection With Simple Additive Weighting Method*, Thesis Faculty of Science and Technology UIN Sunan Kalijaga, Yogyakarta.

Cashmere, (2014), *Bank And Other Financial Institutions*, Revised Edition, Jakarta.

Guidelines for Preparing Lapagan Work, (2016), Faculty of Engineering University of 17 August 1946, Banyuwangi.

Joko Usito, Nugroho, (2013), *Decision Support System Evaluation of Teaching and Learning Process Using Simple Additive Weighting (SAW) Method, Thesis Program of Master of Information Systems of Diponegoro University*, Semarang

Jusuf, Jopie, (2005), *Credit Analysis For Account Officer*, Sixth Print, PT. Gramedia PustakaUtama, Jakarta.

Kusumadewi, Sri; Hartati, Sri; Harjoko, Agus; Wardoyo, Retantyo, (2006), *Multi-Attribute Decision Making Fuzzy (Fuzzy MADM,,* Graha Ilmu, Yogyakarta.

Maulidhia, Rizkia, (2015), *Internal Control System Analysis of Household Lending,* Tulungagung.

Simanjuntak, Marsitta, Roi, Limbong, Toni, (2015), *Decision Support System for business loan with simple additive weighting (SAW) method Case Study of PT. BPR Laksana Guna Percut*, Jurnal Informasi dan Teknologi Ilmiah (INTI), vol. 1, not 2, hh.134.

Sudarsono, Nono, Suciyono, Nanang, Kuswandi, Andi, (2015), *Decision Support System (SPK) Credit granting in Adira Quantum Multifinance Tasikmalaya Branch Method Simple Additive Weighting (SAW)*, hh. 355-356

Sutanto, Noengky, Anastasia, Onik, Djohan, (2005), *Analysis of credit worthiness assessment,* Admad Dahlan University, Yogyakarta.

Suyatno, T, 1988, *Fundamentals of Credit*, Gramedia Pustaka Utama, Jakarta.

Thesis Writing Guidelines, (2016), University of 17 August 1945, Banyuwangi.

Wahab, R, A, (2010), *Decision Support System of Credit Lending Using Satisfactory Mode*. University Computer Indonesia, Tegal.

Wulandary. (2015), *System Analysis And Procedure Of Working Capital Loan At Pd Bpr Bank Pasar Kota Pontianak, Juornal* UTAN, hh. 787-795.

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ANALYSIS ON STABILITY OF 2-DOF MOTION CONTROL SYSTEM APPLIED TO AUTONOMOUS UNDERWATER VEHICLE SYSTEM

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ABSTRACT

This paper analyzes the motion control system stability using Sliding Mode Control (SMC) method with 2-DOF motion equation on Autonomous Underwater Vehicle (AUV). The 2-DOF motion equation consists of surge and roll motions in the form of nonlinear motion equations. The stability analysis was applied to AUV system using Lyapunov method. The simulation results of the SMC control system with the 2-DOF motion equation on the AUV system showed that the system was stable at the determined set-point value with an error of ≤1% and locally, asymptotically stable.

KEYWORDS : AUV, motion control, stability analysis, Lyapunov

1. INTRODUCTION.

The geographical territory of Indonesia covers islands and waters. About one third of Indonesia territory is land area, while the rest, the two-thirds, is water. Indonesia's strategic region with its tropical climate provides a lot of potential and natural wealth contained in it (Oktafianto,2015). An area of approximately 70% of ocean needs special attention to be paid to the natural resources contained therein.Underwater technology is required to explore and safeguard the natural resources of Indonesian state, that is, underwater vehicle (Herlambang et al,2014).

Underwater vehicles that are commonly developed by many countries today are unmanned water robots or unmanned submarines. Such a robot is widely known as Autonomous Underwater Vehicle (AUV) which is one of the unmanned vehicles or the unmanned vehicle that works automatically without any direct control by humans (Herlambang,2017). The benefits of AUV are that it can be utilized not only for marine resources exploration, but also underwater mapping and underwater defense system equipment (Herlambang, 2015).

This study began by making up the model of motion equation with 2-DOF, that is, surge motion and roll motion. Surge and roll motions are translation and rotation motions on the x-axis. Then motion control system design for forward movement was developed by using Sliding Mode Control (SMC). The next step was to find stability analiyisis with Lyapunov Function, and we get system is locally asymptotically stable .

2. AUTONOMOUS UNDERWATER VEHICLE (AUV) MODEL

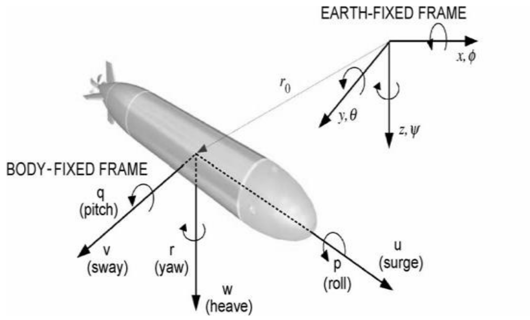

Fig. 1. Six degree of freedom of AUV motion (Yang, 2007)

To analyze the AUV system there are two important things to note, namely the axis system consisting of Earth Fixed Frame (EFF) and Body Fixed Frame (BFF) which have been represented in Figure 1 (Yang, 2007). EFF is used to explain the position and orientation of AUV, where the x-axis position leads northward, the y-axis to the east and the z-axis toward the center of the earth. While the BFF defines the positive x-axis as desired direction of the vehicle, the positive y-axis was direction to the right side of the vehicle, and the positive z-axis as direction to downward (Fosen,2005). The BFF system is used to explain the speed and acceleration of the AUV with the starting point at the center of gravity (Herlambang,2017). This study used motion equations with 2-DOF i.e. surge and roll, ignoring sway motion, heave, pitch and yaw. Below are the motion equations in 2-DOF:

$$\dot{u} = \frac{X_{res}+X_{|u|u}u|u|+X_{prop}}{m-X_{\dot{u}}} \quad (1)$$

$$\dot{p} = \frac{K_{res}+K_{p|p|}p|p|+K_{prop}}{I_x-K_{\dot{p}}} \quad (2)$$

Where X_{res} dan K_{res} are hydrostastic forces and moments in the x-axis direction, X_{prop} dan K_{prop} as force and moment of thrust.AUV specifications are listed in Table 1.

Table 1.Specification of AUV

Weight	18 Kg
Length	1600 mm
Diameter	200 mm
Controller	Ardupilot Mega 2.0
Communication	Wireless Xbee 2.4 GHz
Camera	TTL Camera
Battery	Li-Pro 11,8 V
Propulsion	12V motor DC
Propeller	3 Blades OD : 50 mm
Speed	3.1 knots (1.5m/s)
Maximum Depth	8 m

3. SLIDING MODE CONTROL (SMC)

The design of the SMC controller can be described as follows (Herlambang et al,2017):

a. Determine the function of Switching *S(x,t)* as in the equation $S(x,t) = \dot{e} + \lambda e = 0$ of tracking error of dynamic system.
b. Determine the Sliding surface, ie *S(x,t)=0* of the Switching function obtained.
c. Determine the estimated value of the controller $\hat{u}$. Dynamics under sliding

condition can be written as: $\dot{S} = 0$

by completing the switching function, expression for the estimated value of the controller was obtained as equivalent control. When using dynamic SMC at the moment S=0, $\hat{u}$ was obtained.

d. Define the rules of SMC, that is, using control law,

$$u = \hat{u} - K\,\mathrm{sgn}(S)$$

where the signum function, sgn is defined as:

$$\mathrm{sgn}(x)\begin{cases} -1 & ,x < 1 \\ 1 & ,x \geq 1 \end{cases}$$

e. Substitute the value of $\hat{u}$ in *control law* so as to obtain new *control input* as subtitute of previous *control input*.

f. Determine the value of K in conformance to the *sliding* condition in equation of stage 4.

Then work on designing the SMC control system in the motion equation of non-linear model with 2-DOF.

4. Designing SMC Control System of 2-DOF non-linear Model

In this part the SMC control system was designed to obtain control input for surge and roll motions.

4.1. Surge Control System

To find control of surge, the tracking error of the surge was determined first as follows

$\tilde{u} = u - u_d$ $\qquad$ u_d=constant

Since the system is of order 1, *switching* function was formulated as follows :

$$S(u,t) = \left(\frac{d}{dt}\right)^{n-1}\tilde{u} \qquad \text{with n=1}$$

$$S(u,t) = \left(\frac{d}{dt}\right)^{1-1}\tilde{u}$$

$$S(u,t) = \tilde{u} = u - u_d$$

Whereas the derivative of S is as follows :

$$\dot{S}(u,t) = \dot{u} - \dot{u}_d \qquad (3)$$

Since u_d=constantm then $\dot{u}_d = 0$

By subtituting equation (1) to equation (3), it becameas follows:

$$\dot{S}(u,t) = \frac{X_{res} + X_{|u|u}u|u| + X_{prop}}{m - X_{\dot{u}}} \qquad (4)$$

Then the value of $\hat{X}_{prop}$ in equation (4) where $\dot{S} = 0$ was determined as follows.

$$\frac{X_{res} + X_{|u|u}u|u| + X_{prop}}{m - X_{\dot{u}}} = 0 \qquad (5)$$

So $\hat{X}_{prop}$ obtained was

$$\hat{X}_{prop} = -\left(X_{res} + X_{|u|u}u|u|\right) \qquad (6)$$

Based on *control law* meeting *sliding* condition was :

$$X_{prop} = \hat{X}_{prop} - K_1\,sgn\,(S) \qquad (7)$$

Then from equation (6) and (7) the following was obtained

$$X_{prop} = -\left(X_{res} + X_{|u|u}u|u|\right) - K_1\,sgn\,(S) \qquad (8)$$

By subtituting equation (8) to (5), the following equation was obtained :

$$\dot{S}(u,t) = \frac{X_{res} + X_{|u|u}u|u| + (-(X_{res} + X_{|u|u}u|u|) - K_1\,sgn\,(S))}{m - X_{\dot{u}}}$$

$$\dot{S}(u,t) = -\frac{K_1\,sgn\,(S)}{m - X_{\dot{u}}} \qquad (9)$$

Then the K value was designed by substituting equation (9) into equation (10) in order to meet the sliding conditions:

$$S\dot{S} \leq -\eta|S| \qquad (10)$$

$$-S\frac{K_1\,sgn\,(S)}{m - X_{\dot{u}}} \leq -\eta|S|$$

$$-AA_1K_1\,sgn\,(S) \leq -\frac{\eta|S|}{S}$$

$$K_1 \geq \frac{(m - X_{\dot{u}})\eta}{sgn\,(S)} \qquad (11)$$

From equation (11) the value of K was obtained:

$$K_1 = |\max(m - X_{\dot{u}})\eta| \qquad (12)$$

Then a boundary layer was used to minimize chattering by changing the signum function (sgn) into saturation function (sat) as follows:

$$X_{prop} = \hat{X}_{prop} - K\,sat\,\left(\frac{S}{\phi}\right) \qquad (13)$$

Thus the control system design obtained by substituting equations (6) and (12) into equation (13) is as follows:

$$X_{prop} = -\left(X_{res} + X_{|u|u}u|u|\right) - |\max(m - X_{\dot{u}})\eta|\ sat\ \left(\frac{S}{\phi}\right) \quad (14)$$

4.2. Roll Control System

To find control of the roll,the tracking error of the roll was determined first as follows.

$\tilde{p} = p - p_d$ $\quad\quad$ p_d=constant

Since the system was of order 1, the the switching function was formulated as follows:

$$S(p,t) = \left(\frac{d}{dt}\right)^{n-1}\tilde{p} \quad \text{with n=1}$$

$$S(p,t) = \left(\frac{d}{dt}\right)^{1-1}\tilde{p}$$

$$S(p,t) = \tilde{p} = p - p_d$$

Whereas the derivative of S is as follows :

$$\dot{S}(p,t) = \dot{p} - \dot{p}_d \quad (15)$$

Sincep_d=constant, then$\dot{p}_d = 0$

By subtituting equation (2) into (15), then it became :

$$\dot{S}(p,t) = \frac{K_{res}+K_{p|p|}p|p|+K_{prop}}{I_x - K_{\dot{p}}} \quad (16)$$

Next the value of$\hat{K}_{prop}$in equation (16) with the value of $\dot{S} = 0$ was determined as follows.

$$\frac{K_{res}+K_{p|p|}p|p|+K_{prop}}{I_x - K_{\dot{p}}} = 0 \quad (17)$$

So$\hat{K}_{prop}$ obtained is

$$\hat{K}_{prop} = -\left(K_{res} + K_{p|p|}p|p|\right) \quad (18)$$

Based on*control law* meeting the*sliding* condition is :

$$K_{prop} = \hat{K}_{prop} - K\ sgn\ (S) \quad (19)$$

So from equation (18) and (19) the following was obtained :

$$K_{prop} = -\left(K_{res} + K_{p|p|}p|p|\right) - K\ sgn\ (S) \quad (20)$$

Dengan mensubstitusikan persamaan (20) ke (16), diperoleh :

$$\dot{S}(p,t) = \frac{K_{res}+K_{p|p|}p|p|+\left(-\left(K_{res}+K_{p|p|}p|p|\right) - K\ sgn\ (S)\right)}{I_x - K_{\dot{p}}}$$

$$\dot{S}(p,t) = -\frac{K\ sgn\ (S)}{I_x - K_{\dot{p}}} \quad (21)$$

Then the value of K was designed by subtituting equation (21) into equation (22) so as to meet *sliding* condition, that is :

$$S\dot{S} \le -\eta|S| \quad (22)$$

$$-S\frac{K\ sgn\ (S)}{I_x - K_{\dot{p}}} \le -\eta|S|$$

$$K \ge \frac{(I_x - K_{\dot{p}})\eta}{sgn\ (S)} \quad (23)$$

From equation (23) it was obtained that the K value is :

$$K = \left|\max\left(I_x - K_{\dot{p}}\right)\eta\right| \quad (24)$$

Then a boundary layer was used to minimize chattering by changing the signum function (sgn) into saturation function (sat) as follows:

$$K_{prop} = \hat{K}_{prop} - K\ sat\ \left(\frac{S}{\phi}\right) \quad (25)$$

Thus the control system design obtained by substituting equations (18) and (24) into equation (25) is as follows:

$$K_{prop} = -\left(K_{res} + K_{p|p|}p|p|\right) - \left|\max\left(I_x - K_{\dot{p}}\right)\eta\right|\ sat\ \left(\frac{S}{\phi}\right) \quad (26)$$

5. RESULT OF STABILITY ANALYSIS

The SMC control system design of the nonlinear 2-DOF model was obtained, from AUV 2-DOF motion equations: surge and roll, control law was obtained by using lyapunov function as a candidate is

$$V(u,p) = \frac{1}{2}u^2 + \frac{1}{2}p^2$$

It was shown that function $V(u,p) = \frac{1}{2}u^2 + \frac{1}{2}p^2$ is lyapunov function in conformance to the above definition :

a. Function V is continuous and has partial derivative of S

Function $V(u,p) = \frac{1}{2}u^2 + \frac{1}{2}p^2$ is a quadratic function, it is clear that the quadratic function is continuous in E. Then the partial derivative is also continuous.

b. Take any $T = (u,p) \in \gamma$ with $T \neq T_1$, so $V(T) = \frac{1}{2}u^2 + \frac{1}{2}p^2 > 0$

Take any $T = (u,p) \in \gamma$ with $T \neq T_1$, so $V(T) = \frac{1}{2}0^2 + \frac{1}{2}0^2 = 0$

c. $\dot{V}(u,p) = \frac{\partial V}{\partial u}\dot{u} + \frac{\partial V}{\partial p}\dot{p}$

$\dot{V}(u,p) = u\dot{u} + p\dot{p}$

$$\dot{V}(u,p) = u\left(\frac{X_{res} + X_{|u|u}u|u| + X_{prop}}{m - X_{\dot{u}}}\right) + p\left(\frac{K_{res} + K_{p|p|}p|p| + K_{prop}}{I_x - K_{\dot{p}}}\right)$$

Choose $X_{prop} = -\left(X_{res} + X_{|u|u}u|u|\right) - Ksgn(S)$

Choose $K_{prop} = -\left(K_{res} + K_{p|p|}p|p|\right) - Ksgn(S)$

So the following is obtained

$$\dot{V}(u,p) = u\left(-\frac{K_1 sgn(S)}{m - X_{\dot{u}}}\right) + p\left(-\frac{K_2 sgn(S)}{I_x - K_{\dot{p}}}\right)$$

$$\leq \left[-\frac{K_1}{m - X_{\dot{u}}}\right][u] + \left[-\frac{K_2}{I_x - K_{\dot{p}}}\right][p]$$

Choose $K_1 = [m - X_{\dot{u}}]\eta$ dan $K_2 = \left[I_x - K_{\dot{p}}\right]\eta$

So the followings were obtained $\dot{V}(u,p) \leq [-\eta]|u| + [-\eta]|p|$

$$\dot{V}(u,p) \leq -\eta[|u| + |p|]$$

Having met those three requirement, function $V(u,p) = \frac{1}{2}u^2 + \frac{1}{2}p^2$ is Lyapunov function and locally, asymptotically stable.

6. CONCLUSION.

Based on the results and discussion it can be concluded that the Sliding Mode Control (SMC) method can be applied as a control system of surge and roll motion with an error of ≤1 and is locally asymptotically stable.

7. REFERENCES.

Fossen, T. I. (2005) ,"A Nonlinear Unified State-space Model for Ship Maneuvering and Control in A Seaway". *International Journal of Bifurcation and Chaos*, Vol. 5, pp. 2717-2746, Aug.

Herlambang, T., Nurhadi H and Subchan., (2014). "Preliminary Numerical Study on Designing Navigation and Stability Control Systems for ITS AUV", *Applied Mechanics and Materials*, Trans Tech Publications, Switzerland. Vol. 49, pp. 420-425

Herlambang, T., Djatmiko E.B and Nurhadi H., (2015), "Navigation and Guidance Control System of AUV with Trajectory Estimation of Linear Modelling", *Proc. of International Conference on Advance Mechatronics, Intelligent Manufactre, and Industrial Automation,* IEEE *,* ICAMIMIA 2015,Surabaya, Indonesia, pp. 184-187, Oct 15 – 17.

Herlambang, T., Djatmiko E.B and Nurhadi H., (2015), "Ensemble Kalman Filter with a Square Root Scheme (EnKF-SR) for Trajectory Estimation of AUV SEGOROGENI ITS", *International Review of Mechanical Engineering* IREME Journal, Vol. 9, No. 6. Pp. 553-560, ISSN 1970 – 8734. *Nov.*

Herlambang, T., (2017), "Design Control System of Surge, Sway and Yaw Motion in Autonomous Underwater Vehicle using Sliding Mode Control (SMC) Method" Journal Of Mathematics and Its Applications (LIMITS), Vol. 14, No.1, page 53-60, ISSN 2579-8936. Mei.

Herlambang, T., Apriliani E, Cordova H, Mardlijah., (2017), "Dynamic Sliding Mode

Control (DSMC) for Water Level Control in Steam Drum Boiler", *Technology Science and Engineering Journal,* Vol 1 No 1 February 2017. E-ISSN: 2549-1601X.

Oktafianto, K., Herlambang T, Mardlijah and Nurhadi H., (2015), "Design of Autonomous Underwater Vehcle Motion Control Using Sliding Mode Control Method", *Proc. of International Conference on Advance Mechatronics, Intelligent Manufactre, and Industrial Automation,* IEEE , ICAMIMIA 2015, Surabaya, Indonesia, pp. 184-187, Oct 15 – 17.

Yang, C. 2007. *Modular Modelling and Control for Autonomous Vehicle (AUV)*. Department of Mechanical Engineering National University of Singapore.

Indonesian Naval Technology College
Postgraduate International Conference, Vol. 1, No. 1, pp. 163-178
November, 16th 2017

INTELLECTUAL CAPITAL MODELLING FOR BUSINESS PERFORMANCE STRATEGY.

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ABSTRACT

Intellectual Capital (IC) is a potential standard strategy to measure the value of an enterprise which relies on intellectual competence, due to the fact that the existing financial statements which have been sole source for investors to develop industrial sector of technology, are considered inadequate in representing the true value of enterprises as well as their potentials. Many IC researchers agree that IC comprises three main components; namely Human Capital (HC), Structural Capital (SC) or Organizational Capital, and Customer Capital or Relational Capital (RC). Human capital deals with the knowledge possessed by the organization as the results of having knowledgeable, creative, innovative, and talented employees and managerial staffs. Structural capital involves business processes, procedures, mechanisms, and knowledge which are codified into the system. This research identifies IC variables based on proven constructs obtained from various IC literatures. Not all components identified are expected to have significant influence on the final result of IC measurement. On the other hand, there are several other factors which are possible to influence but not sufficiently covered or represented by those constructs, such as cultural and demographic background, legal status, as well as the nature of business of the organization. These identified variables are selected and validated through several stages and become the basis to formulate strategies to maximize IC in PT Telekomunikasi Indonesia (PT TELKOM). Qualitative measures in a structural equation model yielded several research implications. The resulting structural model allows the organization to gauge the effectiveness of its human capital capabilities thus more efficiently allocate strategic resources with regard to human capital management. PT TELKOM is chosen as the study case since it represents much of Indonesia's information and communication technology market, and it has declared a mission to become the Most Admired Knowledge Enterprise (MAKE), in which the fourth criteria is to maximize intellectual capital. The study will identify the attributes of human capital (HC), structural capital (SC), and relational capital (RC) to maximize overall enterprise IC.

KEYWORDS : Intellectual Capital, human capital management, structural equation modelling.

1. INTRODUCTION

Intellectual Capital (IC) is a potential standard to measure the value of an enterprise, as have been in practices for two decades and demonstrated by Skandia, Celemi, and many other companies which rely on their intellectual competence, particularly information and communication technology (ICT) based enterprises. This is due to the fact that existing financial statements which have been sole source for investors to develop industrial sector of technology, are considered inadequate in representing the true value of enterprises as well as their potentials.

Simply speaking, IC can be considered as the difference between market value (the value of shares or how much an organization is worth) and their book value (accounting value represented by fixed and current assets in financial reports).

It is understandable why a company of modest size can have very high value in the capital market. Investors do not merely rely on corporations' financial performances, but also on business potentials as demonstrated by their commitment to the development of IC.

In an organization, the authority to provide intellectual capital statement belongs to and is the responsibility of Knowledge Management (KM) Department. This statement/report should describe knowledge management strategies and should incorporate goals and mission statement, initiatives as well as the results, in organizational knowledge resource one composition, application, and development. Based on this presumption, knowledge management strategies can be disseminated throughout the organization and communicated to the outside. (Bontis, 2001)

Intellectual capital further be referred to as *IC* statement is a management tool to create value for the organization, and as a means of communication to employees, customers, business partners, and investors, on how organization can create value for them. Like financial statements, IC statements monitor initiatives and achievements, and provide feedback whether or not the organization develops its resources towards the right direction. In this case, IC reports can describe how good the organization is in improving and managing their knowledge resources. (Bose, 2003)

Many IC researchers agree that IC (also known as *intangible assets* or simply *intangibles*) comprises three main components; namely *human capital* (HC), *organizational capital* or *structural capital* (SC), and *customer capital* or *relational capital* (RC). *Human capital* is primarily concerned with the knowledge possessed by an organization as the results of having knowledgeable, creative, innovative, and talented employees and managerial staffs. *Structural capital* involves business processes, procedures, mechanisms, and knowledge which are codified into the system. *Relational capitals* are intangible assets which are not in the form of knowledge, such as customer or supplier relationship, brand or corporate image, and customer base. (Bontis, 2001). Based on the literature review, there is limited research about IC attributes.

Therefore, this research aims to identify IC attributes based on proven constructs obtained and developed from various IC literatures. Not all components identified are expected to have significant influence on the final result of IC measurement. On the other hand, there will be several other factors which are possible to influence but not sufficiently covered or represented by those constructs, such as cultural and demographic background, legal status, as well as the nature of business of the organization. These identified variables will then be selected and validated through several stages and will be the basis to formulate recommendations to maximize IC in an organization.

PT Telekomunikasi Indonesia (PT TELKOM) is chosen as the case study since it represents much of Indonesia's information and communication technology market, and it has declared a mission to become the *Most Admired Knowledge Enterprise* (MAKE). The research is conducted in cooperation with PT Telkom, and the result will be a set of recommendations to be implemented in order to achieve that goal.

While attributes and variables need to be practical and measurable, the implementation should have realistic milestones in order to obtain an objective judgment whether or not the implementation is a success. Most importantly, these recommendations should be in-line with the organization's long term goals. For example, a staff with 4-year university degree and 10-year hands-on experience in installing PSTN cables may not have the same value as another staff with only 3-year diploma but has 2-year experience installing wireless BTS, since the company has redirected its strategic initiative to provide more wireless service provider in five years to come.

The following MAKE criteria have been put into Telkom's agenda:

a. creating an enterprise knowledge driven culture.
b. developing knowledge workers through senior management leadership.
c. delivering knowledge based products/services/solutions.
d. maximizing enterprise intellectual capital.
e. creating an environment for collaborative knowledge sharing.
f. creating a learning organization.
g. delivering value based on customer knowledge.
h. transforming enterprise knowledge into shareholder value.

The research focuses on the fourth agenda (maximizing enterprise intellectual capital) through the identification of various human capital attributes using the findings from previous researches on enterprise IC. If human capital attributes which have significant influence on IC performance can be identified, it is therefore possible to set up a recommendation to maximize IC.Hopefully, this paper makes contribution by providing IC attributes based on the case study of PT. Telkom.

As the first step of the study, a number of scientific literatures on the methods of measuring HC/IC quantitatively will be reviewed. On the ground of some base theories, a hypothesis on some constructs related to Intellectual Capital will be proposed. The hypothesis will then be examined through a process of data collection which will involve a perceptual survey and interviews with some key people. Even though the study will focus on human, structural factors and customer or external aspects which are thought to have significant influence on human, will also be considered.

The result of the survey data will be analysed and triangulated against the quantitative measures of business performance and will be set as an index. This index will be the basis for evaluation to measure the effectiveness and success of the IC implementation programs.

This paper consists of several sections as follows: Introduction, research methods, result and discussion, as well as conclusion.

2. LITERATURE REVIEW

There are several research regarding intellectual capital, such as Intellectual capital and financial returns of companies (Tan, Plowman and Hancock, 2007); modelling the creation of value from intellectual capital from the case study of a Portuguese banking perspective (Cabrita, de Vaz and Bontis, 2007); Intellectual capital and firm performance in Australia (Clark, Sheng and Whiting, 2011); An empirical investigation of the relationship between intellectual capital and firms' market value and financial performance (Chen, Cheng and Hwang, 2005); Intellectual capital accounting research (Guthrie, Ricceri and Dumay, 2012); Statistical analysis on the intellectual capital (Halim, 2010); The IC Rating model by Intellectual Capital Sweden (Jacobsen and Hofman-Bang, 2005); The impact of intellectual capital on firms' market value and financial performance (Maditinos, Chatzoudes, Tsairidis and Theriou, 2011); Intellectual capital and business performance in the pharmaceutical sector of Jordan (Sharabati, Jawad and Bontis, 2010).

Table 1. Manifest (observed) variables for Human Capital construct

Dimensions	Elements (Manifest or Observed Variables)
Managerial Leadership (Bontis, 2002)	Managers' and leaders' communication, performance feedback, supervisory and executive skills, demonstration of key organizational values, inclusiveness, efforts to instill confidence, supported by systems of transitions.
Process Execution, Workforce Optimization (Bontis, 2002)	Establishment of essential processes for getting work done, good working conditions, accountability, hiring decisions and performance evaluation system.
Education (Bontis, 2002)	Level and type of education, practical experience
Knowledge Generation, Learning & Development, Innovation (Bontis, 2002)	The organization's overall ability to learn and improvise, encouragement to innovate, and continually improve, complemented by training and recruitment programs.
Knowledge Integration (Bontis, 2002)	Transform their tacit knowledge into explicit knowledge by codifying their ideas into the systems of the organization.
Knowledge Sharing (Bontis, 2002)	Systematic accessibility, the extent of capability to collaborate and work in teams. Capacity for making knowledge and ideas widely available to employees.
Value Alignment (Bontis, 2002)	Demonstrating the value of learning behavior.
Employee Commitment (Bontis, 2002)	Organization's capacity to secure jobs, recognize accomplishment and provide opportunities for advancement.
Relationships (McBassi, 2004)	Horizontal relationship with coworkers and vertical with super/subordinates.
Work-life balance and Physical Environment (McBassi, 2004)	Work load and time, physical environment.
Employee Motivation (Bontis, 2002)	Initiatives, independence
Attitude towards work itself (McBassi, 2004)	Effective and creative job design to optimize talents and skills.
Attitude towards Products, Brands and Reputation (McBassi, 2004)	Pride and use own products, brands and reputation
Employee Satisfaction (Bontis, 2002)	Staff morale as reflected in the culture.

Retention of Key People (Bontis, 2002)	Systematic ability to retain good performers, determine key drivers of productivity

Table 2. Manifest (observed) variables for Structural Capital construct

Dimensions	Elements (Manifest or Observed Variables)
Management Philosophy (Rudéz, 2005)	Employee empowerment, Customers orientation, Initiative driven staff, Inter-department cooperation
Culture (Rudéz, 2005)	Organization's atmosphere, support for knowledge growth, degree of communication formality, communication between managers and staff.
Business Process (Rudéz, 2005)	Support for innovative ideas, innovations leadership, recognition of good ideas of employees, complaint solving, QoS improvement.
Information Technology (Rudéz, 2005)	Improvement on IT solutions, significance of IT contribution to product quality, connection with environment through IT, proportion of Internet sales.

Table 3. Manifest (observed) variables for Relational Capital construct

Dimensions	Elements (Manifest or Observed Variables)
Customer satisfaction and loyalty (Rudéz, 2005)	Market share growth, overall customer satisfaction improvement, decrease in number of complaints, customer loyalty growth.
Image and brand (Rudéz, 2005)	Image improvement, product feature attraction, relative value against competitors' brand, product development.
Relationship with distribution/supply chain channels (Rudéz, 2005)	Commitment to developing distribution channels, various means of channels, relationship capital (average value)
Relationship with other groups (Rudéz, 2005)	Relationships with commercial partners (success, monitoring, bureaucracy and role for knowledge); quality of representatives; exploitation of opportunity, relationship with the media; importance of media as source of image, obstacles or supports from local community, government, investors, special interest groups, industry association, impact from competitors on supply chain.

3. METHODOLOGY

Intellectual Capital consists of three main constructs namely *Human Capital*, *Structural*

Capital, and *Relational Capital*. This model however suggests that human capital has the greatest influence on the overall business performance. This implies that it can be assumed that maximizing human capital will result in the maximization of business performance. Figure 2 below describes Intellectual capital modelling

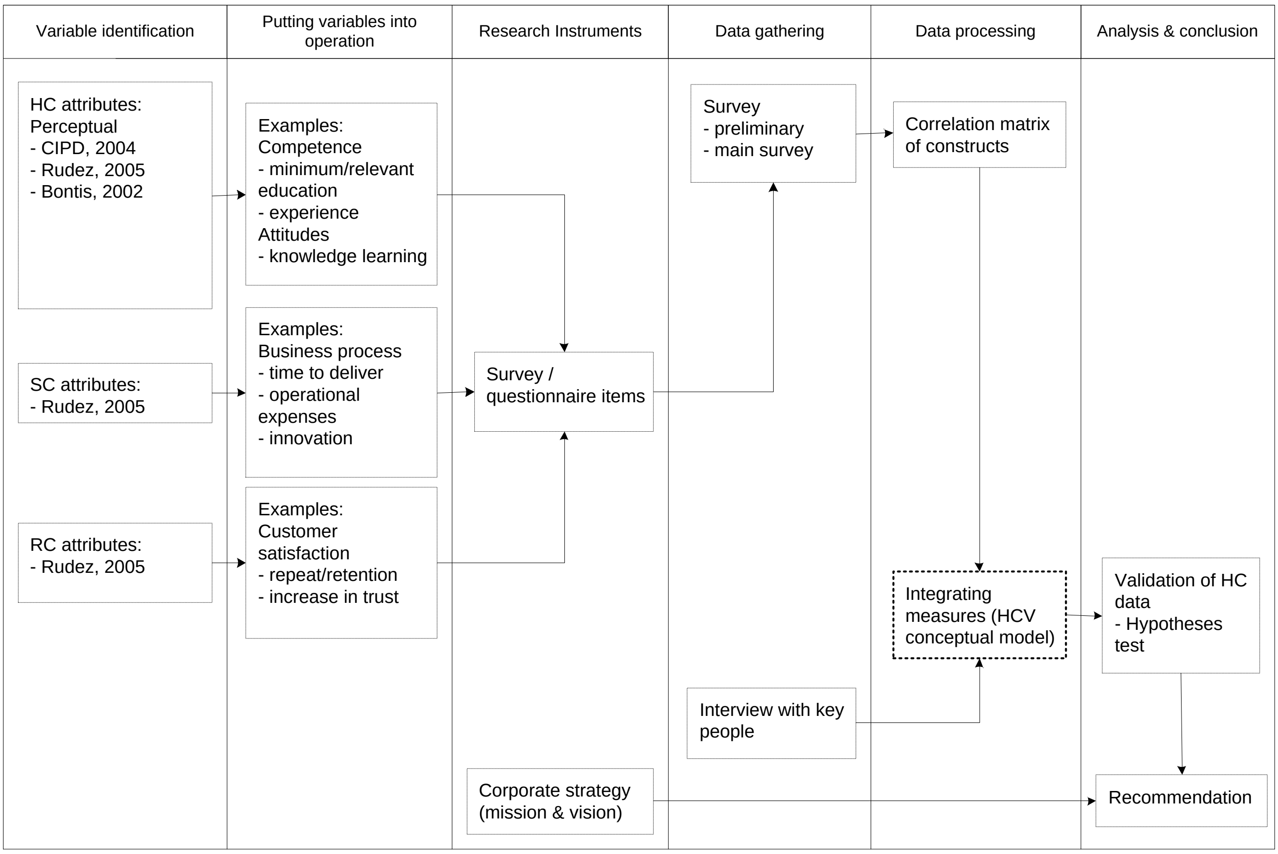

Fig. 1. Research Framework

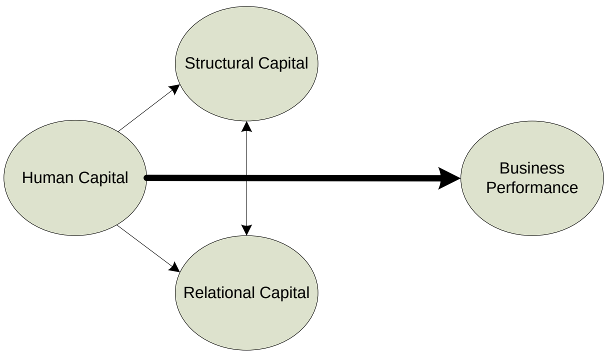

Fig. 2. Intellectual Capital Modelling

PT TELKOM has a total of around 25,000 workforces who are targeted as the subjects for this study. These subjects can be classified into three major categories to reflect the levels of compensation they receive from the company: *executive*, *strategic staff* (directly deal with external customers), and *staff* (do not have direct access to external customers, only deal with internal customers).

A questionnaire based survey is administered in the second phase to collect qualitative perceptual data. The survey consists of 48 (forty-eight) statements reflecting employee perception based on the seven Likert-scale that requires respondents to note their level of agreement with certain items.

These items are developed from scales previously published by the Institute for Intellectual Capital Research. Items for certain constructs are further edited to accommodate other important attributes as proposed by CIPD (2004) and Rudéz (2005).

The questionnaire was uploaded to corporate intranet and emailed to all employees. A brief introductory letter was attached to explain the importance of the research and options for response. As many as 6200 respondents from all levels of management and departments returned the completed questionnaire, which means that the responses should represent all levels and departments. The respondents represent their overall views of the company.

From the survey results, only 2100 responses are valid for further analysis. The identification of correlations between attributes and between attribute to constructs is done using LISREL software, and the confirmation of hypotheses is done using appropriate hypotheses test procedures.

HYPOTHESES

H1: **Balance between work/life and work environment** has **positive influence** on **Human capital**.

H2: **Culture as reflected in the attitudes towards work** has **positive influence** on **Human capital**.

H3: **Interpersonal relationship** has **positive influence** on **Human capital**.

H4: **Education** has **positive influence** on **Human capital**.

H5: **Employee satisfaction** has **positive influence** on **Human capital**.

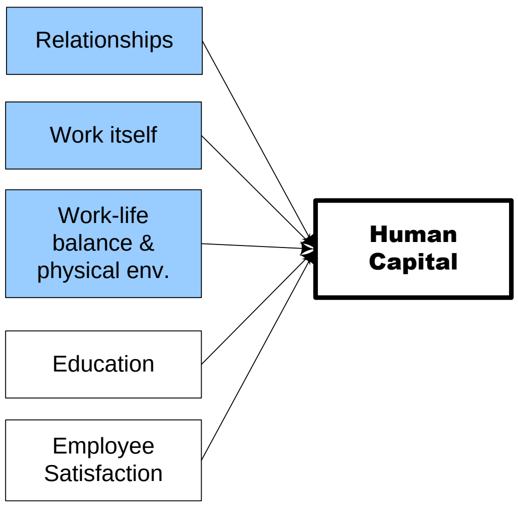

Fig. 3. HC structural model (Bontis, 2002; CIPD; 2004)

H6: **Managerial leadership** has **positive influence** on **Structural capital**.

H7: **Management philosophy** has **positive influence** on **Structural capital**.

H8: **Organizational culture** has **positive influence** on **Structural capital**.

H9: **Business processes** has **positive influence** on **Structural capital**.

H10: **Information technology** has **positive influence** on **Structural capital**.

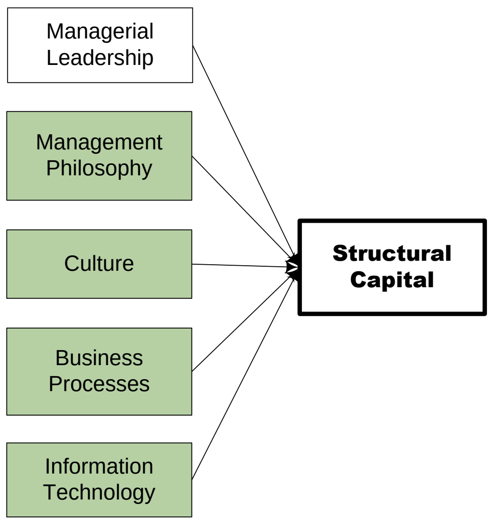

Figure 4. SC structural model
(Bontis, 2002; Rudéz, 2005)

H11: Human capital has **positive influence** on **Relational capital**.

H12: Customer satisfaction has **positive influence** on **Relational capital**.

H13: External relationship has **positive influence** on **Relational capital**.

H14: Product image & brand has **positive influence** on **Relational capital**.

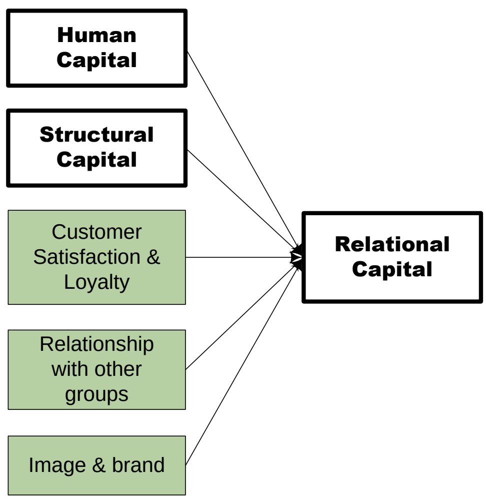

Figure 5. RC structural model
(Bontis, 2002; Rudéz, 2005)

H15: Relational capital has **positive influence** on **Human capital effectiveness**.

H16: Managerial leadership has **positive influence** on **Retention of key people**.

H17: Managerial leadership has **positive influence** on **Value alignment**.

H18: Value alignment has **positive influence** on **Knowledge sharing**.

H19: Employee satisfaction has **positive influence** on **Employee motivation**.

H20: Employee satisfaction has **positive influence** on **Employee commitment**.

H21: Employee commitment has **positive influence** on **Employee motivation**.

H22: Employee motivation has **positive influence** on **Knowledge sharing**.

H23: Employee commitment has **positive influence** on **Knowledge generation**.

H24: Knowledge generation has **positive influence** on **Business performance**.

H25: Employee commitment has **positive influence** on **Business performance**.

H26: Employee commitment has **positive influence** on **Retention of key people**.

H27: Structural capital has **positive influence** on **Relational capital**.

H28: Structural capital has **positive influence** on **Process execution**.

H29: Process execution has **positive influence** on **Knowledge integration**.

H30: Knowledge integration has **positive influence** on **Knowledge sharing**.

H31: Knowledge sharing has **negative influence** on **Human capital depletion**.

H32: Human capital depletion has **negative influence** on **Human capital effectiveness**.

H33: Business performance has **negative influence** on **Human capital depletion**.

4. RESULT AND DISCUSSION

Human Capital Model

The perceptual instruments used in this study are described in latent variables, where Human Capital, Structural Capital, and Relational

Capital are represented by 14, 5, and 3 latent variables respectively. Table 4 and 5 below show the 14 Latent Constructs of Human Capital and 5 Latent Constructs for Structural Capital.

Table 4. 14 Latent Constructs of Human Capital

Employee Satisfaction	Employee Commitment	Education
Employee Motivation	Value Alignment	Retention of Key People
Management Leadership	Interpersonal relationship	Knowledge generation, learning & innovation
Attitudes towards work	Attitudes towards products/company	Environment & Balance between work and life
Knowledge Sharing	Knowledge Integration	

These constructs were selected based on a review of the intellectual capital, organizational learning and knowledge management literatures. Each construct and item was reviewed by a team of representatives from the Saratoga Institute and Accenture for clarity, conciseness and face validity. (Bontis, 2002)

Structural Capital Model

Structural Capital is defined as an IC component which stays in the company when a staff is no longer stays with the organization, such as infrastructure and physical systems owned by the company to operate IC, data, and knowledge base. Structural capital is also referred to as organizational capital because it is a systematic competence or a system which maximizes innovation and organizational ability to create values coherent with knowledge assets in the process or innovation.

Table 5. 5 Latent Constructs for Structural Capital

Management philosophy
Business Process
Intellectual Property Rights
Process Execution and Optimization
Information Technology

One of the branches of *Structural Capital* is Innovation capital, or the ability to renew to sustain business in terms of intellectual property, trademarks and other intangible assets such as certain recipe or business secrets. *Structural Capital* is also referred to as process capital due to its focus on processes or practices in the organization.

It also covers intellectual property rights such as patent, trademarks, copyright, design, and other specifications. Other intangible assets belong to this category is company culture.

Relational Capital Model

Relational capital or often referred to as customer capital or external capital is the relationship with customer base and potential customers as well as other external parties such as distribution channels and supply chain. Table 6 below captures 3 Latent Constructs for Relational Capital. Furthermore, Figure 2 below shows the integrated model.

Table 6. 3 Latent Constructs for Relational Capital

Customer Satisfaction & Loyalty
Product & Brand Image
Relationship with business partner and other groups

Due to the complexity of the model and the limitations in the processing software (LISREL 8.80 Student Edition) which only allows for a maximum number of observed variables of 15, then the model is divided into several parts:

Model 1 consists of the following, mostly representing Structural Capital: Managerial Leadership, Management Philosophy, Culture, Business Process, Information Technology, and Intellectual Property Rights.

Furthermore, since Business Process construct only has one observed variable, it can be combined with Management Philosophy. According to Bontis (2002) those two constructs are considered closely related.

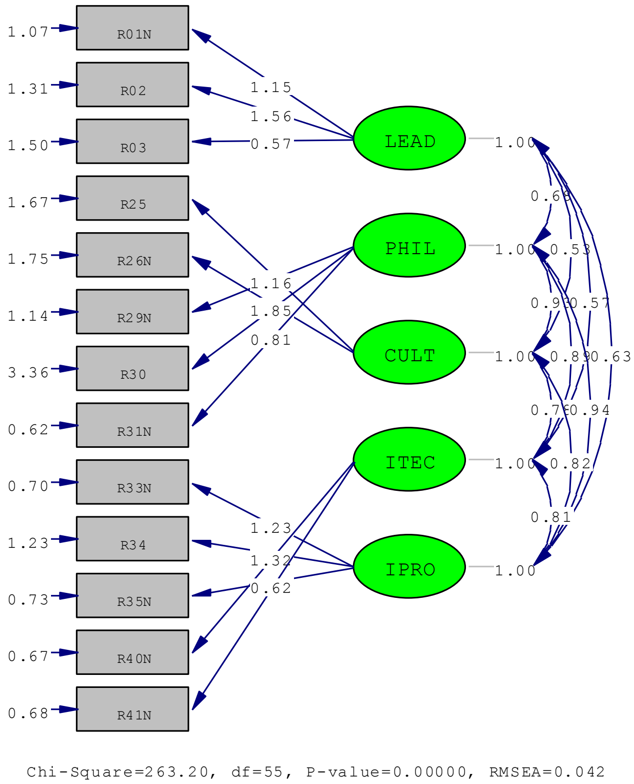

Fig. 6. LISREL Output for Model 1

Model 2 consists of the following constructs, mostly representing Human capital and Structural Capital: Work-life Balance and Physical Environment, Culture as reflected in the attitude towards work itself, Interpersonal Relationships, Education (Human Capital), Customer Satisfaction and Loyalty, Relationships with other groups, and Product Image and Brand.

Following the same reason as Model 1, the construct Culture as reflected in the attitude towards work itself only has one observed variable and therefore should be combined with one of the other constructs.

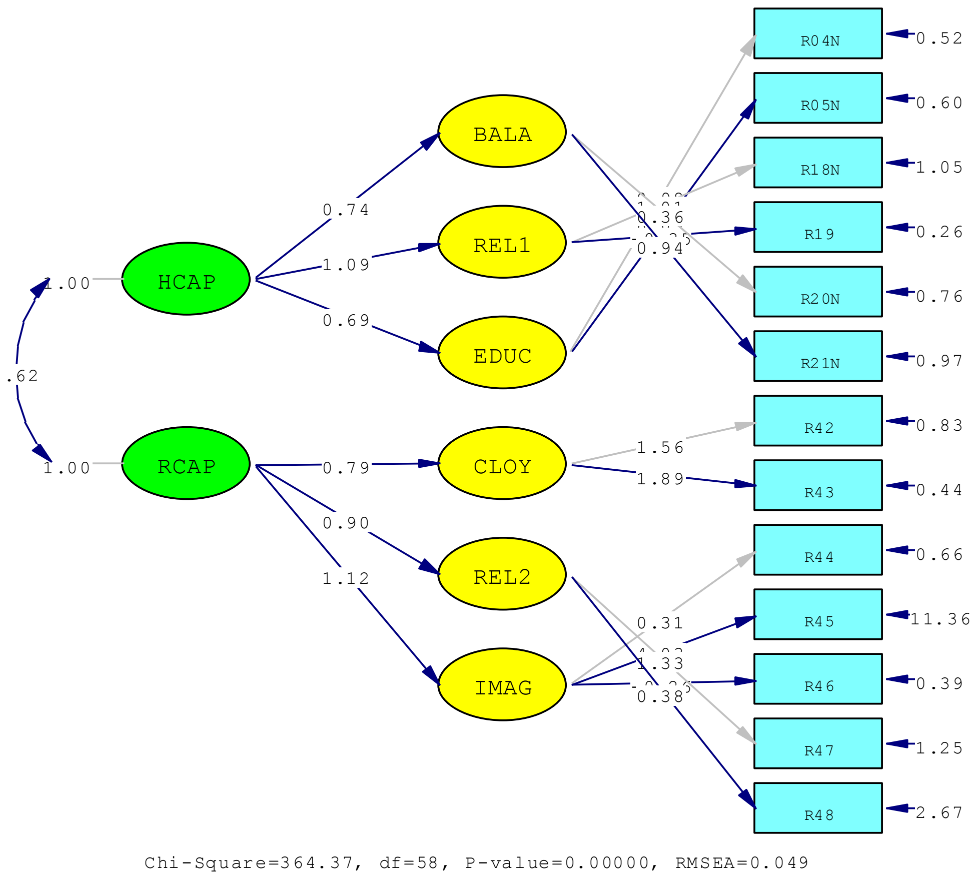

Fig. 7. LISREL Output for Model 2

Model 3 concerns with employee sentiments consisting of Employee Satisfaction, Employee Commitment, Employee Motivation; structural capital attributes such as Process Execution, Knowledge Integration and Knowledge Sharing; and one human capital construct namely Value Alignment. However, the only relationship possible from the model is the following:

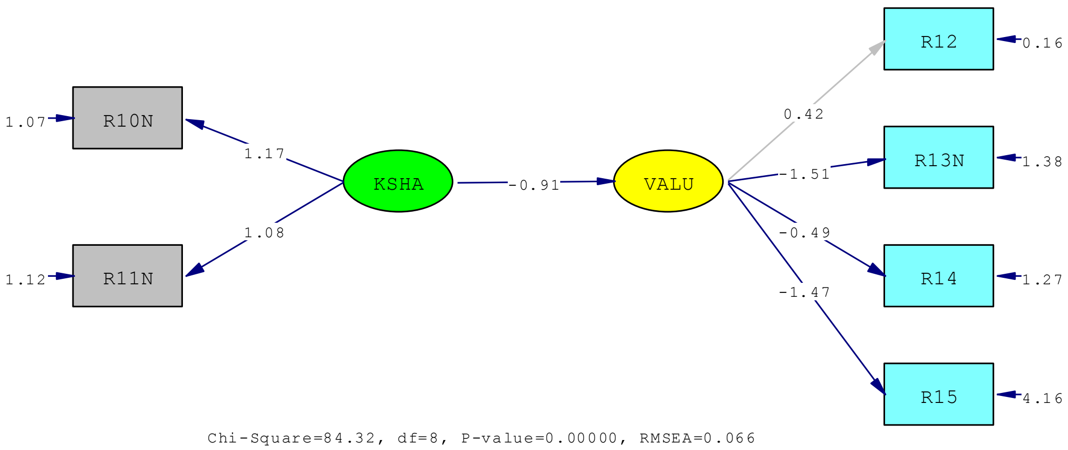

Fig. 8. LISREL output for Model 3

Model 4 is trying to combine several structural capital attributes such as Knowledge Generation, Knowledge Sharing, Process Execution, Knowledge Integration and human capital construct of Value Alignment.

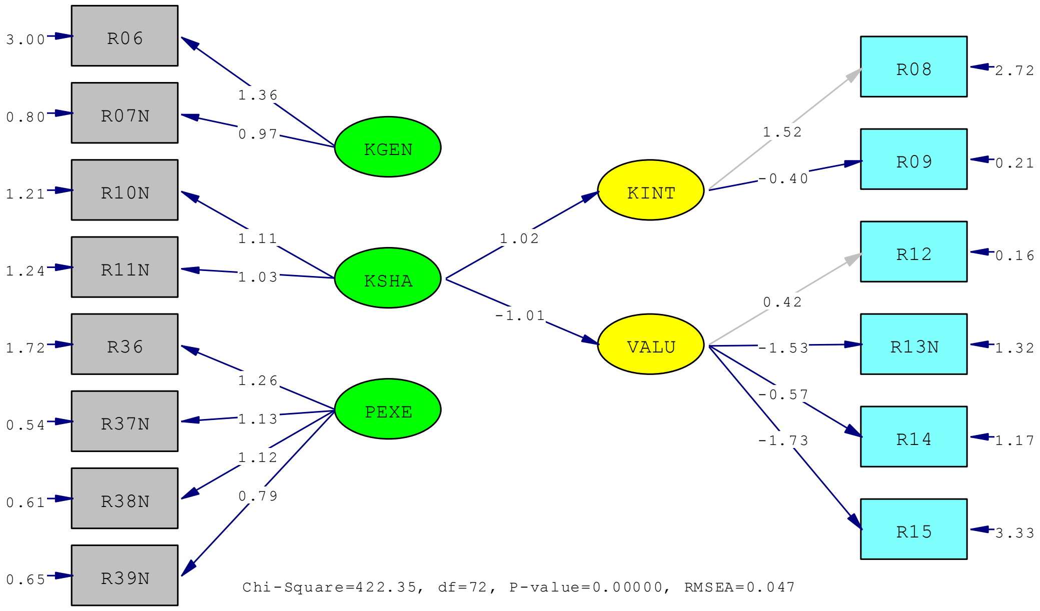

Fig. 9. LISREL output for Correlation of Constructs

HYPOTHESES TEST RESULT

H1: Balance between work/life and work environment has positive influence on Human capital. (Hypothesis accepted; with a significant correlation).

H2: Culture as reflected in the attitudes towards work has positive influence on Human capital. (Hypothesis rejected; no identifiable correlation).

H3: Interpersonal relationship has positive influence on Human capital. (Hypothesis accepted; with a significant correlation).

H4: Education has positive influence on Human capital. (Hypothesis accepted; with a significant correlation).

H5: Employee satisfaction has positive influence on Human capital. (Hypothesis rejected; no identifiable correlation).

H6: Managerial leadership has positive influence on Structural capital. (Not tested).

H7: Management philosophy has positive influence on Structural capital. (Not tested).

H8: Organizational culture has positive influence on Structural capital. (Not tested).

H9: Business processes have positive influence on Structural capital. (Not tested).

H10: Information technology has positive influence on Structural capital. (Not tested).

H11: Human capital has positive influence on Relational capital. (Not tested).

H12: Customer satisfaction has positive influence on Relational capital. (Hypothesis accepted; with a significant correlation).

H13: External relationship has positive influence on Relational capital. (Hypothesis accepted; with a significant correlation).

H14: Product image & brand has positive influence on Relational capital. (Hypothesis accepted; with a significant correlation).

H15: Relational capital has positive influence on Human capital effectiveness. (Not tested).

H16: Managerial leadership has positive influence on Retention of key people. (Not tested).

H17: Managerial leadership has positive influence on Value alignment. (Not tested).

H18: Value alignment has positive influence on Knowledge sharing. (Hypothesis accepted; with a significant correlation).

H19: Employee satisfaction has positive influence on Employee motivation. (Not tested).

H20: Employee satisfaction has positive influence on Employee commitment.

H21: Employee commitment has positive influence on Employee motivation. (Not tested).

H22: Employee motivation has positive influence on Knowledge sharing. (Not tested).

H23: Employee commitment has positive influence on Knowledge generation. (Not tested).

H24: Knowledge generation has positive influence on Business performance. (Not tested).

H25: Employee commitment has positive influence on Business performance. (Not tested).

H26: Employee commitment has positive influence on Retention of key people. (Not tested).

H27: Structural capital has positive influence on Relational capital. (Not tested).

H28: Structural capital has positive influence on Process execution. (Not tested).

H29: Process execution has positive influence on Knowledge integration. (Hypothesis rejected; no identifiable correlation).

H30: Knowledge integration has positive influence on Knowledge sharing. (Hypothesis accepted; with a significant correlation).

H31: Knowledge sharing has negative influence on Human capital depletion. (Not tested).

H32: Human capital depletion has negative influence on Human capital effectiveness. (Not tested).

H33: Business performance has negative influence on Human capital depletion. (Not tested).

5. CONCLUSION

Human capital management both builds and maintains a valuable resource for the organization. It is capable of turning human resources into actual actions and products for the organization. Finally, human capital must be combined with overall intellectual capital strategy to create a more balanced management policy, which can readily assist the business in achieving its objectives.

Stocks of qualifications may hide poor usage and over-qualifications. Qualifications, however, are only a proxy for one part of the skills spectrum. Measurement of generic skill formation and usage are therefore very important. Comparisons need to look at demand for skills. The production of masses of graduates, for example, may be a waste of resource if their skills are not actually needed in the labor market.

Comparisons also need to consider usage of skill. This, in combination with a range of other factors, is important to gauging how well the skills being produced aid economic performance. Supply and demand might be in balance, but if usage is inefficient, or the other drivers of productivity (e.g. R&D) are missing, the economic impact may be small.

All in all, these results suggest that the measuring and modeling of human capital are critical. This view can be attributed to the growing strategic importance of intellectual capital management and the need for HR managers to establish their credibility. The difficulties of human resource managers in achieving this should not be underestimated. It is perceived that they do not have the necessary expertise to carry out appropriate measurement and that many of the measures used lack precision and are too difficult.

Nevertheless, different measurement approaches are used. Whether they are actually providing information that establishes the importance of human capital in its credibility is a moot point. The difficulties are made more difficult by the attitudes of others in the organization. Additionally, it does not speak to human capital issues. To see the future, we need leading indicators. These indicators tell us the state of our human capital, as we prepare for the future The benefit of establishing a causal map of human capital management is clear.

REFERENCES

Armstrong, M., Baron, A., (2007). *Human Capital Management: Achieving Added Value through People*. Kogan Page Limited.

Bontis, N., Jac Fitz-enz. (2002). *Intellectual capital ROI: a causal map of human capital antecedents and consequents*. Journal of Intellectual Capital. 3,3. Emerald. 223-247.

Bontis, N., (2001). *Assessing knowledge assets: a review of the models used to measure intellectual capital*. International Journal of Management Reviews. 3,1. Blackwell Publishers. 41-60

Bose, R., (2004). *Knowledge Management Metrics*. Industrial Management & Data Systems. 104,6. Emerald. 457-468.

Chartered Institute of Personnel and Development (CIPD). (2004). *Human Capital Reporting: An internal perspective*. CIPD. London.

Chen, M.C., Cheng, S.J. and Hwang, Y., (2005). An empirical investigation of the relationship between intellectual capital and firms' market value and financial performance. *Journal of intellectual capital*, *6*(2), pp.159-176.

Clarke, M., Seng, D. and Whiting, R.H., (2011). Intellectual capital and firm performance in Australia. *Journal of Intellectual Capital*, *12*(4), pp.505-530.

do Rosário Cabrita, M. and Vaz, J.L., (2005). Intellectual capital and value creation: Evidence from the por-tuguese banking industry. *Electronic Journal of Knowledge Management*, *4*(1), pp.11-20.

EU MERITUM Project. *Guidelines for Managing & Reporting on Intangibles* (Intellectual Capital Report). 2002.

Guthrie, J., Ricceri, F. and Dumay, J., (2012). Reflections and projections: a decade of intellectual capital accounting research. *The British Accounting Review*, *44*(2), pp.68-82.

Halim, S., 2010. Statistical analysis on the intellectual capital statement. *Journal of Intellectual Capital*, *11*(1), pp.61-73.

Intrapairot, A., Anongnart, 2004. *Measurement of Intellectual Capital of ICT Service Providers in Thailand*. Proceeding for Kest04, September 2004, Beijing China

Jacobsen, K., Hofman-Bang, P. and Nordby Jr, R., (2005). The IC rating™ model by intellectual capital Sweden. *Journal of Intellectual Capital*, *6*(4), pp.570-587.

Kristine, J., Hofman-Bang, P., Nordby, R. (2005). *The IC Rating™ model by Intellectual Capital Sweden*. Journal of Intellectual Capital. 6,4. ABI/INFORM Global. 570.

Maditinos, D., Chatzoudes, D., Tsairidis, C. and Theriou, G., (2011). The impact of intellectual capital on firms' market value and financial performance. *Journal of intellectual capital*, *12*(1), pp.132-151.

Reinhardt, R., Bornemann, M., Pawlowsky, P. & Schneider, U. (2001). *Intellectual Capital and Knowledge Management*. Handbook of Organizational Learning. 775-793.

Sharabati, A.A.A., Naji Jawad, S. and Bontis, N., (2010). Intellectual capital and business performance in the pharmaceutical sector of Jordan. *Management decision*, *48*(1), pp.105-131.

Tsan, W., (2003). *Measurement and Comparison of IT Industrial Intellectual Capital in Taiwan*. Proceeding for International Conference on “New Trends and Challenges of Science and Technological Innovation in a Critical Era”. October Taiwan.

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APPLICATION OF REMOTE SENSING TECHNOLOGY IN FOREST FIRE ASSESSMENT ; A LITERATURE REVIEW

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ABSTRACT

Forest fire is considered to have positive and negative influences for humans and the environment. However, uncontrolled and misuse of forest fire creates significant environmental damage, causes serious problems to human health and threatens life. Therefore, integrative methods to detect and monitor forest fire early before it caused further un-expected effects are needed. Remote sensing technology has become important for mapping and monitoring changes in land cover, and has also proven useful in forest fire monitoring. In order to develop methods which provide accurate measurement of forest fire events and lead to the establishment of fire danger rating systems, many scientists have tried to establish fire modelling. first one is known as empirical models which are inferred from field data analysis. The second one is physical models which are established using laboratory data and physical principles. In conclusion, it has to be admitted that remote sensing technology has become an extensive and important component in forest fire detection, monitoring and impact assessment. Output from satellite images analysis could be an important basic for the governments to produce appropriate policy to overcome forest fire danger problems. In addition, satellite imaginary data may also use to forecast the future forest fire events, so the governments could take some preventive actions and policies to reduce the spread of un-expected fire that might cause negative impact both for the forest ecosystem and humans safety.

KEYWORDS : Forest Fire, Remote Sensing Technology, Satelite.

1. INTRODUCTION

Forest fire is considered to have positive and negative influences for humans and the environment. Fire has been recognized as a tool used to meditate land conversion (Eva & Lambin, 2000). One of the positive impacts of fire is to provide grazing for livestock and it is also used to control pests. Fire can also give advantageous effects on ecosystem resources due to its capability to manage vegetation composition and reduce inherent flammable fuel loads. Furthermore, Roy (2006) emphasizes that fire has a vital ecological role in maintaining biological diversity and in preserving soil nutrient availability.

However, uncontrolled and misuse of forest fire creates significant environmental damage, causes serious problems to human health and threatens life. Forest fire reduces the forest productivity, because it diminished the ability of plant species to recover due to the loss of 85% of seed availability and the decline of flowering and fruiting trees near the burned forest (Cochranne, 2003). Another dangerous effect of forest fire is smoke. Roy has reported that approximately 20 million people in South East Asia are in danger of respiratory problems and cardiovascular illness as an effect of forest fire (Roy, 2006). Smoke from South East Asian forest fires is also recognised as the main factor in smoke- related accidents including ships, automobile and plane crashes (Cochranne, 2003). Although the density of air pollutants produced by forest fire is relatively undetected, evidence indicates that over 40% of annual anthropogenic CO_2 emissions are exhibited by biomass burning as the result of forest fire (Fuller, 2000). Therefore, integrative methods to detect and monitor forest fire early before it caused further un-expected effects are needed.

Remote sensing technology has become important for mapping and monitoring changes in land cover, and has also proven useful in forest fire monitoring. This review of literature from the past decade emphasizes the use of remote sensing in forest fire detection and assessment. However, it is first necessary to examine fire behaviour in forest ecology.

2. Forest Fire Behaviour

The occurrence and widespread incidence of vegetation fire initiated by natural phenomena or human activities depends on several factors, for instance vegetation type, climatic and meteorological condition and land use (Dwyer, et al., 2000). Furthermore, Sunar and Ozkan state that 97% of forest burning is contributed by human activities whereas only 3% caused by natural phenomena, for example lightning (Sunar & Ozkan, 2001). Therefore, Roy emphasizes that the contribution of natural fires is insignificant in comparison with anthropogenic fire. These findings are relevant with the fact that traditional farmers (Roy, 2006).

In the island of Kalimantan use fire to expand their farm land. However, the anthropogenic fire accidents are not always be the main factors. Researches undertaken by Galindo et.al in Mexico (Galindo, et al., 2003), Cochrane and Schulze in Brazilian Amazon (Cochrane & Schulze, 1998) and Williams and Karoly in Australia (Williams & Karoly, 1999) claimed that the 1997 El Nino phenomena generated the long drought season that caused severe forests fire.

In order to develop methods which provide accurate measurement of forest fire events and lead to the establishment of fire danger rating systems, many scientists have tried to establish fire modelling. According to Andrews and Queen, there are two approaches to develop a fire model. The first one is known as empirical models which are inferred from field data analysis. The second one is physical models which are established using laboratory data and physical principles (Andrews & Queen, 2001).

One of the simple physical models is generally known as fire line intensity theory, which mentions that fire line intensity is a function of the heat yield, the availability of fuel, and the rate of fire spread (Perry, 1998)

$$I = H \times W \times R \qquad (1)$$

where

I : fire line intensity (kW.m^{-1})

H : heat yield of the fuel (J.g^{-1})

W : mass of the fuel consumed (g.m^{-2})

R : rate of fire spread (m.sec^{-1})

This model may be too simple and only provides partial information of fire characteristic. It only considers a limited number of factors, omitting for example wind speed direction and humidity. Therefore, this model might not suitable to use for practical objectives.

A better empirical fire model is also provided by Noble *et.al* to use in operational purposes (Perry, 1998). This empirical model is derived from the mathematical relationship for the simplest meter, called the Mark IV grassland fire danger meter.

$$F = 2\exp\left[-23.6 + 5.01\ln(C_d) + 0.0281T_a - 0.226RH^{1/2} + 0.633U_{10}^{1/2}\right] \qquad (2)$$

$$R = 0.13F \qquad (3)$$

where

F : fire danger index

RH : relative humidity (%)

R : rate of fire spread (km.hr^{-1})

U_{10} : wind speed (m.sec^{-1}) at mid-flame height

T_a : air temperature (^oC)

Fire models nowadays also provide quantitative analysis to estimate the correlation between fire spread and fuels (Andrews & Queen, 2001). Barrows explains that fuel is a descriptive term for all flammable components in the forest including duff, grass clump, low shrubs, hanging moss and roots (Andrews & Queen, 2001). This model can be varied due to the change of season and the types of fuel that are involved in fire spread. However, because of this model cannot explain the whole fuel complex, it would be difficult to support the fuel mapping. Andrews and Queen suggested therefore, remote sensing technology and GIS are essential in order to sustain application of spatial characterization of fuel (Andrews & Queen, 2001).

3. Remote Sensing and Fire Detection

Fire is a form of chemical reaction that releases energy including heat and light (Cochrane, 2003). Furthermore, Dwyer et.al tate that, at temperatures between 500 K and 1200 K, fires liberate strong infrared emission at wavelength of 3 - 5µm (Dwyer, et al., 2000). Fuller emphasizes that, fire scars can be distinguished easily from unburned areas within the visible (0.4-0.7 µm), near infra red (0.7 – 1.5 µm) and middle infra red (1.5 – 4 µm) spectrum of electromagnetic waves (Fuller, 2000). Satellite's sensors are able to identify fires and other intense sources of fire if their sensors cover the near 4-µm electromagnetic wavelength. These types of sensors are highly responsive to objects that have temperature above 200°C. Within this range of temperature, objects transmit thermal radiation. Therefore, fire forest areas are suitable targets for remote sensing research (White, et al., 1996). In addition, not only coordinates, time, area extent of burned areas but also the quantity of gases and aerosol released are the type of fire information that provided by satellite data (White, et al., 1996)

Darmawan point out that remote sensing offers advantage regarding its continuity coverage over large areas compared with other conventional methods (Darmawan, et al., 2001). The main benefit of using remote sensing technology is related to its significant speed in collecting data from a broad area of the Earth's surface. For instance the Landsat Thematic Mapper, a spaceborne instrument, can acquire data from an area 185 km square in approximately 30 seconds to have real time assessment (Gareth, 1999). Further explanations in remote sensing advantages for specific purposes, especially in forest fire detection also raised by Justice *et.al* (Fuller, 2000). They addressed several beneficial values including the capacity to provide information of fire location and timing of active fires, burned area, areas that are dry and sensitive to wildfire spreading, and flammable trace gas and aerosol emissions. Moreover, Sunar and Ozkan explain that the combination of satellite sensor imagery data and spatial analysis can be applied to monitor and analyse large areas of forest fire, as well as to assess the global fire frequency (Sunar & Ozkan, 2001). These advantageous facts are likely to be the main consideration to devote remote sensing technology as the principal basis of forest fire detection and monitoring.

According to Sunar and Ozkan there are three methods to detect forest fire using digital image processing (Sunar & Ozkan, 2001). Firstly, is the spectral profile analysis determines the different spectral response of surface features. Secondly, is the vegetation index or NDVI (Normalized Difference Vegetation Index). This method can measure the biomass and vegetative vigour. Thirdly, the classification method is able to classify the fire damaged forest area.

During the last two decades, there were many remote sensing satellites launched in order to support monitoring and assessment of forest fire events. Examples of these satellites including Landsat Enhanced Thematic Mapper (Landsat

ETM), *Systeme Probatoire d'Observation de la Terrre* (SPOT), Advanced Very High Resolution Radiometer (AVHRR) and Geostationary Operational Environmental Satellite (GOES). The capability and accuracy of each satellite may vary due to their spatial resolution and bands range. The table below provides information about satellite characteristics for fire and fire scars detection.

Table.1 Characteristics of current and planned satellite sensors for fire and fire-scar detection (Fuller, 2000)

Sensor	Major applications	Spatial resolution	Swath width	Bands (μm range)	Major advantages	Major limitations
AVHRR	Active fires Fire scars	1.1 km	2400 km	0.58–0.68 0.72–1.10 3.55–3.93[1] 10.3–11.3 11.5–12.5	Widely available, low cost, high temporal frequency	325 K saturation in channel 3
DMSP-OLS	Active fires	0.56 km 2.07 km	3000 km	0.58–0.91 10.3–12.9	High sensitivity; high temporal frequency	Night-time use only during low lunar illumination
SPOT-4	Fire scars	10 m PAN from 0.61 to 0.68 μm 20 m MS[2]	60 km	0.50–0.59 0.61–0.68 0.79–0.89 1.58–1.75	High spatial resolution, MIR band	Low temporal frequency, low area coverage, high cost
SPOT vegetation	Fire scars	1 km	2000 km	0.43–0.47 0.61–0.68 0.78–0.89 1.58–1.75	MIR band, large areas covered, high temporal resolution	Unknown
Landsat TM and ETM+[3]	Fire scars	15 m PAN[4] 30 m MS	185 km	0.45–0.52 0.52–0.60 0.63–0.69 0.76–0.90 1.55–1.75 10.4–12.5[5] 2.08–2.35	MIR band, high spatial resolution, well-known data source	Low temporal resolution, high cost[6]
GOES-8	Active fires	1 km (visible) 4 km (infrared channels)	Hemisphere	0.52–0.72 3.78–4.03 6.47–7.02[7] 10.2–11.2 11.5–12.5	Very high temporal resolution	Coarse spatial resolution; 3.9 μm band saturates at 335 K
ATSR[8]	Fire scars	1 km	500 km	3.51–3.89 1.57–1.63 10.4–11.3 11.5–12.5	Good spectral configuration for fire-scar mapping	Unknown
MODIS	Active fires Fire scars	250 m 500 m 1 km	2330 km	36 bands including 3.9 and 11 μm	Saturation of 450 K at 4 μm and 400 K at 11 μm	Unknown

A simple mechanism of fire detection using remote sensing satellite is explained by Kelha et.al (Kelha, et al., 2000). Soon after the AVHRR satellite detects fire hot spot in a particular location, the information is transmitted to a computerized fire detecting system. After that, tele-fax fire alerts are sent automatically to rescue centres and then fire brigades are dispatched to overcome the fire problem. Figure 1 shows the operation of this system.

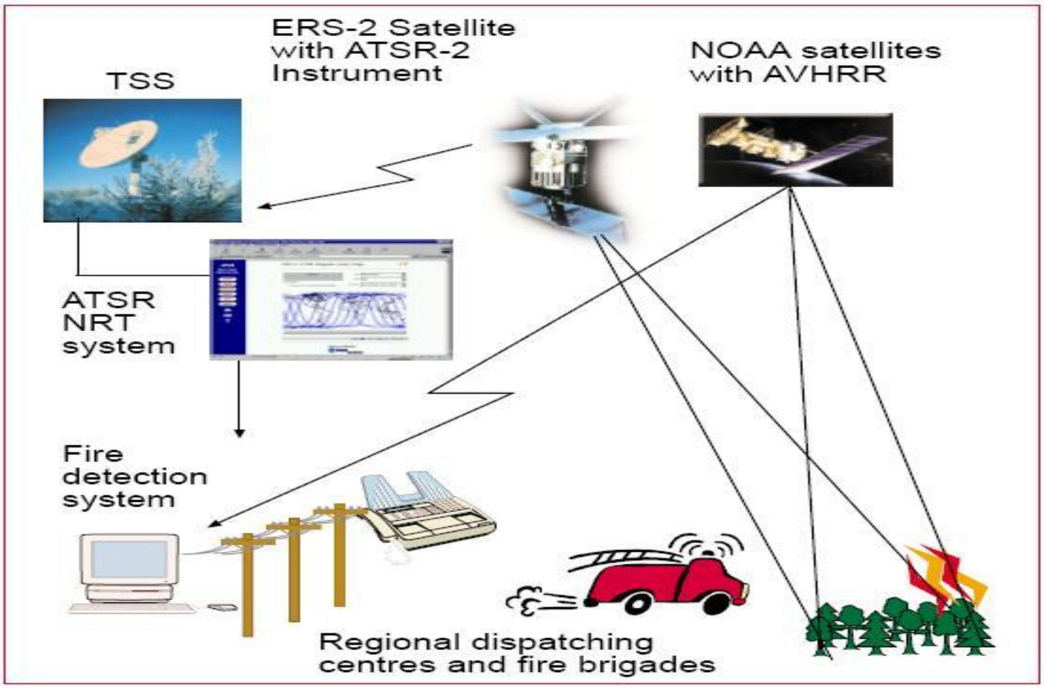

Fig. 1 The satellite based fire detection system
(Kelha et.al, 2006)

It is interesting to note that this fire detection using satellite warning system could help to prevent fire spread. However, this mechanism may only relevant for small and accessible area. It would be very difficult to send fire brigades to extinguish fire in un-accessible and large locations, particularly when fire occurs in the middle of the forest.

4. Case Studies: Forest Fire and Haze Assessment in Indonesia

In 1997, Indonesia suffered a long period of drought. This long drought season caused severe forest fires in the western part of Indonesia including Sumatra and Kalimantan Islands. A Condensed layer of smoke was also generated by these fires events, which was transported and covered the Indonesian islands of Sumatra and Kalimantan. The 1997 forest fires in Indonesia become an international issue when dense smoke also blanketed many regions of Malaysia, Brunei, Thailand and Philippines.

The haze from tropical burning forest consists of high concentration in carbon monoxide (CO), carbon dioxide (CO_2) and nitrogen dioxide (NO_2). Serious health effects, for example asthma, are one of the implications of long term inhalation (Reuters, 1997 cited in Wooster *et.al*, 1998). During this period, poor breathing conditions were reported in cities and rural areas throughout South East Asia (Wooster, et al., 1998).

In order to observe and analyse the extent of fire activities and the related atmospheric impact during the 1997 fire season in Indonesia, Wooster et.al conducted a remote sensing data analysis based on satellite image using the AVHRR Global Area Coverage (GAC) of western Indonesia (Wooster, et al., 1998). GAC data which is available in NOAA satellite active archive provides spatial and temporal distribution of biomass burning activity (Wooster, et al., 1998). Result of this research showed that most fire events are concentrated in around southern coast of Kalimantan and southern Sumatra, whereas smoke and haze which are produced by those hot spots apparently become most dense over the islands. Another result indicated that winds seemed to transport the haze towards mainland Malaysia and Singapore, which explains the poor breathing conditions in these non-burning areas.

This study undertaken in Indonesia during the 1997 fire seasons, when fire conditions were so extreme, was very useful to examine the spread and the impact of fire. It also ascertains the importance of remote sensing in forest fire monitoring, because this technology not only detect the fire spots but also examine the extent effect of fire and smoke-associated pollution.

A further forest fire assessment in eastern province of Kalimantan was also conducted in 1998 (Siegert & Hoffmann, 2000). The aim of this research was to produce the burned scar map for the eastern province of Kalimantan. Satellite image for this research was obtained from the NOAA-AVHRR data and multi-temporal ERS -2 SAR images for burned scar mapping.

Results from this research indicated that in the end of February 1998, the numbers of detected hot spots increased up to 600 and reached a peak with more than 2000 hot spots per day at the beginning of March. When rain started in May, almost the entire area of Kutai district had been burned. The fire continued to spread to the south and then it stopped at the mountainous regions where humidity is higher and dominated by primary forest region. To be able to identify, map and measure the total area that had been burned, Siegert and Hoffman applied data from Multitemporal ERS-2 SAR images (Siegert & Hoffmann, 2000). The result showed that, within approximately 1,860,000 ha surveyed area, over 23% (462,000 ha) of the total area had burned on March 1998. This figure including 85,000 ha suffered total vegetation destruction. In the middle of April, fire had burned over 66% (1,230,600 ha) of the total area with approximately 101,920 ha of forest vegetation had been severely devastated.

The production of burned scar maps is very useful, because it enables government to estimate damage and it could also be used as assessment modes for another region. In addition, with multi temporal image analysis the observers could gather data to examine the trend of fire events. For further research, this trend analysis combine with other meteorological data are substantial to generate fire forecasting and modelling system. The existence of this system could help governments to establish preventive actions and policies that may reduce the financial and ecological loss.

5. Weakness and Potential Improvement of Remote Sensing Technology

It is generally understand that remote sensing methods have a significant role in forest fire detection and assessment. Perry emphasizes that the improving combination of remotely sensed for instance satellite images, aerial photography with spatial information system, is likely to provide accuracy in fire forest detection, risk analysis and wild land fire management (Perry, 1998). However, there are several constraints in fire detection and measurement using remote sensing technology.

Firstly, sometimes satellite sensors fail to detect fire on earth surface due to light or heavy cloud cover. For example, NOAA-AVHRR sensors are not able to acquire any data including forest fire under the cloud cover because the sensors are not designed to penetrate clouds. Another reason that explains the failure of sensors to detect fire is that sometimes the fire temperature is too low to rise and do not reach the sensor's temperature threshold. For example, in order to be identified as hot spots for infrared sensors, fires must have temperature at least 315 K (42^{o}C) for day capturing and 310 K (37 ^{o}C) for night capturing. That may lead to un-detected fire reports in satellite image analysis (Forest, 2003).

Secondly, errors in fire detection may appear due to sun glint effects. Sun glint effect occurs as a result of un-expected reflectance disturbance caused by high reflection intensity materials such as water surface, sandy bare land and metals (Basyiruddin, 1996). In addition, Cochrane states that this type of error could lead to false fire identification (Cochrane, 2003).

Finally, satellite sensors could fail to obtain data due to signal receiving problems .If other objects for example tall buildings are surrounded or blocked the receiving direction of antenna, either the receiving station or earth observer would not gain enough data to be analysed (Forest, 2003). This failure may lead to lack of data, which causes noise of image and errors of hot spots coordinate identification (Basyiruddin, 1996)

In order to reduce errors in fire assessment due to weather condition and sun glint effects from reflective surfaces, Dweyr et.al suggests the importance of integrated data collection from different observing satellite. This approach is believed as one of the solutions to improve qualitative and quantitative fire assessment (Dwyer, et al., 2000). These include, for example, combining global data sets to identify active fires and burned areas using Japanese Earth Resources Satellite (J-ERS) Synthetic Aperture Radar (SAR) and data set from Along Track Scanning Radiometer (ATSR) of The European Space Agency (ESA).

Moreover, to enhance spatial resolution, sensor sensitivity and saturation characteristics, newer satellite sensors have been launched to expand fire monitoring. One of those satellites is The Tropical Rainfall Measuring Missions-Visible Infrared Scanner (TRMM-VIS) which is designed to detect un-ordinary large fire events and it has ability to distinguish fires from other heat sources. Another new satellite which is equipped with new generation of infrared array sensor is The Bi-Spectral Infrared Detection (BIRD). This satellite with its 300 meter spatial resolution can discriminate smoke and water clouds. Finally, the Moderate Imaging Spectroradiometer (MODIS) with its higher saturation level is considered to provide better information for active fire events than preceding satellite platforms (Cochranne, 2003).

6. Conclusion

In conclusion, it has to be admitted that remote sensing technology has become an extensive and important component in forest fire detection, monitoring and impact assessment. Output from satellite images analysis could be an important basic for the governments to produce appropriate policy to overcome forest fire danger problems. In addition, satellite imaginary data may also use to forecast the future forest fire events, so the governments could take some preventive actions and policies to reduce the spread of un-expected fire that might cause negative impact both for the forest ecosystem and humans safety.

7. REFERENCES

Andrews, P. L. & Queen, L. P., 2001. Fire Modelling and Information System Technology. *International Journal of Wildland Fire,* Volume 10, pp. 343-352.

Basyiruddin, U., 1996. *Forest Fire Study Using NOAA-AVHRR Satellite in Kalimantan Area 1995. Undergraduate Thesis.* Yogyakarta: Gadjah Mada University.

Cochrane, M. A., 2003. Fire Science for Rainforests. *Nature,* Volume 421, p. Nature.

Cochrane, M. A. & Schulze, M. D., 1998. Forest Fire in Brazillian Amazon. *Conservation Biology,* 12(5), pp. 948-950.

Cochranne, M. A., 2003. Fire Science for Rainforests. *Nature,* Volume 241, pp. 913-919.

Darmawan, M., Aniya, M. & Tsuyuki, S., 2001. *Forest Fire Hazard Model Using Remote Sensing* *and GIS: Toward Understanding of Land and Forest Degradation in Lowland Areas of East Kalimantan, Indonesia.* Singapore, Paper presented at the 22nd Asian Conference on Remote Sensing.

Dwyer, E., Pinnock, S. & Gregoire, J., 2000. Global Spatial and Temporal Distributions of Vegetation Fire as Determined from Satellite Observations. *International Journal of Remote Sensing,* 21(6&7), pp. 1289-1302.

Eva, H. & Lambin, F. E., 2000. Fires and Land Cover Change in Tropics: A Remote Sensing Analysis at the Landscape Scale. *Journal of Biogeography,* Volume 27, pp. 765-776.

Forest, P. E. C. I., 2003. *Work Document: Hot Spot Field Survey Methodology Banjarbaru: South and Central Kalimantan Production Forest Project,* s.l.: European Comission-Indonesia Forest Programme.

Fuller, D. O., 2000. Satellite Remote Sensing of Biomas Burning with Optical and Thermal Sensors. *Progress in Physical Geography,* 24(4), pp. 543-561.

Galindo, I., Lopez-Perez, P. & M.Salazar-Evangelista, 2003. Real Time AVHRR Forest Fire Detection in Mexico (1998-2000). *International Journal of Remote Sensing,* 24(1), pp. 9-22.

Gareth, R., 1999. *The Remote Sensing Book.* New York: Cambridge University Press.

Kelha, V., Rauste, Y. & Buongiorno, A., 2000. Forest Fire Detection by Satellite for Fire Control. *Earth Observation Quarterly,* 56(12), pp. 114-120.

Perry, G., 1998. Current Approaches to Modelling The Spread of Widland Fire: A Review. *Progress in Physical Geography,* 22(2), pp. 222-245.

Roy, P., 2006. Forest Fire and Degradation Assessment Using Satellite Remote Sensing. *Satellite Remote Sensing and GIS Applications in Agricultural Meteorology,* pp. 361-400.

Siegert, F. & Hoffmann, A., 2000. The 1998 Forest Fire in East Kalimantan (Indonesia): A Quantitative Evaluation Using High Resolution, Multitemporal ERS-2 SAR Images and NOAA-AVHRR Hotspot Data. *Remote Sensing Environment,* Volume 72, pp. 64-77.

Sunar, F. & Ozkan, C., 2001. Forest Fire Analysis with Remote Sensing Data. *International Journal of Remote Sensing,* 22(12), pp. 2265-2277.

White, J. D., Ryan, K. C., Key, C. C. & Running, S. W., 1996. Remote Sensing of Forest Fire Severity and Vegetation Recovery. *International Journal of Wildland Fire,* 6(3), pp. 125-136.

Williams, A. A. J. & Karoly, D. J., 1999. Extreme Fire Weather in Australia and the Impact of El-Nino Southern Oscillation. *Australian Meteorological Magazine,* 48(1), pp. 15-22.

Wooster, M., Ceccato, P. & Flasse, S., 1998. The 1997 Indonesian Fires Observed Using AVHRR. *International Journal of Remote Sensing,* 19(3), pp. 383-386.

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CONSTRUCTION OF INDONESIAN ADDITIONAL MILITARY LAYER INTEGRATED WATER COLUMN (AML IWC) PROTOTYPE

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ABSTRACT

The NATO has produced what they called Additional Military Layer (AML) which basically Electronic Chart for Military purposes. Based on NATO STANAG 7170, AML is defined as : ‘’...a unified range of digital geospatial data products designed to satisfy the totality of NATO non navigational maritime defence requirements’’.One of AML type is called Integrated Water Column Component 1 (AML IWC Component 1) in which contain water column physical properties of temperature and salinity. The purpose of IWC gridded dataset, is to provide marine climatological data to describe the likely conditions found within the water column. IWC is delivered in the netCDF format. Meanwhile US Navy has also developed the same climatological gridded dataset as AML IWC which they called Generalized Digital Environmental Model (GDEM). Inspired by the existence of AML IWC and GDEM, authors are willing to research the possibility of constructing Indonesian AML IWC Component 1 that cover the sea area of Indonesia. Observation temperature and salinity profiles are downloaded from World Ocean DataBase13 (WOD13). These thousands observation profiles collected for more than 100 years in Indonesian waters and surrounding area then processed with Ocean Data View and Mathlab to make a gridded data set with 1/4° spatial resolution and monthly temporal resolution In only one netCDF format file.

KEYWORD : Indonesian AML IWC, netCDF, salinity, temperature, WOD13.

1. INTRODUCTION

Successful execution of ASW operations (detection, prosecution, localization) depends on four factors i.e. : The ambient acoustic and meteorologic conditions, Own-force asset capabilities, The nature and tactics of the opposition, The strategic and tactical acumen of the ASW commander and his staff. When at sea, the first three factors are the ASWC's states of nature. Keen understanding of the principles of the propagation of sound through the water and the effects of the meteorologic conditions thereon is requisite since underwater sound (sonar) is virtually the only means of detecting submerged submarines (M.G. Alexandridis, 1984).

ASW acoustic predictions are done with the aid of sound velocity profiles from areas of the ocean. ASW sensor selection and tactics are determined by these acoustic predication (B.H. Brunson, 1989). One of the general form of the equation for the speed of sound was developed by Mackenzie who derived the empiric formula from three variables, they are : temperature, salinity and depth (Mackenzie, 1960).

For years, experts of Defence Maritime Geospatial Infromation has produced varies form of paper military charts. With the move to digital products, NATO has produced AML (Additional Military Layer) to provide maritime geospatial information to the defence user in an efficient and standardised digital format. AML is defined as ‘’...a unified range of digital geospatial data products designed to satisfy the totality of NATO non navigational maritime defence requirements'' (Captain Jones, 2016). One type of AML that related to water column is Gridded AML products (UKHO, 2008). This type of AML shows the spatial and sometimes temporal variation in an environmental feature (UKHO, 2006). For example, gridded products can represent a large number of CTD observations collected over a long period giving the user information about the temperature and salinity that may be expected at a specific month (Peter C. Chu, 2004). Gridded information may be presented to the user in a variety of ways, including isolines derived from the grid and colour banding. Alternatively the data may be used by a specific system for computational purposes without directly representing the data to the user through a Graphical User Interface (GUI) (Captain Jones, 2016).

The NATO AML Integrated Water Column product specification is further divided into three components, which are water column physical properties, ocean currents and marrine mammals (UKHO, 2006). For this research, authors are willing to produce an AML IWC Component 1 consisting of temperature and salinity monthly variation for Indonesian Sea and surrounding in 1/4° spatial resolution. Raw data of temperature and salinity profiles are downloaded from World Ocean Database 13 (WOD13) which cover all available observations in and arround Indonesian Waters. The observation data collected then filtered and prepared to be used in estimation process of temperature and salinity values at each standar depth and spatial coordinates with a quarter degree interval. The estimation values of temperature and salinity for each month then compiled into an array for further writing become a netCDF file format which is the standard file format for AML IWC (UKHO, 2006). From that standing point, authors propose a hypothese that Indonesian AML IWC netCDF file could be constructed from WOD13 database utilizing some already available function in ODV (Schlitzer, 2013) and netCDF package in mathlab (Mathworks, 2015).

Once the Indonesian AML IWC netCDF file succesfully made, it can be presented to give a better situasional awareness for a Navy ships or operator may extract temperature and salinity data from it for computational purpose such as ray tracing of hull mounted sonar (HMS) or variabel depth sonar(VDS) so the anti submarine ship could predict its HMS shadow zone or its best VDS operational depth to get the optimum coverage. With the availability of AML IWC component 1 netCDF file may prevent the necessity of a anti submarine ships to deploy CTD or XBT to get temperature and salinity data in its operation area (W.J. Teague, 1990).

2. MATERIALS AND METHODOLOGY

2.1. Observation Data

To produce a climatological gridded data set such as AML IWC, we must have an adequate observations that not only has good spatial distribution but also temporally long enough with at least 50 years period time span of observations. For example in the making of first GDEM in 1990, US NAVOCEANO had been collecting for more than 100 years (W.J. Teague, 1990). And in 2010 GDEM report it was writen that final data set for GDEM4 construction consist of 4,412,454 temperature profiles and 1,969,081 salinity profiles (M. Carnes, 2010). In order to fulfill the pre-requisite of constructing a climatological dataset, authors have selected World Ocean Data Base for the reason that this product of National Oceanographic Data Centre (NODC) Ocean Climate Laboratory (OCL) is claimed as the world's largest collection of freely available oceanographic data that dating back to the late 1700's (NOAA, 2017).

As previously mentioned that temperature and salinity profiles data set used in the calculation of Indonesian IWC Component 1 was downloaded from NODC/Ocean Climate Laboratory/OCL Products/WOD13. From here, authors proceed to WOD data sorted geographically to get the webpage that shows 10 degrees square geographically sorted data set. For Indonesian sea area, authors downloaded ten squares with square number 1009, 1010, 1011, 1012, 1013, 3009, 3010, 3011, 3012 and 3013. Inside the respective square there are some types of data that collected in a .gz compression format with respect to the equipment of data acquisition, they are : OSD, MBT, CTD, XBT, PFL, MRB, DRB, APB, UOR, GLD, SUR (NOAA, 2017).

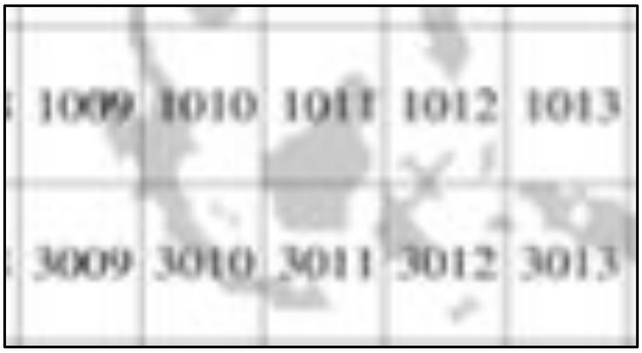

Fig 1. WOD 13 square download (NOAA, 2017)

The downloaded temperature and salinity dataset then imported, readed, extracted or collected into Ocean Data View (ODV) software for further process (Schlitzer, 2013). Based on data import statistic in ODV software, the ten downloaded squares containing 169,959 observation points with the oldest time recorded is 1827 and the newest time recorded is 2017. So this data base has been collected for 190 years. But it was not until 1914 the count of observations is more than 100 observation per year. And starting from 1961 the recorded observation hit more than 1,000 per year. The poin is with such number of observation and such a long periode historical data, the WOD13 is valid to be used in calculation, estimation and construction of Indonesian AML IWC.

2.2. Horizontal Gridding and Estimation

Once the WOD13 data sets are all imported into ODV collection, first thing to do is to prepare the xy coordinate text files. The Indonesian AML IWC is planned to have 1/4° x 1/4° spatial resolution. Meanwhile the area is limited by 90 ºE to 140 ºE and 10 ºS to 10 ºN. Using these data, authors produce a grid file utilizing the grid file generator tool that provided in the ODV software (M.R. Carnes, 2009).

Secondly, authors planned to make The Indonesian AML IWC into 63 standard depth levels. This standard depth level starts from 0 m up to 3000 m. The intervals between depth level are set so the upper layer interval will be shorter than the lower layer interval. For example the interval between 0 m to 10 m depth is set in 2 m between each standar depth, but the interval between 2000 m to 3000 m depth is set in 200 m between each standar depth (M.R. Carnes, 2009).

Before the estimation can be done, authors should add the isosurface variables for temperature and salinity at each standar depth so it can be plotted in surface window as Z values. There will be 126 isosurface variables to be added one by one (Schlitzer, 2013).

In order to be able to use the 2D estimation function in ODV software, the imported data should be gridded in the surface window. But before gridding, authors verify that station selection criteria has been done for the selected month and selected variable in the map window and sample selection criteria has been done for only accepted value data. After both criteria checks have been passed, authors plot the isosurface variable by gridding method. The gridding method used is DIVA gridding. DIVA is a gridding software developed at the University of Liege that offers a number of advantages over the weighted averaging methods built into ODV. DIVA allows analyzing and interpolating data in an optimal way, comparable to optimal interpolation (OI). Unlike OI, DIVA also takes into account coastlines and bathymetry features to structure and subdivide the domain on which estimation is performed. Calculations are performed on a finite element mesh adapted to the specific gridding domains (Schlitzer, 2013) (Troupin, 2012).

With 2D estimation function, for each xy coordinates in the input file, ODV will estimate a Z-value, and will write the estimated values together with the respective xy coordinate to an output file. The output file is written to the same directory as the input file, and the file name is of the form <name>_est.<ext>, where <name>.<ext> is the name of the input file. Each line in the output file contains the X, Y, and Z values of one estimation point. A Z value of -1.e10 indicates that the particular xy coordinate is far from any data point and that no reliable estimation could be performed. Z values at points outside the window domain or in regions exceeding the window's quality limit (white areas in the plot) are set to -1.e10 (Schlitzer, 2013).

2.3. Bathymetri

Bathymetri is also important for construction on netCDF file. As mentioned above that the estimation through 2D estimation with DIVA gridding method takes into account coastlines and bathymetri features to perform estimation. The Indonesian AML IWC bathymetry for estimation process in ODV software is loaded from GEBCO_2014_6X6min_Global (S. Tani, 2017). Meanwhile bathymetry bottom depth at each grid point on the ¼º x ¼º grid was derived by estimation from GEBCO_2014_2D_90.0_-10.0_140.0_10.0.nc file. The bottom depth estimation was done in ODV software, the similar way as temperature and salinity estimation. The bottom depth estimation will be writen into the netCDF file (Schlitzer, 2013) (Mathworks, 2015).

2.4. Constructing one temperature array, one salinty array and one bottom depth array from the estimation txt files

From the estimation process, authors are able to produce 63 txt files for each month and each temperature and salinity variabel and 1 txt file for bottom depth. In order to be able to be writen into a netCDF format file, authors sholud combine the values into 1 array of variabel with pre-defined dimension planned.

For temperature and salinity variables the pre-defined dimension will be 201 x 81 x 63 x 2. The dimension consist of longitude by latitude by depth by month. While bottom depth variabel will have 201 x 81 dimension consist of longitude by latitude.

2.5. Construction of netCDF file from the 4-dimension and 2-dimension arrays.

NetCDF is a widely used file format in atmospheric and oceanic research – especially for weather and climate model output – which allows storage of different types of array based data, along with a short data description. The NetCDF format (Network Common Data Format, http://www.unidata.ucar. edu/software/netcdf/) has been developed since 1988 by Unidata (a programme sponsored by the United States National Science Foundation) with the main goal of making best use of atmospheric and related data for education and research (R. Rew et al, 1990) (R. Rew et al, 2011).

A NetCDF dataset contains a symbol table for variables containing their name, data type, rank (number of dimensions), dimensions, and starting disk address. Each element is stored at a disk address which is a linear function of the array indices (subscripts) by which it is identified. Hence, these indices need not be stored separately (as in a relational database). This provides a fast and compact storage method (R. Rew et al, 2006). The advantage of the NetCDF library is that there is no need for the user to take care of the physical representation of multidimensional data on the disk.

One particular advantage of NetCDF over some other binary formats, such as the RData format used by R, is the ability to access and modify arbitrary sections of array data. This allows massive datasets to be processed efficiently, even if they are larger than the virtual memory available on a particular system. To reduce disk space requirements, floating-point values are often packed into 8- or 16-bit integers, and the NetCDF-4 (HDF5) format supports transparent compression using the zlib library (Pavel Michna et al., 2013).

For the Indonesian AML IWC experiment, authors used mathlab software to construct the netCDF file. the script is writen by netCDF package library that already available in the mathlab software. Generally the scripting steps is the un-interupted steps from the 4-D arrays and 2-D array construction (Mathworks, 2015).

Shortly, the netCDF file is produced as the following sequences :

- preparing the arrays to be writen which are longitude, latitude, depth, month, temperature, salinity and bottom depth.
- Create the netCDF file.
- Writing the global attributes.
- Define the dimension which are longitude, latitude, depth and month.
- Writing each dimension attributes.
- Define the variables which are longitude, latitude, depth, month, temperature, salinity and bottom depth.
- Writing each variable attributes.
- Writing the array to respective variable.

Result of this process is Indonesian AML IWC in the form of netCDF file.

Standard deviation of estimation values for each 4-dimension coordinate is calculated using mathlab software (M.F. Al-Saleh et al., 2009) (UKHO, 2006). This calculation utilizes the above previously produced netCDF file . The result of this step is two 4-dimension array of temperature standard deviation and salinity standard deviation. After that, those two variables will be writen into netCDF files so the last product will have 5 variables, which are temperature, salinity, temperture standard deviation, salinity standard deviation and bottom depths.

3. RESULT AND DISCUSSION

3.1. Input File Facts

The Input files facts used for the experiment that has been downloaded from the WOD13 could be extracted from WOD13 meta data which can be analyzed from the statistic function inside the ODV software (Schlitzer, 2013). Below are Input files facts summary table showing general statistic of the input data.

Table. 1 Input File facts summary

1	Format	US NODC Formats/World Ocean Data Base
2	File type	.gz
3	Size	457 MB(compressed)
4	Longitude	90 E to 140 E
5	Latitude	10 S to 10 N
6	Time	28/91827 to 2/4/2017

7	Points observed	169,959
8	Avg. points obs. by month	14,164
9	Points with T var	162,820
10	Points with Sal var	82,892

Table. 2 Input File dataset based on acquisition method

1	OSD	bottle, low res CTD and XCTD, plankton data
2	MBT	MBT, DBT, Micro BT data
3	CTD	high res CTD data
4	XBT	expandable bathytermograph data
5	PFL	profiling float data
6	MRB	moored buoy data
7	DRB	drifting buoy data
8	APB	autonomous pinned bathytermograph data
9	UOR	undulataing oceanographic recorder data
10	GLD	glider data
11	SUR	surface data

3.2. Output File Facts

From this input data, this experiment investigates the possibility of Indonesian AML IWC construction utilizing ODV software and mathlab software. General information of how to construct a climatology of ocean temperature and salinity is described in refrence describing about GDEM, products of US Navy (M.R. Carnes, 2009) (M. Carnes, 2010). These documents is the primary reference used by authors on developing steps of Indonesian AML IWC, while the decision to delivere it in the form of netCDF format file is because of it is the standard of AML IWC which produced and maintained by UKHO (UKHO, 2006).

In the netCDF output files every xyz coordinates must have values. As consequences the values on the lands and at the depth levels less than 3000 m that limited by the bathymetri will be set as -1.e10. The facts summary regarding the output files are as follows.

Table. 3 Output File facts summary

1	File type	.nc (netCDF)
2	Size	62.7 MB(uncompressed) 2 months climatology
3	Longitude	90 E to 140 E

4	Latitude	10 S to 10 N
5	Time	January and February
6	gridded sta 1 month	16,281
7	Visible gridded sta 1 month	13,125
8	gridded sta overland 1 month	3,156
9	key variables	temperature, salinity, temp_sd, sal_sd, bottom depth

This Indonesian AML IWC size is 62.7 MB equivalent with 13,125 profiles x 1 variable x 2 month equal to 26,250 profiles per variable or 105,000 profiles temperature, salinity and each standard deviation. By a simple math the 12 month Indonesian AML IWC could take about 62.7 MB x 6 or equal to 376.2 MB.

Authors also try to export the complete data from Indonesian AML IWC into text file using ODV software. The exported text file is a tab delimited single file with the size of 106 MB about twice bigger the size of netCDF file.

Each gridded station of netCDF file could be exported or extracted to be used for further calculation or modelling. Authors investigates the size of a single gridded station export which consist of station meta data, temperature, salinity and sound speed data and founded that the size of text file approximately 5.05 KB. If we want to export each Indonesian AML IWC gridded station into different text file it will take about 5.05 KB x 13,125 station or equivalent with 66.3 MB per month or 132.6 MB for 2 month, about twice larger than the size of netCDF file. Not to mention we should handle 13,125 different files only for one month.

While the usual observation data is generally delivered as txt file or excel file. With netCDF format, authors are able to compile thousands of temperature and salinity profiles for Indonesian area in only one single file with less memory storage required. This bring benefit over the storing of every temperature and salinity profiles in different txt or excel files.

3.3. Discussion

Indonesian AML IWC is more regularly spaced compared to original WOD13 observation data which maintain their observation position as reported. Below figures shows the differences between WOD13 and Indonesian AML IWC spatial distribution.

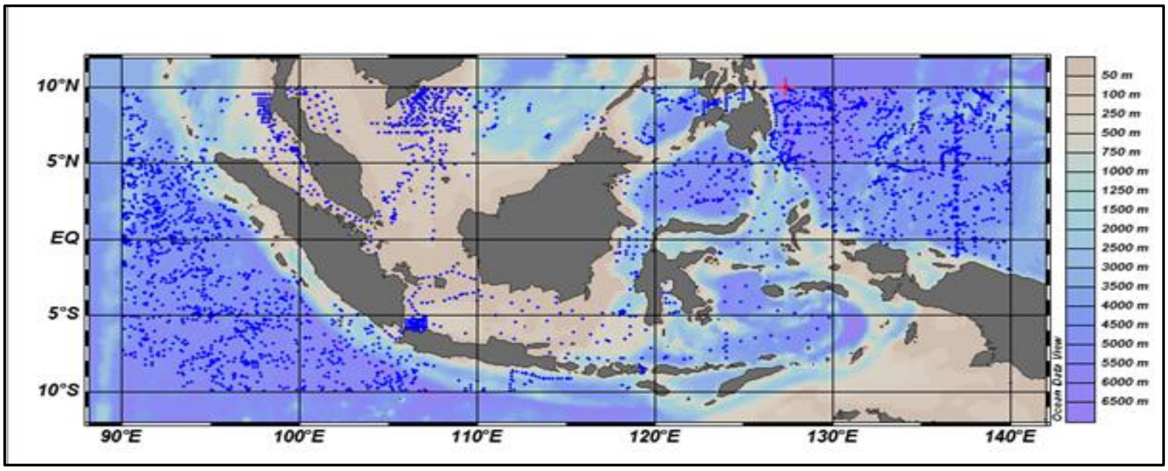

Fig 2. Spatial distribution of WOD 13 in January

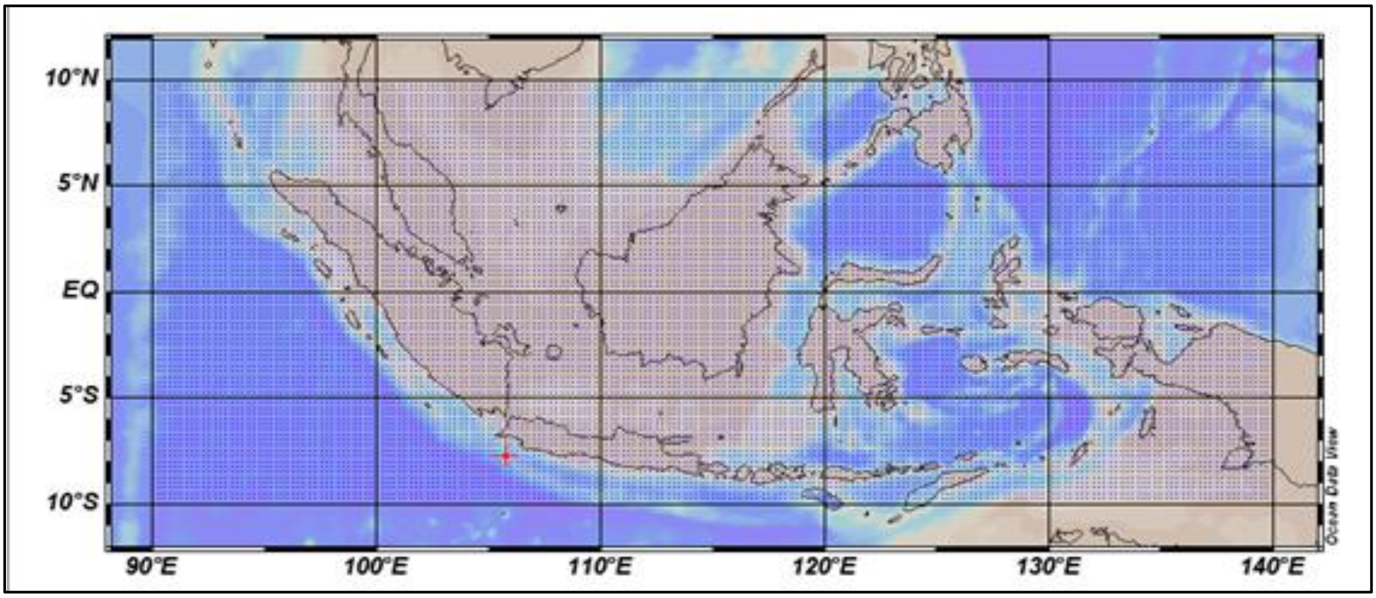

Fig. 3 Spatial distribution of Indonesian AML IWC in January

A pictorial comparisons of the input and output file plotting are also conducted to check the validity of the output file. surface plotting temperature at depth 0 metre for January are compared for WOD13 and Indonesian AML IWC as follows.

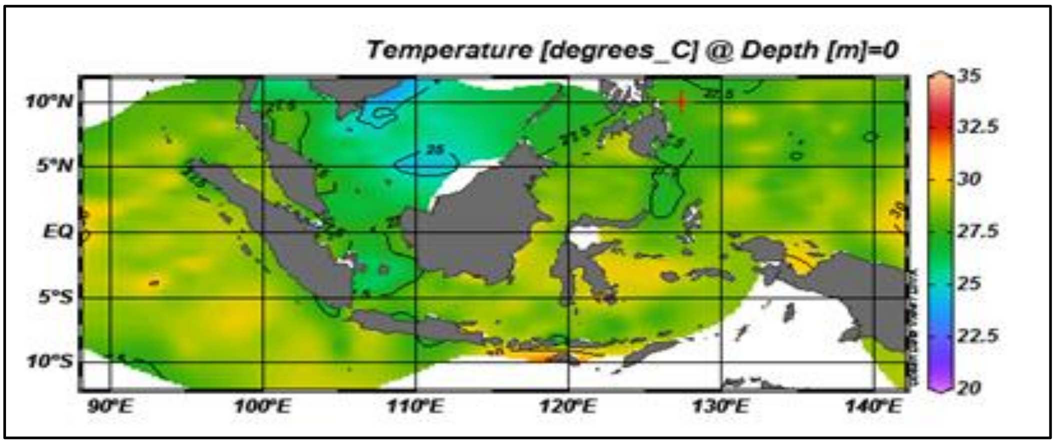

Fig 4. Surface plot of WOD 13 in January

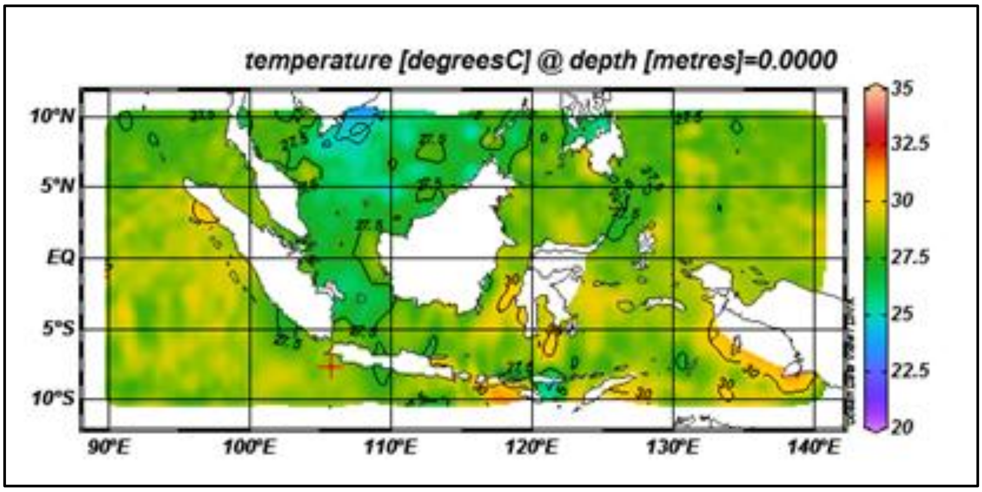

Fig 5. Surface plot of Indonesian AML IWC in January

For station comparison authors take sample of observation point located at 106° E and 8° S. Both temperature data with the same point location from WOD 13 and Indonesian AML IWC then plotted on the station plotting window with the a very similar profile.

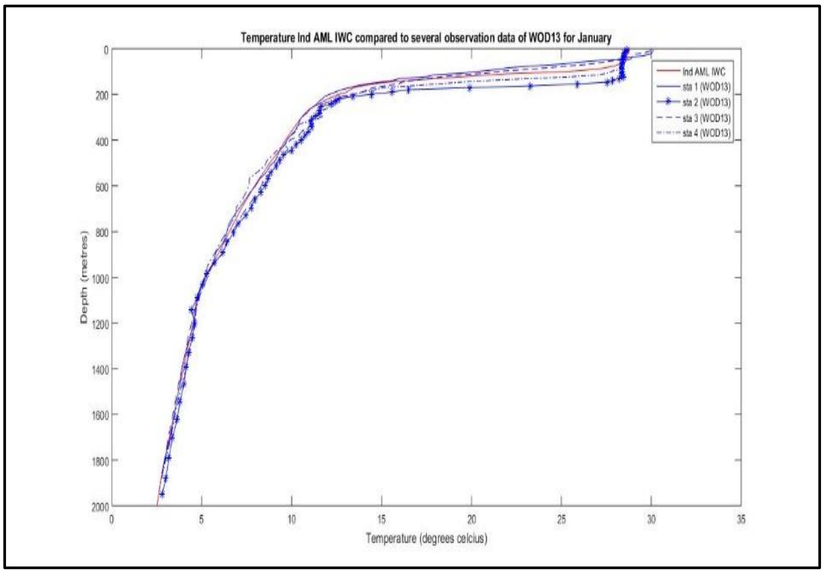

Fig 6. Station plot comparison between WOD13 obs and Ind AML IWC on January at about 106 E and 8 S

3.4. Outlook

Validation is a working process in an experiment to compare a result to another tipically same product. In this experiment validation of Indonesian AML IWC will be compared to World Ocean Atlas 13 (WOA13) temperature and salinity climatology product of NODC/OCL. General production method of WOA is described in WOA 13 tutorial with the title of WORLD OCEAN ATLAS 2013 Volume 1 : Temperature (R.A. Locarnini et al., 2013). Generally the production concept is the same for both products. But, off course each institution has copyright and details that is not published. For that reason there will be some differences between WOA 13 and Ind AML IWC.

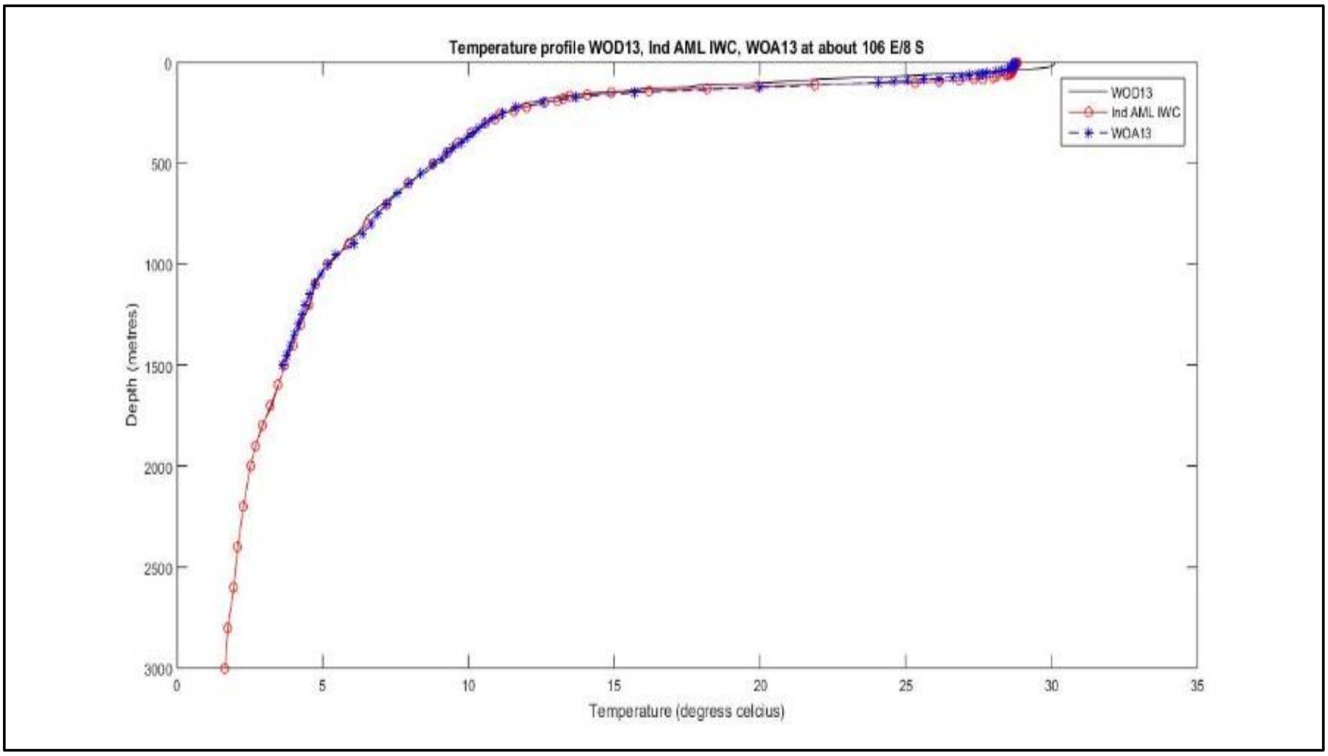

Fig. 7. Station plot comparison between WOD13 obs, Ind AML IWC, WOA 13 on January at about 106 E and 8 S

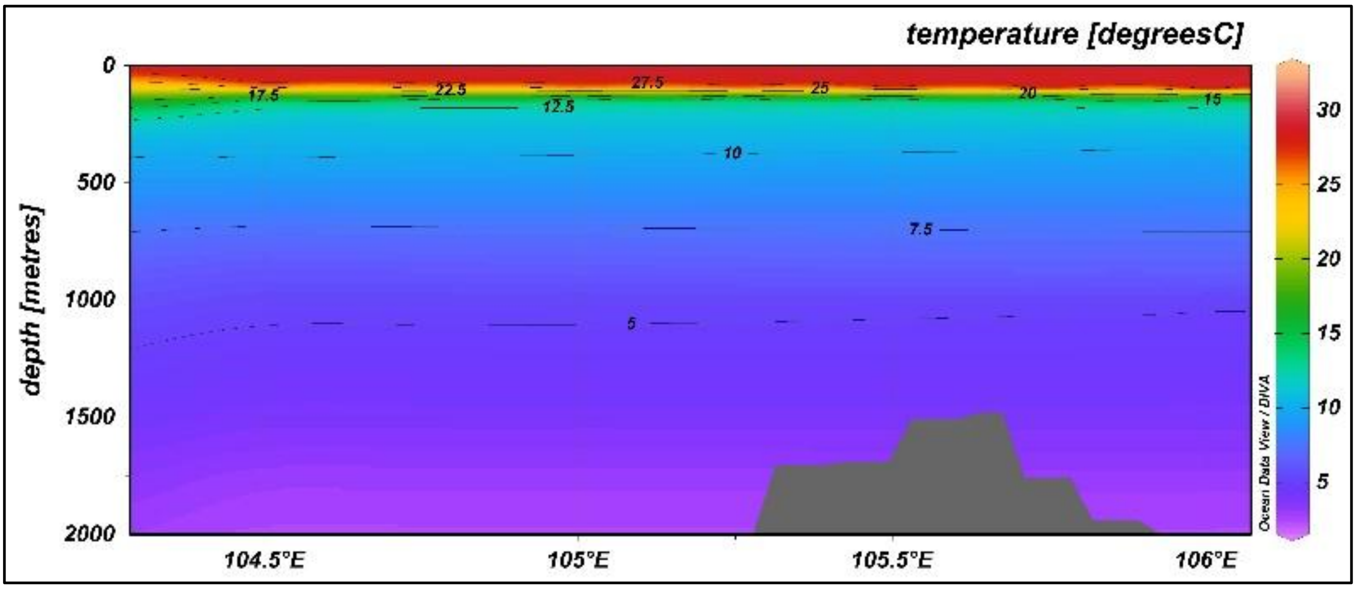

Fig. 8. Section plot Ind AML IWC on January at south of West Java

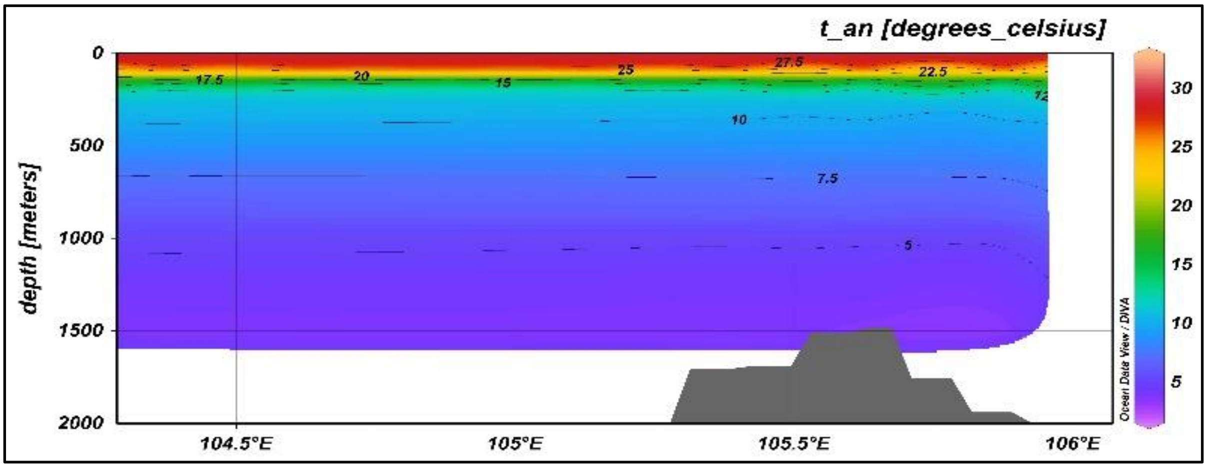

Fig. 9. Section plot WOA 13 on January at south of West Java

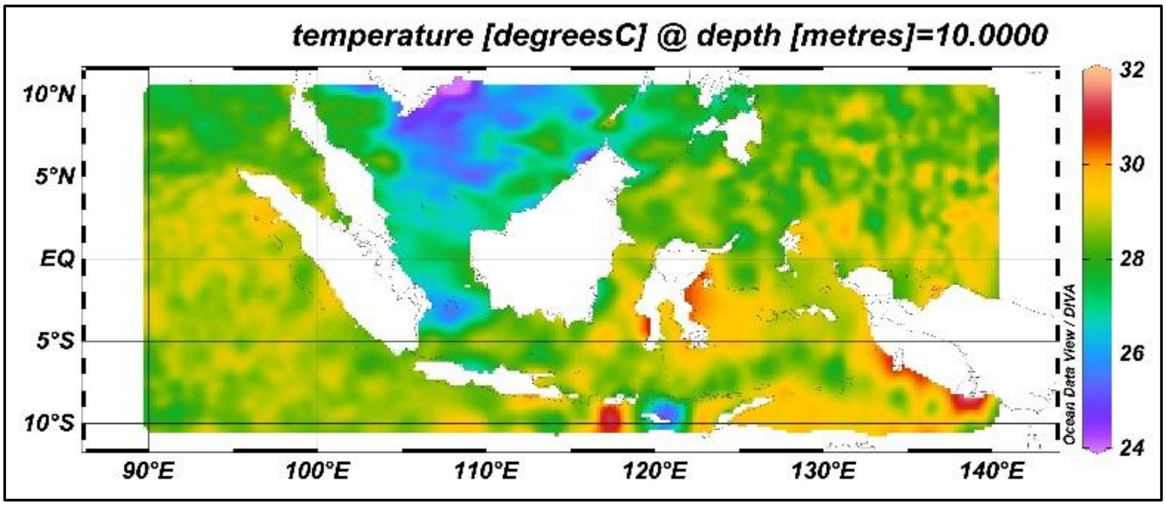

Fig. 10. Surface plot Ind AML IWC on January at 10 m

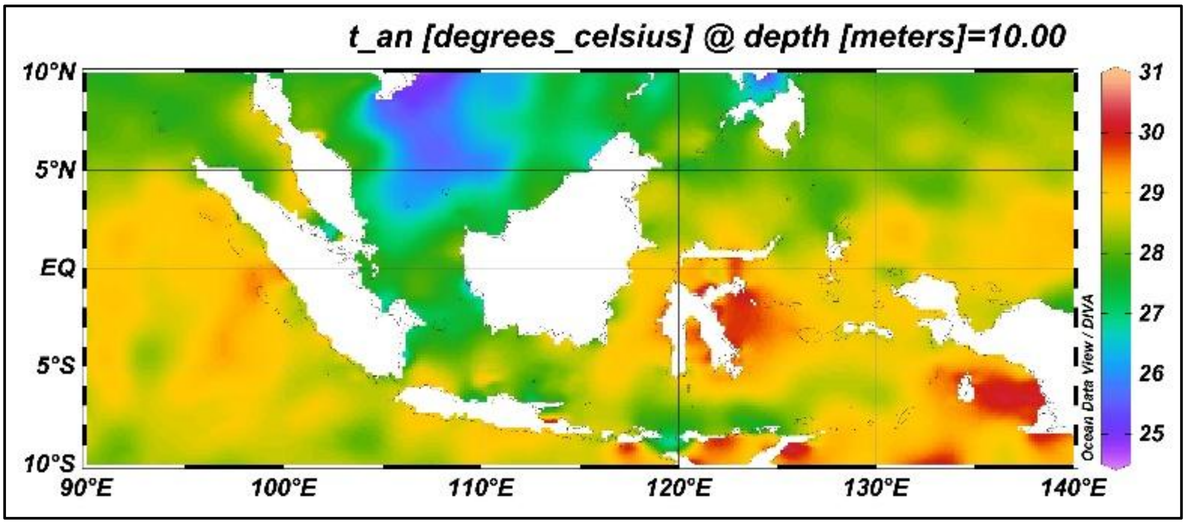

Fig. 11. Surface plot WOA 13 on January at 10 m

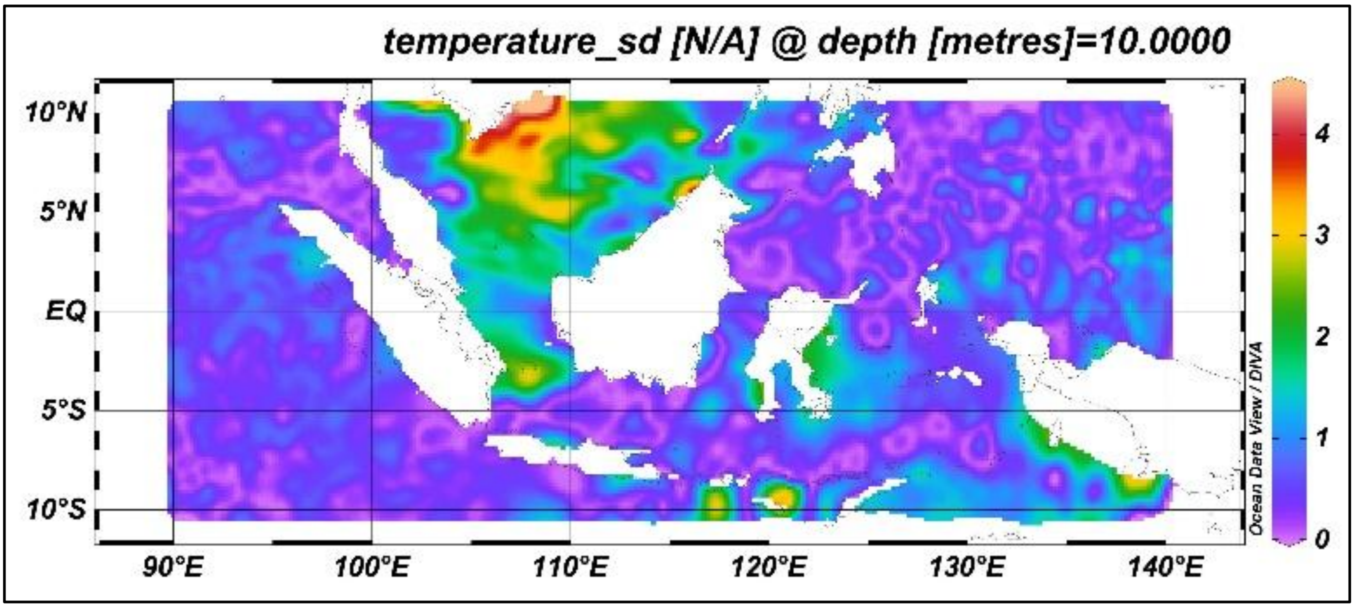

Fig. 12. Surface plot Ind AML IWC temperature standard deviation on January at 10 m

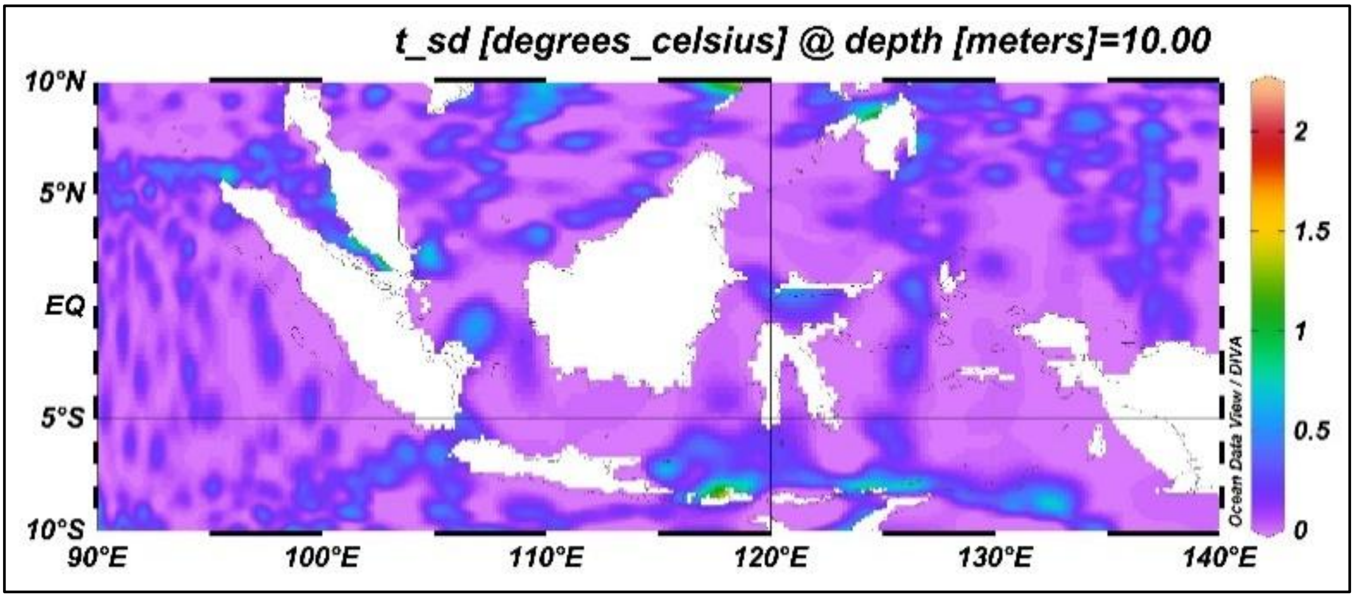

Fig. 13. Surface plot WOA 13 temperature standard deviation on January at 10 m

4. CONCLUSION

In conclusion, the proposed hypothese of this paper that Indonesian AML IWC netCDF file could be constructed from WOD13 database utilizing some already available function in ODV and netCDF package in mathlab has been successfully tested and can be accepted. This experiment has resulted Indonesian AML IWC, a gridded data set products in the form of netCDF file that has been tested its representation and data extraction in ODV software.

The experiment conducted by the authors utilizing raw observation temperature and salinity data set from WOD13 with the support of ODV and Mathlab software resulted a netCDF file containing temperature and salinity profiles regularly distributed geographically in monthly temporal resolution. This file basically has the same product specification with NATO AML IWC Component 1.

The Indonesian AML IWC plotting pictorial comparison with raw WOD13 data showed both files are similar. Therefore it is valid for presentation of likely condition in an environment or profile data extraction for further calculation, prediction or simulaton concerning military operation in the sea such as anti submarine warfare operation.

This paper may contribute to the production initiation of gridded data products of AML by Indonesian Navy Hydrograpy and Oceanoraphy Centre for the support of Indonesian Navy Military Operation. As this file existence onboard a ships may prevent the ships to launch CTD or XBT to get temperature and salinity profiles in particular sea area. Since in the time of war, decision oftenly should be made in a split seconds. In the other hand we don't have enough time to get the information we need such as launching CTD. In such particular situation AML IWC could help the officer in charge to make the right battle manoevres to gain advantages from the environment.

5. ACKNOWLEDGEMENT

This work was supported by ODV Software and Mathlab Software. Raw data was extracted from WOD13 and validation product WOA 13 are products of NODC Ocean and Climate Laboratory. 4 dimension netCDF data writing sample was downloaded from unidata website. Bathymetri was downloaded from GEBCO.

6. REFERENCES.

B.H. Brunson, U. N., 1989. *Anti Submarine Warfare on The Continental Shelf,* Alabama: Air War College.

Captain Jones, R. N., 2016. *NATO AML Handbook.* London: UKHO.

M. Carnes, R. H. C. B. J. D., 2010. *Validation Test Report for GDEM4,* Mississippi: Naval Research Laboratory.

M.F. Al-Saleh et al., 2009. Properties of the Standard Deviation that are Rarely Mentioned in Classroom. *Austrian Journal of Statistics,* 38(3), pp. 193-202.

M.G. Alexandridis, E. E. J. W. J. D., 1984. *Cognitive Simulation on an Anti-Submarine Warfare Commander's Tactical Decision Process,* Burlington, Massachussets: ALPATECH, Inc..

M.R. Carnes, 2009. *Description and Evaluation of GDEM V-3.0,* Mississippi: Naval Research Laboratory.

Mackenzie, K., 1960. Formulas for the Computation of Sound Speed in Sea Water. *The Journal of The Acoustical Society of America,* 32(1).

Mathworks, I., 2015. *Mathlab help documentation,* Massachussets: Mathworks, Inc..

NOAA, 2017. *Access to World Ocean Database Geographically Sorted Data.* [Online] Available at: www.nodc.noaa.gov/OC5/WOD/datageo.html [Accessed 1st October 2017].

NOAA, 2017. *NOAA National Centre for Environmental Information.* [Online] Available at: www.nodc.noaa.gov/about/index.html [Accessed 1st October 2017].

Pavel Michna et al., 2013. RNetCDF - A Package for Reading and Writing NetCDF Datasets. *The R Journal,* 5(2).

Peter C. Chu, M. D. P. E. L. G. D. S. C., 2004. *Satellite Data Assimilation for Improvement of Naval Undersea Capability,* Monterey: Naval Postgraduate School.

R. Rew et al, 1990. NetCDF : An interface for scientific data access. *IEEE Computer Graphics and Applications,* 10(4), pp. 76-82.

R. Rew et al, 2006. *The NetCDF Users Guide version 3.6.1,* Boulder, CO: Unidata Program Centre.

R. Rew et al, 2011. *NetCDF Users Guide version 4.1.3,* Boulder, CO: Unidata Program Centre.

R.A. Locarnini et al., 2013. *World Ocean Atlas 2013, Volume 1 : Temperature,* s.l.: NOAA.

S. Tani, 2017. Understanding oceans. *The UNESCO Courier,* pp. 65-69.

Schlitzer, R., 2013. *Ocean Data View.* [Online] Available at: http://odv.awi.de [Accessed 1st October 2017].

Troupin, C. e. a., 2012. Generation of Analysis and consistent error fields using the Data Interpolating Variational Analysis (DIVA). *Ocean Modelling,* Volume 52-53, pp. 90-101.

UKHO, 2006. *ADDITIONAL MILITARY LAYERS INTEGRATED WATER COLUMN (Phase 1) PRODUCT SPECIFICATION,* London: UKHO.

UKHO, 2006. *ANNEX C to ADDITIONAL MILITARY LAYERS INTEGRATED WATER COLUMN PRODUCT SPECIFICATION,* London: UKHO.

UKHO, A., 2008. *ADDITIONAL MILITARY LAYERS AML Guidance and Implementation Manual,* London: UKHO.

W.J. Teague, M. C. P. H., 1990. A Comparison Between the Generalized Digital Environmental Model and Levitus Climatologies. *Journal of Geophysical Research,* Volume 95, pp. 7167-7183.

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PREVENTIVE MAINTENANCE OPTIMIZATION BASED TIME DELAY USING MARKOV DECISION PROCESS

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ABSTRACT

In KRI operations, often as the user aware of a phenomenon predicted that the system that is in use is experiencing a decline in performance, so that the system is damaged and must carry out repairs with no small cost. To support the reliability-based maintenance system, need to be analyzed in determining the appropriate rate of damage, such as determining the condition of a system based on time delay. Maintenance concept based on the time delay before the system is malfunctioning, the system will provide signs indicating reduced performance. Implementation of the field to apply the concept of time-based maintenance of this delay is difficult to apply because it must have the appropriate data in the form a model of time delay. In this study, the paper apply time-based maintenance delay with the combination of policies in the operation pattern, then performed the observations with the approach of Markov Decision Process. Showed that in general, both the policy pattern 1, 2 and 3 as in this study, to implement preventive policies based on time delay, to minimize operating costs and maintenance time KRI damaged during the operation.

KEYWORDS : Time delay, Markov Decision Process, reliability

1. INTRODUCTION

One effort to ensure readiness KRI is undergoing maintenance, maintenance and repair appropriately and implemented. The activity aims to maintain a level of reliability KRI order to function in accordance with operational needs. Maintenance system that is in use Navy currently uses Planned Maintenance system that are customized to maintenance handbook of the manufacturer and or using General Guidance Material Navy (Headquarters, 1983) Developments in science today, helping checks on preventive maintenance actions become increasingly accurate. With a capital of operating experience and high maintenance it is possible to construct reliability-based maintenance systems. KRI to support operations by implementing maintenance systems based reliability, it is necessary to analyze the right to determine the rate of damage, such as determining the condition of a system based on time delay. Several previous studies have discussed about the system based on time delay, such as that written by (Christer & Waller, 1984), (Das & Acharya, 2004), to study the pattern of damage accelerated which is modeled by using Accelerated failure Time (Putro, 2008).

In the model time delay difficulty in modeling time delay is how to determine the estimated distribution time delay h and determine a starting point u, so as to facilitate the research object on conscientious assumed in new condition, despite a history of never repaired, (Christer, 1987). These difficulties are well-founded where the model time delay is based on the initial data are sufficient. In the period u, the data obtained from the registration data symptoms towards the damage, while in the period h as the assumptions on the model of the time delay in which the system is considered as good as new, the distribution model in the period of h is obtained from the results of studies that have been carried out, collectively the data systems that are identical, the data from the manufacturer,

In Indonesia in the period h, the distribution of the data difficult to obtain where as users, especially at KRI, the model reliability is not applied so that the model in the period h is hard to come by, while to get data from the manufacturer may also have problems because the manufacturer did not release the results of testing reliability a unit or system. To refer to models h period if used data from an agency like the IAEA (International Atomic Energy Agency, 1998) also can not be applied directly, where conditions or circumstances (room temperature, humidity, etc.) at the time of the test item / unit are not necessarily together with the existing situation in the field.

From the above constraints, the need for approaches with corresponding methods, one method of maintenance policy optimization is the method of Markov Decision Process. In this study, researchers took one example of a system that has the data corresponding to the model time delay, then the data acquired to be some circumstances (state) and then make an optimization approach Markov Decision Process by considering the costs due to damage and operating costs, so that the results of such an approach is obtained an input for consideration in decision making.

2. MATERIALS AND METHODOLOGY

2.1. Maintenance

Definition of maintenance is the maintenance or maintenance of a system in an effort to keep or maintain the condition. In the sense of making adjustments or replacements are required to obtain a condition to match the existing operational planning (Levitt & Joel, 2003). Understanding maintanace in general is a series of activities (both technical and administrative) that the need to preserve and maintain a product or system remains in a safe condition, economical, efficient and optimal operation.

According to Anthony in the book Maintenance Management Techniques in terms of time of execution of the work, maintenance categorized in two ways, namely the maintenance of planned and unplanned maintenance (Anthony, 1992). Planned maintenance is carried out in a planned maintenance in anticipation of damage to equipment in the future. Planned maintenance has the characteristic that the scheduled maintenance. These activities tend to be passive only resolve the issue on a regular basis, but sometimes there are also some that are reactive.

Barlow and Proschan describes the replacement policy based on age namely a standard item on the system replaced when damaged by the failure replacement or items replaced when if no damage or preventive replacement whichever occurs first (Barlow & Proschan, 1965). In research conducted by Dekker and Smeitink with the title Opportunity Based Block Replacement, policy replacement carried out periodically in accordance with the schedule determined opportunity (Dekker & Smeitink, 1991).

Opportunity Based Replacement Age. In the model based-age replacement opportunity of this, the component replaced on an occasion when the life of these components has been achieving optimal replacement interval (Dekker & Dijkstra, 1992).

Preventive Maintenance at Opportunities of Restricted Duration.In this policy item will be replaced at the time of emergence (Dekker & Smeitink, 1994).The opportunity to use the priority criteria multicomponent which will be the replacement of only one component with probability p and with probability 1-p when two components once replaced. The main idea of this research is form the most optimal model for implementing the package induvidu maintenance costs and develop criteria among some optimal circumstances with respect to time.

An Extended Opportunity Based Age Replacement, In this policy components studied are personal computer (PC) with the emergence of the opportunity to follow the process poisson and because the opportunity arises is the technology factor new (Iskandar & Sandoh, 2000). The decision variables in this study are S and T. The paper considers the warranty and opportunity for their new technological factors, while according to Yun-Choi, the emergence of the new system enables life cycle system is getting shorter if the opportunity came shortly after consumers buy a system, the consumer may be replace the system after used for a certain time where the system is quite feasible to be replaced. However, if the system not immediately replaced after the opportunity, from the time of arrival of opportunity until the system is replaced, here is actually the consumer suffered losses in the form of an opportunity to get profit, operating expenses, or maintain selling prices.

2.2. Reliability

Reliability according to Ebeling, can be defined as the probability of a system that has the performance to match the required functions in a given time period (Ebeling, 1997). Reliability can also be defined as the probability of a system that functions according to the way it should be at a certain period. To illustrate the mathematical relationship can be determined a continuous random variable T which states the time of a system failure (T ≥ 0). The probability of occurrence of damage at the time T <t is expressed by F (t), the Cumulative Distribution Function (CDF) as follows :

$$(t) = P\{T \leq t\} = \int_0^t f(t) \qquad (1)$$

Then the reliability function is expressed by the following equation:

$$(t) = 1 - P\{T \leq t\} = 1 - (t) = 1 - \int_0^t f(t) \qquad (2)$$

In analyzing the reliability of a system, often used the term Meann Time To Failure (MTTF) in characterizing reliability expressed by the following equation:

$$= \mu = \int_0^\infty t f(t) \qquad (3)$$

To state how easily an item has failed and can last up to time T, known as the rate of damage, can be written sebabagi follows:

$$= \mu = -\int_0^\infty t\, [\, \frac{d}{dt} R(t)\,] \qquad (4)$$

In analyzing the reliability is very important to know one of the functions of r (t), R (t), or f (t). Knowing one of the functions of the other two functions that can be determined.

2.3. Time delay

Nowakowski and Werbińska-Wojciechowska grouped into 3 time delay models The main groups based maintenance strategy, namely the Time-Based Inspection Models, Condition-Based Inspection Models, and Reliability Centered Maintenance Models (Nowakowski & Werbińska-Wojciechowska, 2011). Maintenance of the time delay analysis technique was first introduced in 1973 by Christer and Wang, which then continues to grow and a lot of application in industry (Christer & Wang, 1994). Model time delay appear based on the observation that a component does not experience a sudden breakdown. In contrast to the concept of probability rate of damage, where the damage rate measured by the extensive damage to the components per unit time in an experiment. In the model time delay, the damage is measured based on preliminary data the event of a system failure, then the probability of total failure of the system is identified and modeled, to obtain the probability / likelihood the extent to which the system can still be used.

A Delay-Time Model With Safety Constraint. In the study conducted by Terje Aven (2009), the system maintenance applied to preventive maintenance based on a time delay which is given 2 state with constraints limit safe, ie the probability of failure of the latter with intervals (0, A) which may not exceed the probability ω1 and fraction time experiencing symptoms of a system failure should not exceed ω2 limit. The main problem is to find the value of T for minimize Cd (T) (Aven & Castro, 2009). Completion resolved method expected discounted cost criterion.

A Multi-Component And Multi-Failure Mode Inspection Model Based On The Delay Time Concept,The concept of time delay and engineering maintenance optimization models have much discussed in previous studies (Wang, 2010). For systems multi-component and subject to many of the symptoms of damage. Different, is one interesting research where the arrival of symptoms and time inspection inspection failure.The approach using stochastic theory, this is what conscientious by Wang entitled "A Multi-Component And Multi-Failure Mode Inspection Model Based On The Delay Time Concept“ (Wang, 2010). Model time delay that is initiated by Christer, developed analytically in accordance with the conditions given by the researcher then simulate. The result is calculation then simulated with good results, where results dependent approach to the value of p (x) for the calculation of costs against time. In this study, to be assessed more depth where the parameters are not calculated whether affecting the model is given (Christer, 1987).

A Joint Parts And Maintenance Inspection Optimization Model Using The Delay-Time Concept.Spare parts and maintenance is closely linked to the activities logistics where maintenance requires spare parts to the process maintenance (Wang, 2011). When preventive maintenance is done, the possibility of require more parts. This study investigated optimization of three decision variables, namely, the number of bookings, interval reservations and inspection intervals.

An Overview Of The Recent Advances In Delay-Time-Based Maintenance Modeling. Maintenance concept covering all actions which contribute to retain the assets in accordance with its function (Wang, 2012). For program in addition to the PM, an examination of inspection is an activity that is in need, because it shows the information of the status of the items in check and to facilitate a decision, and implementation of repair and replacement.

Testing an "exponential Delay Time model "against a" Random Sign Censoring model "in Reliability (Dauxois, 2014). According to researchers Dauxois, the cause of failure considered to be related. It is necessary for maintenance certain (Dauxois, 2014). Corrective Maintenance (CM) is generally performed after critical failure. Sometimes Preventive Maintenance (PM) also. The randomized when after the observed degradation. In (Dauxois, 2014) all the improvements considered gives a perfect result, the system is considered as new back after maintenance.

In Dauxois, researchers combined the concept Competing risk, Bunea et al, the concept of Delay-Time, Hokstad and Jensen, the method of Random Sign censoring censorship, Cooke and Repair Alert, Lindqvist. Because the data less accurate, then Dauxois expand the dataset to estimate the following empirical certain behaviors (Dauxois, 2014).

A component before the component is broken, there will be something that gives the sign where it shows reduced performance. At the time delay where the concept model the failure process is divided into two stages: the identification of the failure at the point u and the occurrence of failure at a point during the delay time t h (Figure 1). The difficulty in modeling the time delay is how to determine the estimated distribution h time delay and determine a starting point u, so as to facilitate the research object in strictness assume the new state, despite a history of never repaired (Christer, 1987).

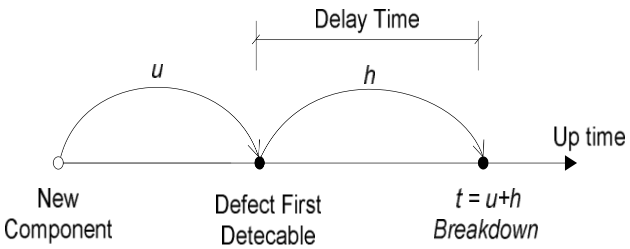

Fig. 1 Model Time Delay

H time span of the period is expected to be carried out maintenance inspection or an opportunity to identify and prevent damage. This concept shows that are useful to help a modeling of the effects of periodic checks on the rate of failure of the system.

Suppose the first identification abnormality is found (point point-u), initial time point u has a PDF - g (u), and the form of CDF - G (u), while the delay time h has the form of a PDF - f (h), and CDF form - F (h) and independent of u, where u + h ≤ t, then the probability of occurrence of damage is expressed by P (t), the Cumulative Distribution Function (CDF) as follows:

$$(t) = \int_0^t g(u)F(t-u) \qquad (5)$$

Then the reliability function is expressed by the following equation:

(R) = 1 − P(t) (6)

2.4. Markov Chain

Some analytical techniques can be used to evaluate the reliability of a system. Although teknikteknik can be applied both to the components repairable and non-repairable, but teknikteknik presupposes that the process of improvement (repair) done quickly or need a very short time is relatively much smaller than the operating time of the component. In other words, these techniques do not accommodate the repair time to be taken into consideration in the evaluation system reliability. To explain the meaning of Markov Decision Procces (MDP), will given an example of a policy engine maintenance Companies (Hillier & Lieberman, 2008).

This is certainly not true for all systems, even systems nonelektronik generally have characters that contrary to the assumption above. Therefore we need a technique that is able to enter into a time component repair system reliability evaluation process. One technique that is able to accommodate the repair time into the evaluation of reliability of the system is a Markov Modeling. Markov process is a stochastic process in which the past has no influence on the future when the present is known. There are several requirements in order Markov method can be applied in the evaluation of the reliability of the system. These requirements are :

a. The system must be characterized by lack of memory. Where the conditions of the future system are not affected by the previous state (independent).

b. The system must be stationery or homogeneous. This means that behavior is always the same throughout the life of the system.

c. State is identifiable, Conditions that are possible on the system must be clearly identifiable. 100% success and failure.

Markov Chain can generally be classified into two, namely Discrete and Continuous Markov Chain Markov Chain. Markov chain is said to be discrete when the displacement situation occurs with discrete fixed time interval. Instead, Markov chain is said to be continuous if the displacement situation occurs with a span with continuous random variables.

2.5. METHOD

The rate of damage that change over time and can not be predicted will affect the reliability of a system that will ultimately affect the maintenance schedule and operational.

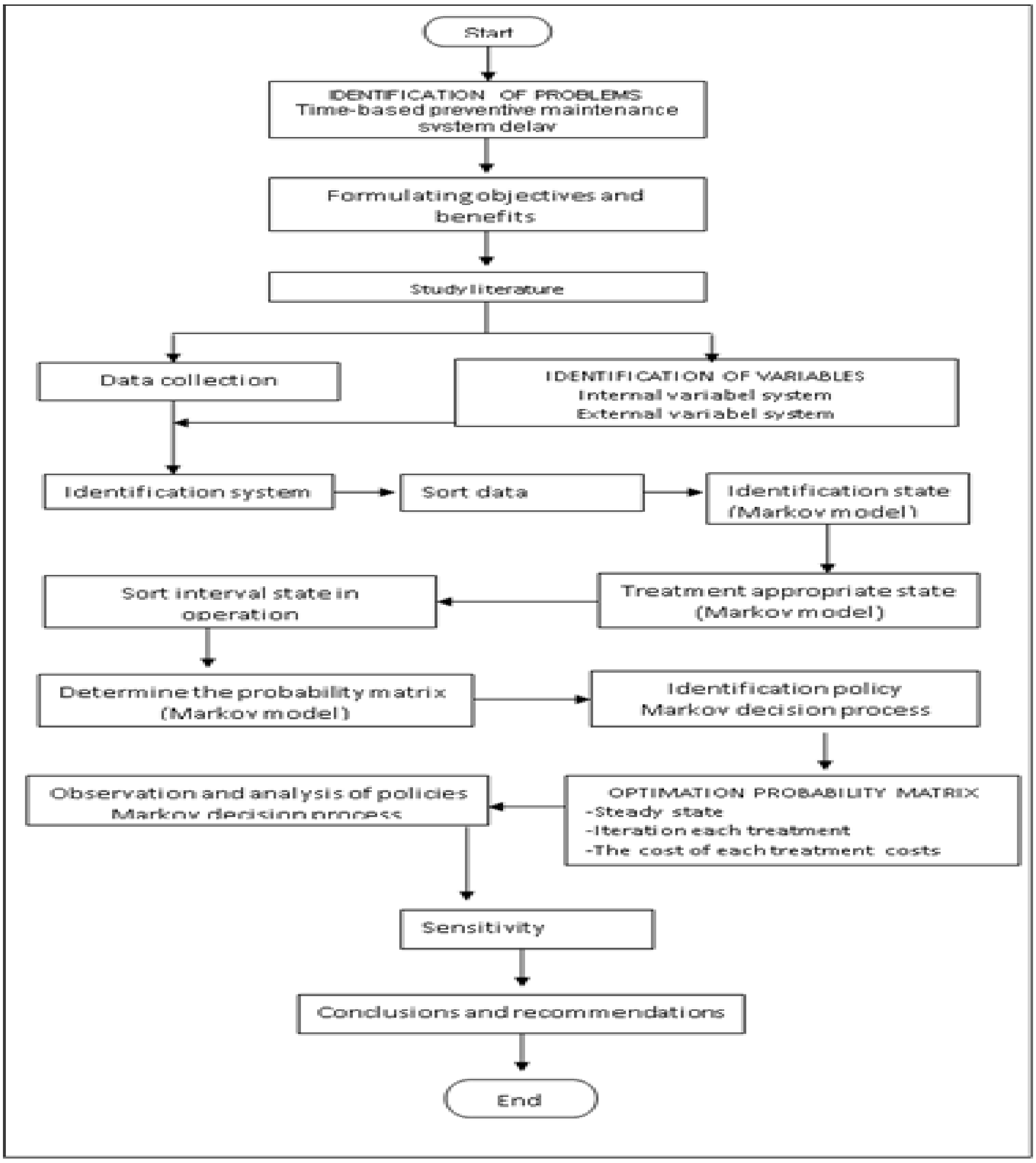

Fig. 2 Flowchart Research

In this research, the writing will make observations based maintenance system time delay, to obtain optimum results from several alternative policies with approach Markov Decision Process.

3. RESULTS AND DISCUSSION

Operational costs in this study is the operational support costs for 78 personnel and the cost of fuel when operating with duration of 5 days and 2 day surgery provision in the nearest base. The author assumes that the calculation of fuel consumption is calculated at the time of a change of 10-20%, engine rpm to 800 rpm, the operation pattern 1 week. The division of the condition (state) when the operation (Figure 3) consists of :

a. Normal condition (state 0). Conditions for a total cost of operation in 7 days is Rp. 1.243.389, -.

b. Conditions state 1 (state 1). Conditions to change by 10%, and total operating cost in 7 days is Rp. 1.437.597, -.

c. Condition 2 state (state 2). Condition with a change of 20%, and total operating cost in 7 days is Rp.1,908,429,000, -.

d. 3-state conditions (state 3). Condition where the system can not be used again, and the total cost of operations in 7 days is Rp. 2,256,802,000, -.

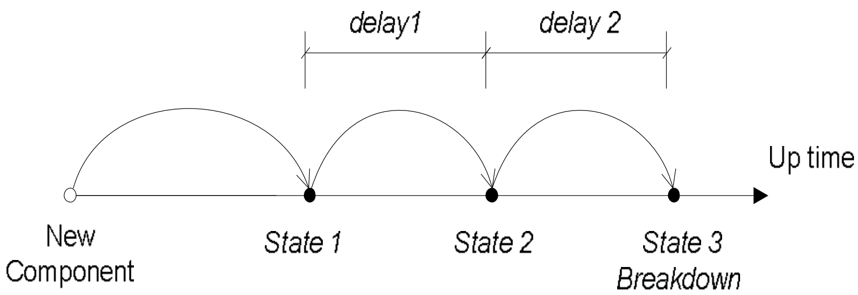

Fig. 3 Distribution of condition / state

While in the handling of maintenance, gather in the treatment group, include:

a. Treatment A. That treatment by not changing any condition (do nothing). So no maintenance costs.

b. Treatment B. That treatment with light maintenance actions at a cost of Rp.32,557,172.91.

c. Treatment of C. That treatment with heavy maintenance action / replace with a cost of Rp 194,753,425.32.

So that the data obtained from the treatment table and state as follows:

Table. 1 Treatment and state

No	Hours of Operation		STATE			TREATMENT
	JP	INTERVAL	1	2	3	
1	679	679	1	-	-	A
2	1017	338	1	-	-	A
3	1030	13	1	-	-	A
4	1342	312	-	1	-	A
5	1496	154	1	-	-	A
6	1520	24	-	-	1	C
7	1534	14	1	-	-	A
8	1576	42	-	1	-	B
9	1910	334	-	-	1	C
10	3010	1100	-	-	1	C
11	3613	603	1	-	-	A

No	Hours of Operation		STATE			TREATMENT
	JP	INTERVAL	1	2	3	
12	4220	607	-	-	1	C
13	4962	742	-	-	1	C
14	5776	814	-	1	-	A
15	6210	434	1	-	-	A
16	7274	1064	-	1	-	A
17	8370	1096	-	-	1	C
18	8720	350	1	-	-	A
19	8925	205	-	1	-	A

Having obtained the data according to their treatment and conditions, it needs to be made an interval / interval that can be approached following conditions in accordance with the properties of Markovian. From JP usage data for the system at intervals of 1 week or 7 days x 24 hours = 168 hours, of the total activities according to the data obtained during the 54-week intervals.

In determining the probability matrix is obtained based on the treatment and the interval. obtained:

Table. 2 Treatment A

State	0	1	2	3
0	0667	0128	0077	0128
1	0500	0125	0250	0125
2	0667	0333	0	0
3	0	0	0	1

Table. 3 Treatment B

State	0	1	2	3
0	1	0	0	0
1	1	0	0	0
2	1	0	0	0
3	0	0	0	1

Table. 4 Treatment C

State	0	1	2	3
0	1	0	0	0
1	1	0	0	0
2	1	0	0	0
3	0833	0167	0	0

In determining decisions, policies to be taken on the Inventory of possibilities, among it:

a. At state 0, no maintenance / treatment A (normal operation).

b. Treatment C (heavy maintenance), only for the maintenance of the state 3 (State 3 can not be treated with treatment A and treatment B). So that made such a policy contingency table in Table 5.

Table. 5 Policies

POLICY	STATE			
	0	1	2	3
I	A	A	A	C
II	A	A	B	C
III	A	B	A	C
IV	A	B	B	C

Of iterations of each policy obtained from a cost and figure 4 of the graph of each policy and operational costs as follows :

a.	Policy **I**	Rp. 1,455,612,321.43
b.	Policy **II**	Rp. 1,450,404,067.93
c.	Policy **III**	Rp. 1,421,312,993.49
d.	Policy IV	Rp. 1,422,239,798.89

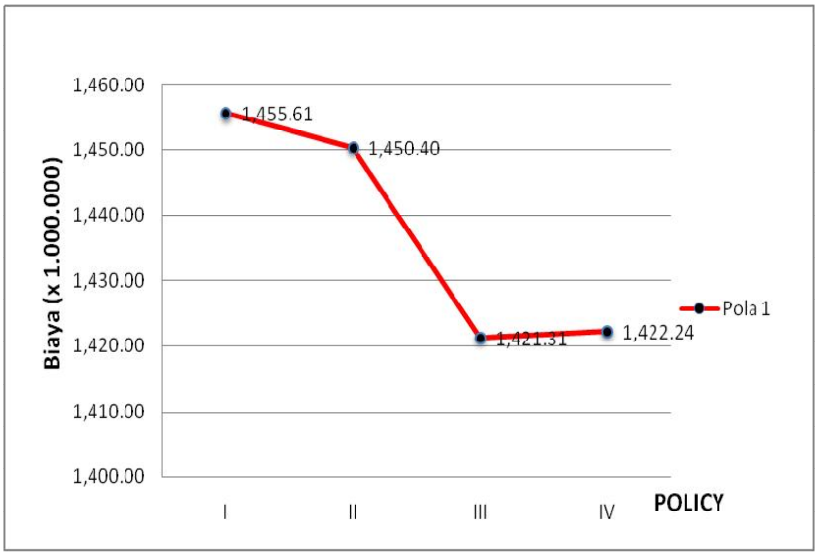

Fig. 4 Graphs Cost of Each Policy And operational

From the data processing show that active role ABK as a user in the recognition and identification system damage that has given the symptoms of damage, you can take immediately remedial action and maintenance. As for the operating budget of management, of course, require some alternative decision to support the decision if KRI who are conducting operations can not carry out duties in accordance with the operational plan. Therefore it is necessary several alternative patterns of policies that can support the implementation of the operation. Alternative policies of the 4th policy, with the pattern of these policies include:

a. Patterns Policy 1. As the initial policy, namely if KRI that is implementing operation having damaged, then must there is KRI replacement that imported from Surabaya home base.

b. Policy pattern 2. If KRI who have experienced damage no can operate and do not get KRI successor for continued security of the operating area.

c. Policy pattern on the base aju 3. If there are two similar operating KRI alternating with intervals of 1 week.

From the policy pattern 1, pattern 2 policy and the policy pattern 3 obtained image 5 about the relationship graph of each policy and operational cost of each policy patterns as follows :

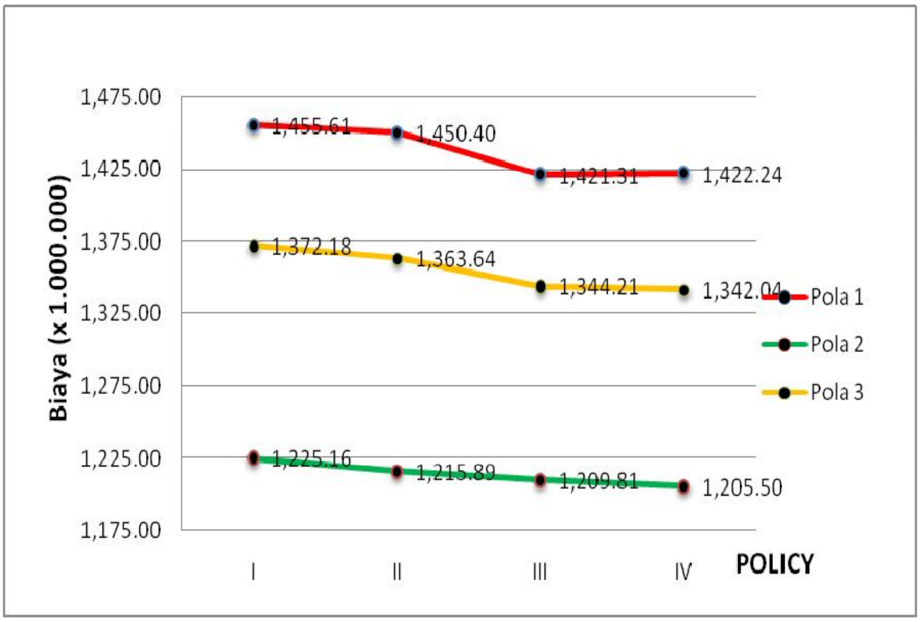

Fig. 5 Graph Optimization Each policy

4. CONCLUSIONS

From the observation of some of the policies / policy whereby as a result of the treatment system at any condition / state, causing differences in operating costs and maintenance on warships. So it can be concluded as follows :

a. As are shown in the picture 5 where in general by implementing a maintenance system based on time delay in an operation KRI, to minimize operating and maintenance costs when KRI damaged in the operation. Policy patterns 1, 2 and 3 are almost identical, where the policy patterns 2 and 3, the direction of policy I to policy IV decreasing, so that the policy patterns 2 and 3, the lowest cost is for each policy IV namely service / maintenance with treatment B if it occurs in state 1 and state 2, as well as C treatment if it occurs in state 3. in the policy pattern 1, which is the lowest cost in the third policy, where policy is actually almost the same as the policy IV, ie as in the probability of treatment B where at the time of treatment B,

b. In general the policy pattern (2) is the policy pattern with the lowest operating costs, which, if 1 (one) KRI who can not operate it is not prepared to secure the replacement KRI / area operasi. If no urgency to secure the region / area of operation as well as the limitations of the operational and maintenance costs, it is the policy pattern (2) can be considered its application.

To improve these results it is his advice:

a. In this study does not determine the probability of failure between the time interval of failure, so the need for more research on the maintenance and operating system-based time delay with Markov method.

b. If reliability based time delay applied in the Navy in particular, the need for research on a system similar to obtain the rate of damage in the period h, and if using data from standardization bodies foreign or manufacturer, hence the need for tolerance in the parameter distribution can be accounted for .

5. REFERENCES

Anthony, S., 1992. *Maintenance Management Techniques.* Surabaya: Erlangga.

Aven, T. & Castro, I., 2009. A Delay-Time Model With Safety Constraint. *Reliability Engineering and Systems Safety,* Volume 94, p. 261– 267.

Barlow, R. & Proschan, F., 1965. *Mathematical Theory of Reliability.* New York: John Willey.

Christer, A., 1987. Time-delay model Of Reliability Of Equipment Subject To Inspection Monitoring. *Journal of the Operational Research Society,* Volume 38, pp. 329-334.

Christer, A. & Waller, W., 1984. Delay Time Models Of Industrial Inspection Maintenance Problems. *Journal of the operational Research Society,* Volume 35, pp. 401-406.

Christer, A. & Wang, W., 1994. A Delay-time Based Maintenance Model Of A. *IMA Journal of Mathematics Applied in Business,* Volume 6, pp. 205-22.

Das, A. & Acharya, D., 2004. Age Replacement of Components During IFR Delay Time. *IEEE Transactions on Reliability,* Volume 53, pp. 306-312.

Dauxois, J., 2014. Testing an “Exponential Delay Time Model” Against A “Random Sign Censoring model” in Reliability. *Journal de la Société Française de Statistique,* Volume 155, pp. 104-119.

Dekker, R. & Dijkstra, C., 1992. Opportunity-Based Age Replacement. *Naval Research Logistics,* Volume 39, pp. 175-190.

Dekker, R. & Smeitink, E., 1991. Opportunity-based block replacement. *European Journal Operation Research,* Volume 46-63, p. 53.

Dekker, R. & Smeitink, E., 1994. Preventive Maintenance at Opportunities of Restricted Duration. *Naval Research Logistics,* Volume 41, pp. 335-353.

Ebeling, C., 1997. *An Introduction to Reliability and Maintainability Engineering.* McGraw-Hill, New York: University of Daytona.

Headquarters, I. N., 1983. *General Guidance Material Navy.* Jakarta: Indonesian Naval Headquarters.

Hillier, F. S. & Lieberman, G. J., 2008. *Introduction to Operations Research.* New York: McGraw-Hill.

International Atomic Energy Agency, 1998. *Component Reliability Data For Use In.* Austria: IAEA-TECDOC-478.

Iskandar, B. & Sandoh, H., 2000. An Extended Opportunity-Based Age Replacement Policy. *RAIRO Operations Research,* Volume 34, pp. 145-154.

Levitt & Joel, 2003. *Complete Guide to Preventive and Predictive.* USA: Industrial Press.

Nowakowski, T. & Werbińska-Wojciechowska, S., 2011. *Developments Of Time Dependencies Modeling Concepts, Advances In Safety, Reliability And Risk.* s.l., ESREL, pp. 832-838.

Putro, F., 2008. *Optimal Preventive Replacement Interval Delay Time to Consider During machine operation expenses.* Bandung: ITB.

Wang, W., 2010. A Multi-component and Multi-failure Mode Inspection Model Based on the Delay Time Concept. *Reliability Engineering and System Safety,* Volume 95, p. 912–920.

Wang, W., 2011. A Joint Spare Part And Maintenance Inspection Optimisation Model Using The Delay-Time Concept. *Reliability Engineering and System afety,* Volume 96, p. 1535–1541.

Wang, W., 2012. An Overview Of The Recent Advances In Delay-Time-Based Maintenance

Modeling. *Reliability Engineering and System Safety,* Volume 106, p. 165–178.

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THE PROPULSION ANALYSIS OF 60 METER FAST MISSILE BOAT (KCR 60 M) WITH NUMERICAL COMPARISON METHOD AND MODEL TEST

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ABSTRACT

60 Meter Fast Missile Boat (KCR 60 M) is the first 60 meter battleship built at PT. PAL Surabaya. According to calculations from the shipyard (PT PAL), the maximum speed of KCR 60 M at draft of 2.4 (half load, displacement 319 tons), engine power (PB) 5760 kW can reach 28 knots. However, based on the results of retesting the field speed with a draft condition of 2.4 m (half load), the maximum speed of KCR 60 M under these conditions was only 23.3 knots. The calculation of shaft power was obtained from calculations by software (TRIBON, DESPPC, PREFDF) and model test at Indonesian Hydrodynamics Laboratory (LHI-UPT BPPH). The result of MARIN DESPPC program calculation at loaded 2,4 m was at 28 knots, propeller B5-105 with diameter of 1,550 required power (PS) equal to 6777 kW. While the maximum speed of KCR 60 M ship with engine power (PB) of 5760 kW at 2.4 m draftwas 26.30 knots. The underlying factor of the maximum speedlack of achievement at KCR 60 with engine power (PB) of 5760 kW was due to the lack of propeller ability to absorb the power generated by the machine.

KEYWORDS : KCR, Powering, Propulsion.

1. INTRODUCTION.

60 Meter Fast Missile Boat (KCR 60 M) is the first 60 meter battleship built in Surabaya. The vessel has a total length (LOA) of 60 meters, with the width of 8.10 meters and displacement of 460 tons at 2.6 meters draft (full load) (Susanto.et.al. 2017). According to calculations from the shipyard using a shaft power (PS) of 5396 kW at laden 2.4 m maximum speed of 60 M KCR can reach 28 knots. However, based on the results of the field operation with a 2.4 m draft condition and the use of 100% MCR engine power (PB = 5760 kW, PS = 5702.4 kW), the ship was unable to reach a maximum speed of 28 knots. The maximum speed of KCR 60 under these conditions was only 23.3 knots.

This paper have some literature to support the research about it, for example paper with title Introduction to Naval Architecture (Tupper E. , 1975). Basic Ship Theory (Tupper K. R., 2001). Practical Ship Design (Watson, 1998). Practical Ship Hydrodynamics (Bertram V. , 2000). Ship Design and Contruction (D'arcalengelo, 1969). Resistance Propulsion and Steering of Ship (WPA Van Lamerren, 1984). Hydrodynamic of Ship Propellers (Andersen, 1994). Ship Design for Efficiency and Economy (Bertram H. S., 1998). Design of Propulsion Systems for High-Speed Craft (Bartee, 1975). Amethod of Calculation of Ship Resistance on Calm Water Useful at Preliminary Stages of Ship Design (Zelazny, 2014). An Inventigation Into The Resistance Components of Converting a Traditional Monohull Fishing Vessel Into Catamaran Form (Samuel, 2015). Empirical Prediction of Resistance of Fishing Vessels (Kleppesto, 2015). Designing Constraints in Evaluation of Ship Propulsion Power (Charchalis, 2013). Coefficients of Propeller-hull Interaction in Propulsion System of Inland Waterway Vessels with

Stern Tunnels (Tabaczek, 2014). Numerical Investigation of the Influence of Water Depth on Ship Resistance (Premchand, 2015). The Wageningen Propeller Series (Kuiper, 1992). Principles of Naval Architecture Second Revision (Lewis, 1988). Marine Propulsion (Sladky, 1976).

Failure to achieve a maximum speed in 60 M KCR might be caused by several things: the amount of installed engine power was not in accordance with the needs of propulsion (Adumene 2015), the installed propeller was not able to distribute the full power of the engine, errors in engine propeller matching and errors in designing hull ship which resulted in relatively larger ship resistance (Herdzik 2013).

This Paper is organized as follows. Section 2 is a review about the basic ship theory. Section 3 is result and discussion of the research. Finally, the conclusion this paper would be described in Section 4.

2. RESEARCH METHODOLOGY

2.1 Technical Concept

The ship propulsion analysis with KCR 60 M boat objects was focused on two main topics:

a. The vesselwas at 2.6 m draft (full load)

b. The vessel was at 2.4 m draft (half load). In this condition, the main problem was emerged, namely failure in achieving the desired speed of the vessel in accordance with the desired speed of 28 knots.

2.2 Vessel Main Size

2.2.1 Elongated Vessel Main Size.

AP = After Perpendicular

FP = Fore Perpendicular

Lpp = Length between perpendicular

Lwl = Length on the water line

Loa = Length Overall

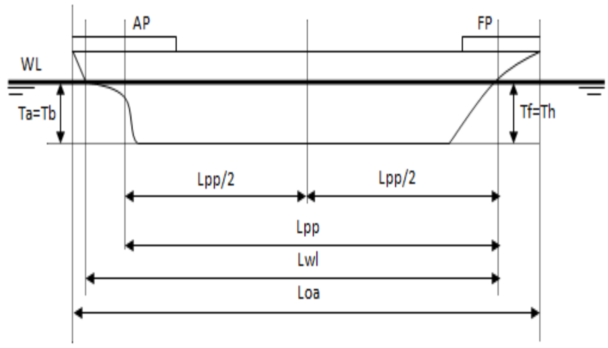

Fig. 1 Longitudinal Vessel Shape

2.2.2 Transversal Main Vessel Size

B/Bmld = *Breadth moulded*

T = draft/draught

H = depth

F = freeboard

CL =centre line

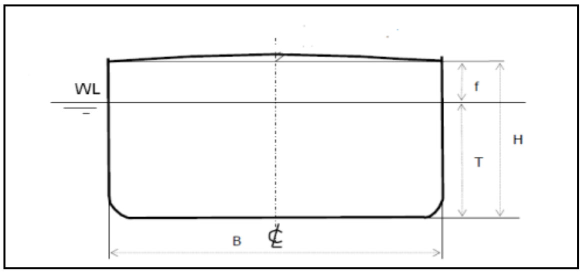

Fig. 2 Transversal Vessel Shape

2.3 Vessel Propulsion System Plan

The vessel must have the ability to maintain service speed (Vs) as planned (Barras 2004). This means that the vessel must have a propulsion system design that can overcome the overall resistance forces that occur in order to meet the standard of service speed. Errors in design, would bring enormous 'consequences' to the following conditions (Harvald 1992);

a. Failure to reach the desired ship service as planned.

b. Inefficient fuel consumption.

c. The decline in the economic value of the vessel.

d. Effect on the level of vibration that occurs on the body of the ship, and so on.

2.4 Vessel Propeller Motor Power

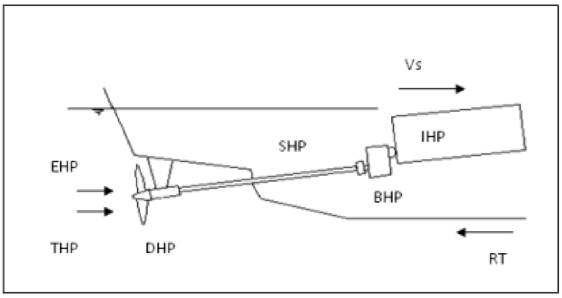

Fig. 3 Vessel Propulsion System

P_E = Effective Power (kW)

R_T = Total Resistance (kN)

V_S = Service Velocity of Vessel (knot,m/s)

P_T = Thrust Power (kW)

T = Thrust Force (kN)

V_a = Advanced Velocity of fluid flow in the stern of the vessel (m/s)

w = wake fraction

P_D = Distributed Power (kW)

Q_D = Propeller Torque in the stern of the vessel (kN)

n_P = Propeller rotation (rpm;rps)

P_D = Distributed Power (kW)

ηS = Axis Efficiency

ηG = Gear Reduction 0.98

$P_{B\text{-}MCR}$ = Machine power onmaximum continuous rating (kW/HP)

$P_{B\text{-}CSR}$ = Machine Power continuous service rating (kW/HP)

2.5 Engine Propeller Matching (EPM)

Engine propeller matching is a synchronization between ship hull, engine and propeller. There are 2 (two) basic terms in determining synchronization between the master machine with propeller (Anthony F. Molland 2011).

Propeller load factor/ PLF

$$PLF = \frac{Qxn^3}{\rho xVa^5} \quad (1)$$

$$ELF = \frac{P_D xn^2}{2x\pi \times Va^5} \quad (2)$$

$$PLF < ELF \quad (3)$$

$$\frac{Qxn^3}{\rho xVa^5} < \frac{P_D xn^2}{2x\pi \times Va^5} \quad (4)$$

2.6 MARIN DESPPC Program

Numerical calculations using the MARIN DESPPC program required some data, namely:

a. Main size data of KCR 60.

b. Hydrostatic data of KCR 60

c. Propeller and shaft data installed and its position

d. Data of the steering wheel blade along with the location of the installation

Fig. 4 MARIN DESPPC Program View

Fig. 5 MARIN DESPPC Program View

2.7 MARIN PREDFDS Program

The input data for the MARIN PREDFDS program are:

a. The main size data of KCR 60 M.

b. Hydrostatic data of KCR 60 M.

c. Propeller and shaft data installed along with its position

d. Data of steering wheel bladewith the location of installation

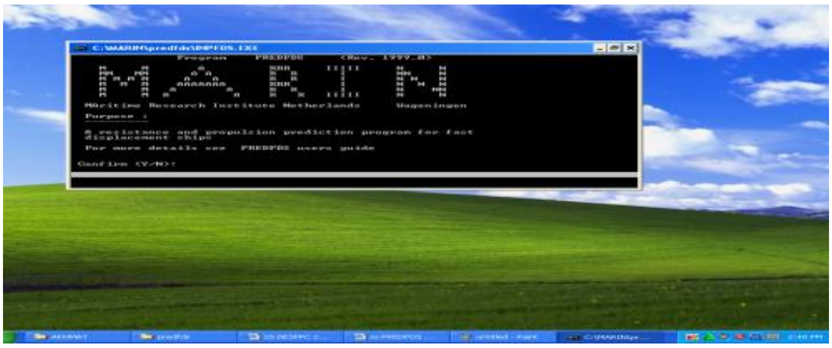

Fig. 6 MARIN PREDFDS Program Profile

Fig. 7 MARIN PREDFDS Program Profile

2.8 Method of Research.

The data analysis was conducted based on the results of ship speed retest and ship technical report of ship powering calculation by PT PAL (software TRIBON). Numerical methods were used for further analysis and the model was used for test results (UPT-BPPH).

The data analyzed were:

a. The result of shaft power (PS) calculation from numerical method (DESPPC

Program, PREDFDS, TRIBON) and ship model test method (UPT-BPPH) KCR 60 M at 2.4 m draft.

b. Existing Data on KCR 60 M which included re-test of speed, main engine and existing propeller.

c. The analysis of the achievement failure in vessel speed was performed based on the evaluation of all the data above.

3. RESULT AND DISCUSSION

3.1 The Propulsion Analysis of 60 Meters Fast Missile Boat (KCR 60 M)

The propulsion analysis on KCR 60 M was used to determine the value of the ship shaft power (PS) and the technical specifications of the propeller in order to meet the desired service speed (VS) (Gerr 2001). Powering calculations using numerical methods (MARIN DESPPC and PREDFDS programs) and model test results obtained from Indonesian Hydrodynamics Laboratory (LHI-UPT BPPH).

3.2 The Selection of KCR 60 M Propulsion Calculation Method.

To obtain an appropriate calculation method for performing a 60 M KR propulsion analysis, the authors compared the results of propulsion calculations at 2.4 m. The propulsion analysis was carried out at a load of 2.4 m due to:

a. The vessel speed test is carried out at a load of 2.4 m

b. Half load KCR at laden 2.4 m.

3.2.1 Vessel Propulsion Calculation at Draft 2,4 M Using Program Marin DESPPC, PREDFDS and LHI model test.

The calculation of total resistance and ship power resulting from TRIBON program wasperformed from the shipyard. While the results of model KCR 60 M test was taken from the test results in the Laboratory Hydrodynamics Indonesia (LHI)

Table. 1 Powering Calculation Results (*powering* KCR 60 M) using TRIBON program and LHI model test at draft 2,4 M

Vs (Knots)	TRIBON P_S (kW)	LHI MODEL TEST P_S (kW)
20	2083	
20,5	2281	
21	2486	
21,5	2697	
22	2914	
22,5	3137	
23	3365	
23,5	3599	
24	3838	
24,5	4083	
25	4332	4662
25,5	4529	4888
26	4715	5119
26,5	4893	5352
27	5063	5585
27,5	5226	5820
28	5396	6067
28,5	5605	6316
29	5815	6550
29,5	6027	6773
30	6243	6982

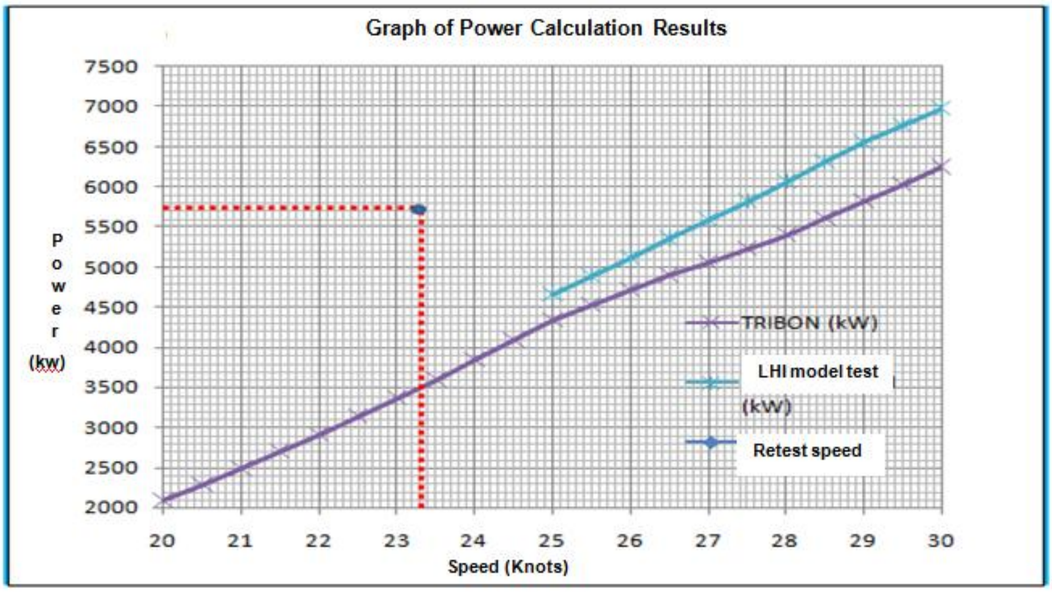

Fig. 8 Graph of Power Calculation Results (*powering* KCR 60 M) using TRIBON program and LHI model test

Table. 2 Power Calculation Results (*powering* KCR 60 M) using TRIBON, MARIN DESPPC , PREDFDS programs and LHI model test at Draft 2.4 M

Vs (Knots)	DESPPC (P_S)(kW)	PREDFDS (P_S)		TRIBON (P_S) (kW)	LHI MODEL TEST (P_S) (kW)
		BAILEY (kW)	HOLTROP (kW)		
20	2739	2443,07	2869,52	2083	
20,5	2979	2656,06	3329,66	2281	
21	3226	2877,57	3818,28	2486	
21,5	3481	3102,76	4334,53	2697	
22	3742	3300,65	4861,86	2914	
22,5	4010	3505,17	5402,26	3137	
23	4284	3716,47	5935,75	3365	
23,5	4565	3915,11	6451,67	3599	
24	4850	4115,2	6944,23	3838	
24,5	5142	4320,4	7409,37	4083	
25	5424	4522,58	7845,76	4332	4662
25,5	5678	4721,74	8253,18	4529	4888
26	5916	4924,73	8633,05	4715	5119
26,5	6145	5136,96	8994,37	4893	5352
27	6364	5343,11	9326,48	5063	5585
27,5	6572	5556,21	9665,72	5226	5820
28	6777	5772,25	10039,54	5396	6067
28,5	6978	5988,76	10399,46	5605	6316
29	7197	6207,65	10744,5	5815	6550
29,5	7460	6428,78	11080,57	6027	6773
30	7757	6650,43	11410,13	6243	6982

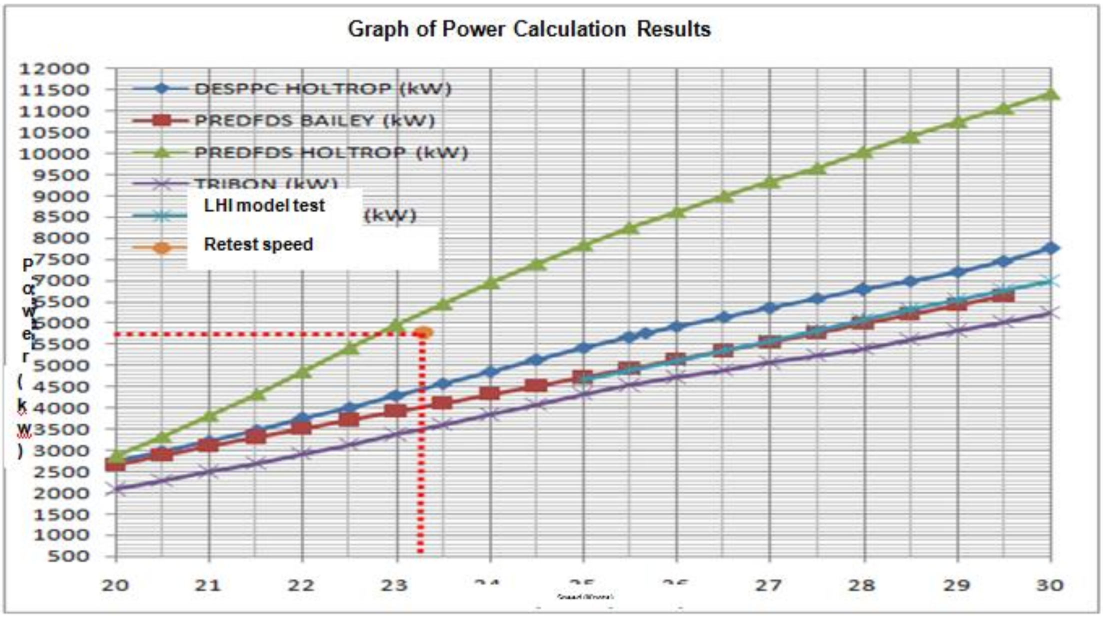

Fig. 9 Graph of Power Calculation Results (*powering* KCR 60 M)
using MARIN DESPPC, PREDFDS, TRIBON programs and LHI model test at draft 2.4 m.

3.3 Powering Calculation at Draft 2.6M (*Full Load*)

Based on the KCR 60 M data, it was known that the maximum draft was 2.6 m (full load). In addition to the main size of the ship, input data (input) that was needed in powering calculations using the MARIN DESPPC program were:

Table. 3 Power Calculation Results (*powering* KCR 60 M) using MARIN DESPPC program and at Draft 2.6 M (Full Load)

VS [knots]	THRUST [kN]	N [1/Min]	PS [kW]
15.00	91.8	261.9	1128
15.50	97.0	270.0	1230
16.00	102.6	278.3	1343
16.50	109.2	287.0	1473
17.00	117.0	296.4	1627
17.50	126.5	306.5	1814
18.00	137.1	317.1	2028
18.50	148.6	327.9	2266
19.00	160.6	338.7	2521
19.50	172.3	349.2	2782
20.00	184.0	359.4	3052
20.50	195.6	369.5	3331
21.00	207.3	379.5	3620
21.50	218.9	389.2	3918
22.00	230.4	398.8	4224
22.50	241.9	408.3	4538
23.00	253.4	417.6	4860
23.50	264.9	426.8	5191
24.00	276.2	435.9	5528
24.50	287.5	444.9	5874
25.00	298.0	453.5	6211
25.50	306.9	461.5	6517
26.00	314.8	469.2	6806
26.50	322.0	477.1	7083
27.00	328.5	484.8	7351
27.50	334.4	492.3	7613
28.00	339.7	499.6	7869
28.50	344.6	506.7	8118
29.00	349.1	513.7	8360
29.50	353.3	520.5	8598
30.00	357.1	527.2	8830

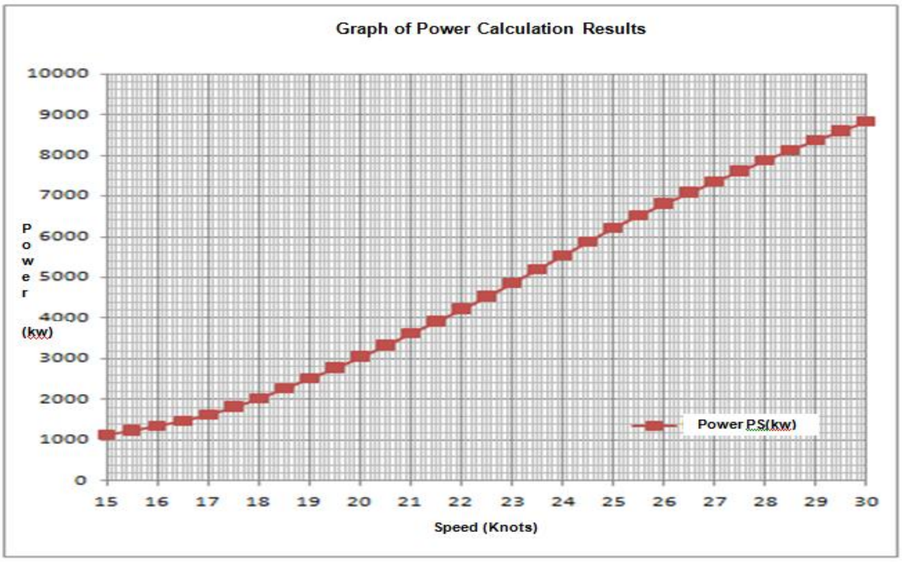

Fig. 10 Graph of Power Calculation Results (*powering* KCR 60 M) using MARIN DESPPC program at Draft 2.6 M (full load)

3.4 Powering Calculation at Draft 2.4 m (*half load*).

When the (KCR 60 M) re-test speed was performed at 2.4 m draft (half load) with 100% machine-powered MCR (PB = 5760 kW, PS = 5702.4 kW), the maximum speed achieved was 23.3 knots. This was not in accordance with the design of the shipyard that the calculation of TRIBON on 2.4 M draft can reach 28 knots speed. The calculation of the ship's power (PS) on a 2.4 m draft was performed using MARIN DESPPC program to analyze the problem.

Table. 4 Power Calculation Results (*powering* KCR 60 M) using MARIN DESPPC program and at Draft 2.4 M (Half Load)

VS [knots]	THRUST [kN]	N [1/Min]	PS [kW]
15.00	78.9	265.5	917
15.50	83.5	273.8	1002
16.00	88.7	282.4	1098
16.50	94.7	291.6	1210
17.00	101.8	301.2	1342
17.50	110.7	311.8	1505
18.00	120.4	322.6	1685
18.50	129.9	333.1	1871
19.00	139.4	343.5	2066
19.50	148.9	353.6	2268
20.00	158.4	363.6	2477
20.50	167.9	373.4	2693
21.00	177.3	383.1	2915
21.50	186.7	392.6	3144
22.00	196.0	402.1	3379
22.50	205.3	411.3	3621
23.00	214.6	420.5	3868
23.50	223.8	429.6	4122
24.00	232.9	438.5	4380
24.50	241.8	447.3	4642
25.00	250.0	455.8	4895
25.50	256.7	463.5	5120
26.00	262.4	470.9	5331
26.50	267.7	478.1	5535
27.00	272.4	485.1	5730
27.50	276.6	492.3	5917
28.00	280.5	499.5	6102
28.50	284.1	506.6	6285
29.00	288.3	514.0	6485
29.50	293.6	522.2	6725
30.00	299.9	530.9	6996

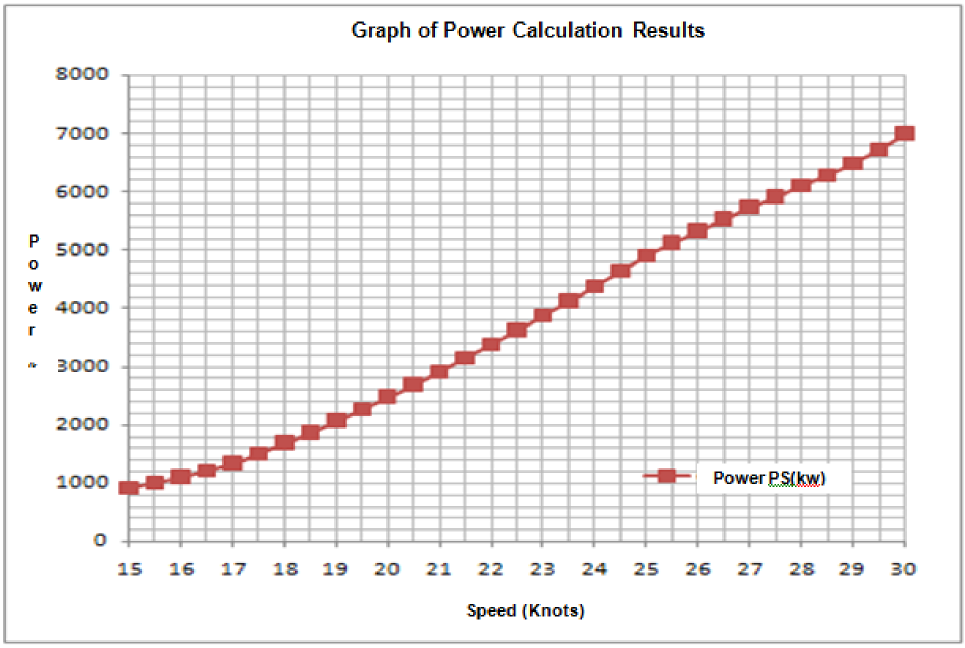

Fig. 11 Graph of Power Calculation Results (*powering* KCR 60 M) using MARIN DESPPC program andat Draft 2.4 M (*half load*).

3.5 Discussion

3.5.1 Propeller Performance Analysis (*Propeller Matching*) at Draft 2,4 M

Based on the results of the re-test of KCR 60 M velocity, on average draft condition of 2.4 m with 100% engine power (PB) MCR (PB = 5760 kW, PS = 5702.4 kW), the maximum speed was only 23.3 knots. Therefore, it was necessary to calculate the performance of propeller installed in KCR 60 M and compared it with propeller type B5-105.

Table. 5 Comparison of propeller performance installed in 60 M KCR with propeller B5-105

Propeller Installed in KCR 60 M		**Comparative Propeller (B5-105)**	
Propeller type	PL 506	Propeller type	B5-105
Number of blades	5	Number of blades	5
PDRA	1,460	PDRA	1,321
AEAO	1,06	AEAO	1,05
Diameter (D)	1,550	Diameter (D)	1,550
Propeller rotation (n)	693 rpm	Propeller rotation (n)	589,9
Tribon Program data (PT PAL):		Marin DESPPC program data:	
Wake friction (w)	0,046	Wake friction (w)	0,069
Vessel speed (Vs)	28 knots	Vessel speed (Vs)	28 knots
	(14,4032 /s)		(14,4032 m/s)
Propeller rotation	693 rpm	Propeller rotation	589,9 rpm
	11,550 rps		9,832 rps
Then the was of the advanced coefficients was: $J = \frac{Va}{nxD} = \frac{Vsx(1-w)}{nxD}$ $J = \frac{14{,}4032\ x\ (1-0{,}046)}{11{,}55\ x\ 1{,}550}$ J = 0,767 Based on the propeller maker performance		Then the was of the advanced coefficients was: $J = \frac{Va}{nxD} = \frac{Vsx(1-w)}{nxD}$ $J = \frac{14{,}4032x(1-0{,}069)}{9{,}832x\ 1{,}550}$ J= 0,879 Based on the B-series B5-105 propeller	

Propeller Installed in KCR 60 M	Comparative Propeller (B5-105)
diagram (annex K.1), the things bellow could be obtained: KT: 0,160 KQ: 0,028 η_0: 0,695 Thrust produced by Tribon's calculated propeller was described as follows: $T = K_T \ x\ \rho\ x\ n^2\ x\ D^4$ $T = 0{,}160\ x\ 1025\ x\ 11{,}55^2\ x\ 1{,}550^4$ $T = 126.280{,}0105\ N$ $T = 126{,}280\ kN$ The thrust value for 2 propellers was: 252,560 kN. While the torque value (Q) was described as follows: $Q = K_q\ x\ \rho\ x\ n^2\ x\ D^5$ $Q = 0{,}028\ x\ 1025\ x\ 11{,}55^2\ x\ 1{,}550^5$ $Q = 34.253{,}453\ N$ $Q = 34{,}253\ kN$ The torque value for 2 propellers was: 68,506 kN. So, the power distributed by propeller was described as follows: $P_{Dc} = 2\pi x Q x n$ $P_{Dc} = 2\ x\ 3{,}14\ x 34.253{,}453\ x\ 11{,}55$ $P_{Dc} = 2.484.539{,}96\ W$ $P_{Dc} = 2.484{,}539\ kW$ P_{Dc} (2 propeller)= 4.969,078 kW With the value of $\eta S . \eta B$ = 0,98 the value of axis power (Ps) was: $P_s = \frac{PDc}{\eta S . \eta B}$ $P_s = \frac{4.969{,}078}{0{,}98}$ $P_s = 5070{,}488\ kW$	performance diagram (annex L.1), the things bellow could be obtained: KT: 0,2626 KQ: 0,05775 η_0: 0,6437 Thrust produced by B5-105 propeller was described as follows: $T = K_T \ x\ \rho\ x\ n^2\ x\ D^4$ $T = 0{,}2626\ x\ 1025\ x\ 9{,}832^2\ x\ 1{,}550^4$ $T = 150.185{,}885\ N$ $T = 150{,}186\ kN$ The thrust value for 2 propellers was: 300,372 kN. While the torque value (Q) was described as follows: $Q = K_q\ x\ \rho\ x\ n^2\ x\ D^5$ $Q = 0{,}05775\ x\ 1025\ x\ 9{,}832^2\ x\ 1{,}550^5$ $Q = 51.193{,}885\ N$ $Q = 51{,}194\ kN$ The torque value for 2 propellers was: 102,388 kN. So, the power distributed by propeller was described as follows: $P_{Dc} = 2\pi x Q x n$ $P_{Dc} = 2\ x\ 3{,}14\ x 51.193{,}885 x\ 9{,}832$ $P_{Dc} = 3.160.964{,}382\ W$ $P_{Dc} = 3.160{,}964\ kW$ P_{Dc} (2 propeller) = 6.321,928 kW With the value of $\eta S . \eta B$ = 0,98 the value of axis power (Ps) was: $P_s = \frac{PDc}{\eta S . \eta B}$ $P_s = \frac{6.321{,}928}{0.98}$ $P_s = 6.451\ kW$

3.5.2 Engine propeller Matching at Draft 2.4 M

Engine propeller matching was necessary in optimization of the installed machine in KCR 60 M (MTU 4000M73L, PB = 2880 kW, PS = 2851.2 kW) in order to reach the maximum speed in draft 2.4 m (half load).

Table. 6 Comparison of Propeller Load Value (PLF) and Machine Load Value (ELF) at Draft 2.4 m

N (RPM)	V_S (knot)	T(kN)	Q(kN)	PLF	ELF	P_S(kW)
309	15	41,04118	137,7386	0,0042	0,0224	454,5655
318,6	15,5	42,7885	145,9113	0,0048	0,0238	496,4974
328,6	16	44,82462	154,7306	0,0056	0,0253	543,0327
339,3	16,5	48,28004	165,3132	0,0066	0,0270	599,0646
350,7	17	53,0282	177,5232	0,0079	0,0289	664,9257
363,3	17,5	56,92507	192,4391	0,0095	0,0310	746,6912
376,3	18	61,09313	208,7358	0,0115	0,0332	838,9063
388,9	18,5	65,27077	224,8645	0,0137	0,0355	933,9879
401,3	19	70,04167	241,1627	0,0161	0,0378	1033,622
413,4	19,5	74,65173	256,9542	0,0188	0,0401	1134,51

N (RPM)	V_S (knot)	T(kN)	Q(kN)	PLF	ELF	P_S(kW)
425,2	20	79,3365	272,9882	0,0217	0,0424	1239,708
436,8	20,5	84,02432	289,0434	0,0249	0,0448	1348,429
448,3	21	88,77495	305,3186	0,0284	0,0472	1461,855
459,5	21,5	93,43661	321,3088	0,0322	0,0496	1576,85
470,6	22	98,14257	337,4576	0,0364	0,0520	1696,108
481,5	22,5	102,8109	353,492	0,0408	0,0544	1817,851
492,2	23	107,431	369,3774	0,0456	0,0569	1941,754
502,7	23,5	111,8016	384,4695	0,0505	0,0593	2064,206
513,3	24	116,5316	400,744	0,0561	0,0619	2196,952
524,5	24,5	121,8595	419,0198	0,0626	0,0646	2347,266
535,6	25	127,2519	437,4191	0,0696	0,0674	2502,192
545,7	25,5	131,8296	453,3223	0,0763	0,0699	2642,064
546,7	25,55	132,3023	454,8993	0,0769	0,0702	2656,114
555,2	26	135,9905	467,7467	0,0829	0,0724	2773,592
564,4	26,5	139,9465	481,5002	0,0896	0,0748	2902,457
573,2	27	143,5947	494,2398	0,0964	0,0772	3025,702
581,6	27,5	146,9199	505,9147	0,1030	0,0795	3142,563
589,9	28	150,827	516,5548	0,1098	0,0817	3254,446
598	28,5	154,7281	527,5132	0,1168	0,0840	3369,122
606,5	29	158,2172	539,846	0,1247	0,0864	3496,898
616	29,5	163,3782	555,534	0,1345	0,0891	3654,884
626,3	30	168,7866	574,0641	0,1460	0,0921	3839,946

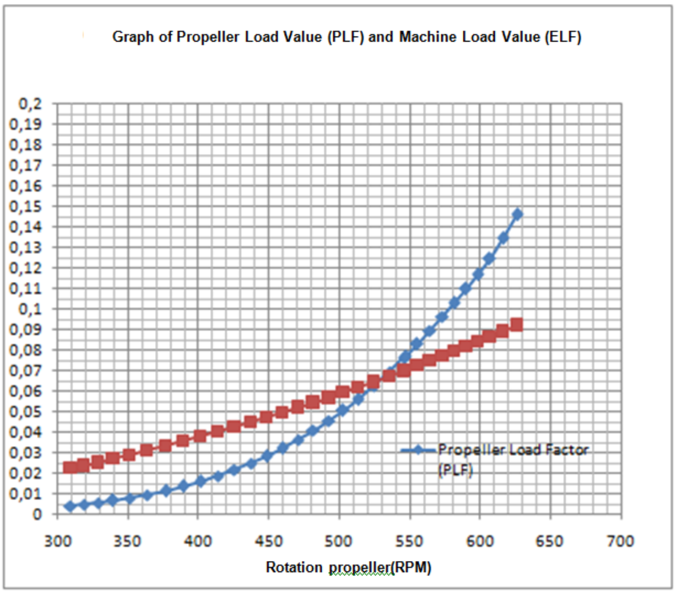

Fig. 12 Graph of Propeller Load Value (PLF)
and Machine Load Value (ELF) Comparison at Draft 2.4 m

3.5.3 Effect Analysis of Propeller Diameter on Ship Velocity

The size of the ship's propeller diameter should ideally be 0.6-0.7 of the maximum s. The data propeller diameter used was 1,550 m (the diameter size was same with diameter of propeller installed in KCR 60 M) and 1,800 m (result of data size input in program with minimum value of 1,500 m and maximum value of 1,800 m). Based on the calculation of MARIN DESPPC program in draft condition of 2.6 m and 2.4 m with diameter of 1.8 m and 1.550 m, it was presented in the table below.

Table. 7 Comparison of *propeller* B-series (B5-105) Use with propeller diameter of 1,8 m and 1,5 m towards velocity (V_S) and axis power (P_S)

V_S (KNOTS)	DRAFT 2,6 m	DRAFT 2,4 m	
	Ø 1,800 m	Ø 1,550 m	Ø 1,800 m
	POWER (P_S)	POWER (P_S)	POWER (P_S)
15	1128	1005	917
15,5	1230	1098	1002
16	1343	1203	1098
16,5	1473	1326	1210
17	1627	1472	1342
17,5	1814	1654	1505
18	2028	1855	1685
18,5	2266	2063	1871
19	2521	2281	2066
19,5	2782	2506	2268
20	3052	2739	2477
20,5	3331	2979	2693
21	3620	3226	2915
21,5	3918	3481	3144
22	4224	3742	3379
22,5	4538	4010	3621
23	4860	4284	3868
23,5	5191	4565	4122
24	5528	4850	4380
24,5	5874	5142	4642
25	6211	5424	4895
25,5	6517	5678	5120
26	6806	5916	5331
26,5	7083	6145	5535
27	7351	6364	5730
27,5	7613	6572	5917
28	7869	6777	6102
28,5	8118	6978	6285
29	8360	7197	6485
29,5	8598	7460	6725
30	8830	7757	6996

4. CONCLUSION

Based on the results of the powering calculation (axis power (PS)) of the numerical method (DESPPC, PREDPDS and TRIBON) and calculations through the model test, the appropriate calculations could be obtained to calculate the 60 KCR power requirement which was MARIN DESPPC program. The calculation was performed using the MARIN DESPPC program, and itshowed that the KCR 60 M at 2.6 m (full load) required a 7869kW axis power (PS) to reach a speed of 28 knots using a 1.8 m diameter propeller B5-105. Meanwhile, in a 2.4 m (half load)),it required a shaft power (PS) of 6777 kW to reach a speed of 28 knots using a 1.550 m diameter propeller B5-105.

The desired speed of KCR 60 M was in accordance with the MARIN DESPPC program calculation in the 2.4 m draft state with installed engine power (PB) of 5760 kW (PS = 5702.4 kW) and using a 1.550 m diameter propeller of 24, 5 knots with 82.325% Maximum continuous rating (MCR) and maximum speed of 26.30 knots with 100% MCR machine power usage.

5. Acknowledgement

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6. REFERENCE

Adumene, NSAS 2015, 'Predictive Analysis of Bare-Hull Resistance of a 25,000 Dwt Tanker Vessel', *International Journal of Engineering and Technology*, pp. 194-198.

Andersen, JP 1994, *Hydrodynamic of Ship Propeller*, Elsevier, Cambridge.

Anthony F. Molland, SR 2011, *Ship Resistance and Propulsion*, Practical Estimation of Ship Propulsive Power, United Stated of America.

Barras, C 2004, *Ship Design and Performance for Masters and mates*, Elsevier, Oxford.

Bartee, DL 1975, 'Design of Propulsion Systems for Hidh-Speed Craft', *The Society of Naval Architects and Marine Engineers*, pp. 1-17.

Bertram, HSAV 1998, *Ship Design for Efficiency and Economy*, Butterworth-Heinemann, Great Britain.

Bertram, V 2000, *Practical Ship Hydrodynamic*, Great Britain, Inggris.

Charchalis, A 2013, 'Designing Constraints in Evaluation of Ship Propulsion Power', *Journal of KONES Powertrain and transport*, pp. 1-6.

D'arcalengelo, AM 1969, *Ship Design and Contruction*, Professor of Naval Architecture and Marine Engineering University of Machigan, Michigan.

Gerr, D 2001, *Propeller Handbook*, International Marine, United Stated.

Harvald, SA 1992, *Resistance and Propulsion of Ships*, John Wiley and Sons, New York.

Herdzik, J 2013, 'Problems of propulsion systems and main engines choice for offshore support vessels', *Scientific Journals Zeszyty Naukowe*, vol 2, no. 1733-8670, pp. 45-50.

Kleppesto, K 2015, 'Empirical Prediction of Resistance of Fishing Vessels', *NTNU Trondheim Norwegion University of Science And Technology*, pp. 1-87.

Kuiper, G 1992, *The Wageningen Propeller Series*, MARIN, Netherland.

Lewis, EV 1988, *Principles of Naval Architecture Second Revision*, The Society of Naval Architecs and Marine Engineers, New Jersey.

Premchand, PK 2015, 'Numerical Investigation of the Influence of Water Depth on Ship Resistance ', *International Journal of Computer Applications* , pp. 1-8.

Samuel, MI 2015, 'An Inventigation Into The Resistance Components of Converting a Traditional Monohull Fishing Vessel Into Catamaran Form', *International Journal of Technology*, pp. 1-10.

Sladky, J 1976, *Marine Propulsion*, The Winter Annual Meeting of The American Society of Marine Engineers, New York.

Susanto.et.al., AD 2017, 'Analysis of The Propulsion System Towards The Speed Reduction of Vessels Type PC-43', *International Journal of Engineering Research and Application*, pp. 8-15.

Tabaczek, JK 2014, 'Coefficients of Propeller-hull Interaction in Propulsion System of Inland Waterway Vessels with Stern Tunnels', *International Journal on Marine Navigation and Safety of Sea Transportation*, pp. 1-8.

Tupper, E 1975, *Introduction to Naval Architecture*, Great Britain, Inggris.

Tupper, KR 2001, *Basic Ship Theory*, Great Britain, Inggris.

Watson, DGM 1998, *Practical Ship Design*, Elsevier Science Ltd, Netherlands.

WPA Van Lamerren, TL 1984, *Resistance Propulsion and Steering of Ship*, Harleem Holland, Holland.

Zelazny, K 2014, 'Amethod of Calculation of Ship Resistance on Calm Water Useful at Preliminary Stages of Ship Design', *Scientific Journal Maritime University of Szuczecin*, pp. 125-130.

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ALTERNATIVE MATERIALS IN PLACE OF TAIL SHAFT THAT WEAR AND TEAR ON SHIP

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ABSTRACT

The propeller shaft is a ship propulsion that must be repaired when undergoing a shape change, in which case the shaft is subjected to wear and tear, it must be replaced immediately if it can not find the same material to replace its axis then sought material that has a characteristic like the previous axis. To obtain the same propeller axle characteristic then the research will be carried out in the material used. The method used is by using tensile, bending, impact, hardness, microscopic, and chemical composition test using ASTM A370 and ASTM E23 standard which prior to heat treatment testing. The results of the test material research that can be done to replace the material that experienced the previous wear. Material 4340 has the highest ultimate tensile strength value 1097, 51 N/mm$^{2.}$ Material 4340 has the highest curvature value 308, 73 N/mm$^{2.}$ Material 4140 has the highest impact value 2,281J/mm^2. Material HQ 705 has the highest hardness value 350,3 N/mm$^{2..}$ In the third microscopic test the material contained perlite and ferrite where the ferrite contained is more dominant. Observation of ANOVA on tensile testing can't affect the material but in bending, impact, and hardness testing may effect but not significantly.

KEYWORDS : *Propeller, heat treatment, Anova.*

1. INTRODUCTION

On a ship propulsion system, the propeller shaft is one of the most important parts of ship. If there is damage to the form in this case experiencing wear, bent and broken so that the ship can still go steadly and in the future does not cause more harmful impact then the shaft must be carried out replacement and repair on the material. The shaft part consists of : thrust shaft, intermediate shaft and tail shaft.

If the propeller shaft is cracked or even broken, then the shaft must be replaced immediately, if not able to find the same material to replace the shaft it must be sought material that has characteristics such as the previous axle heat treatment.

In this research, takes the problem of a propeller shaft of a ship that has been used for more than 25 years and the propeller shaft has undergone a mechanical or welding process to repair the propeller shaft, because it has aged and experienced wear and often find alternatives that are suitable or even better.

And until now there has been no research on alternative material as a replacement for broken shafts on the ship. So, in this case it is necessary to test the material that can be used as an alternative material whose characteristic properties as the same or even better that the material used previously. By using the testing of some material and the sought the most approaching characteristic properties that we would recommend to replace the material weary tail shaft.

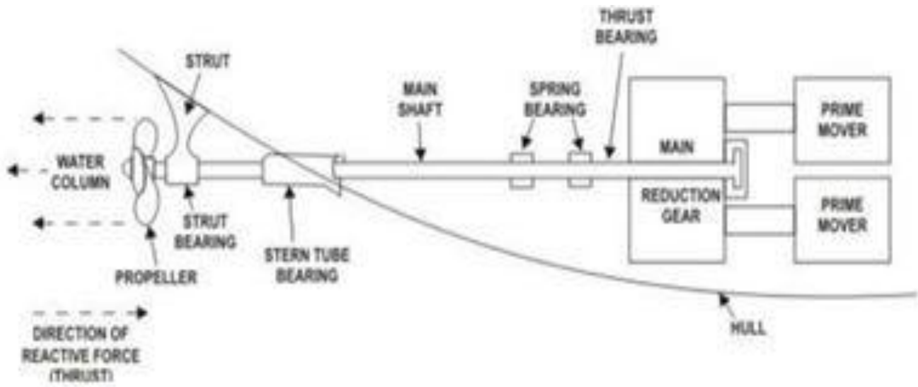

Fig. 1 General Principle Of Geared Ship Propulsion (Boddapati et al., 2015)

Method used for testing shaft propeller material is by using tensile, bending, impact, hardness, microscopic and chemical composition test using ASTM A370 and ASTM E23 standard prior to heat treatment testing. Some of the conventional heat treatments procedure chosen include: annealing, normalizing, quenching (in automobile engine oil and water) and tempering after water quenching. Two other sample were also set aside to serve as control for the assessment of the heat treated ones (Momoh et al., 2013)

In this research, there are some literature used among other journals with the title Design and Materials Selection for Environmentally Friendly Ship Propulsion System (Roldo et al., 2013). Shaft Line Alignment Analysis Taking Ship Construction Flexibility And Deformations Into Consideration (Murawski, 2005). Study on Performance of a Ship Propeller Using a Composite Material (Taketani et al., 2013). Propeller Excitation of Longitudinal Vibration Characteristics of Marine Propulsion Shafting System (GanboZhang et al., 2014). Propeller Induced Structural Vibration Through The Thrust Bearing (Pan et al., 2002). Reliability Improvement of Stern Tube Bearing Considering Propeller Shaft Forces during Ship Turning (Kuroiwa et al., 2007). Design and Development of Composite/ Hybrid Propeller Shaft (Khan et al., 2013). Vibration Analysis On A Propeller Shaft (Harish et al., 2015). Modeling and Analysis of a Shaft Blade for its Strength (Dinesh & Mani, 2016). Performance evaluation of composite marine propeller using L8 orthogonal array (Raj & Reddy, 2011). Model identification and dynamic analysis of ship propulsion shaft lines (Jalali & Ahmadian, 2015). Effect of heat treatment on mechanical properties of H11 tool steel (Qamar, 2009). Effect of tempering behavior on heat treated medium carbon (Murugan & Mathews, 2013).

This reseach sought and selected alternative materials instead of tail shafts that experienced wear on the ship. The purpose of this paper is to know the comparism of mechanical properties of the results of some suitable materials to replace tail shafts that wear and tear. The benefits of such writing as literature and reference standards for ship owners in the selection of materials on propeller shaft as suitable alternatives to replace wear-affected tail shafts.

In writing this scientific paper presented systematic as follows, part 1 introduction, part 2 on the material and methodology used, part 3 result and discussion of research, part 4 is the conclusion of research.

2. MATERIALS AND METHODOLOGY.

2.1. Shaft

The shaft line alignment consists of determining the location of the main engine driving axis, intermediate bearing axis. Propeller shaft has a function as the main mechanical power from the main engine to the propeller so that it can generate thrust on the ship. In general the propeller shaft is divided into 3 parts namely : thrust shaft, intermediate shaft and tail shaft. (Boddapati et al., 2015)

2.2. Heat Treatment

Heat treatments procedure chosen include: annealing, normalizing, quenching and tempering after water quenching. Annealing, normalizing and quenching are the most important heat treatments often used to modify the mechanical properties of engineering materials particularly steels (Tanwer, 2014).

2.3. Hardness Measurements

The hardness of the untreated and post-treated welded samples was evaluated using a Vickers Hardness (LECO AT700 Microhardness Tester). Brinnel hardness testing aims to determine the hardness of a material resistance to the indentor that is emphasized on the surface of the test material (Arasu et al., 2013). Brinell hardness testing using a steel ball with a diameter of 10.

2.4. Tensile Testing

Tensile testing conducted to determine the yield point force, yield point stress, max force, max stress (ultimate tensile strength), max strain (break elongation), break force, reduction of area, strain, and modulus young). (Momoh et al., 2013)

2.4.1. Reduction of Area

Reduction of area that is in the area broken will happen reduction of cross-sectional area (Ghazi & Mashloosh, 2015). Where the percentage of the reduction of cross-sectional area can be formulated as follows :

$$ROA = \frac{Ao - A1}{Ao}\ x\ 100\% \qquad (1)$$

Where :

A_0 = First cross-sectional area (mm^2)

A1 = Cross-sectional area after tensile test (mm^2)

2.4.2. Strain

Strain that is on the broken area will be an extension of material. Strain can be calculated by the following formula:

$$\varepsilon = \frac{L1 - Lo}{Lo}\ x\ 100\% \qquad (2)$$

Where :

ε = strain (%)

L_1 = the length of the end of the test rod (mm)

L_0 = the initial length of the test material (mm)

2.4.3. Modulus young

Elastic modulus is required for calculating the elasticity of the test material and its non-fixed properties. The magnitude of elastic modulus can be calculated by the following formula:

$$E = \frac{\delta\mu}{\varepsilon} \qquad (3)$$

Where :

σ = *ultimate tensile strength* (Kg/mm^2, psi, MPa)

E = Strain (%)

2.5. Bending Test

Figure obtained after implemented bending test, when the maximum load fiven can be seen visually is material test bent or broken when pressed by tool. To find the curve stress can be calculated by the following formula:

$$T = \frac{\frac{1}{2} P\ x\ \frac{1}{2} L}{\frac{\pi}{32} x\ d^3} \qquad (4)$$

Where :

P = Maximum load acceptable for test material

L = Length of material support

d = The diameter of the material test

2.6. Impact Test

To find the Impact value can be calculated by the following formula:

$$HI = \frac{w}{a} = \frac{m.g.R(\cos\beta - \cos\alpha)}{A} \qquad (5)$$

Where :

HI = Impact Value

m = mass pendulum

g = gravity

R = Length of pendulum arm

A = Cross-sectional area material under the impact

2.7. Micro Test

The microstructures were then examined using metallurgical microscope Model- Axio at magnification of 100xx. (Seidu & Kutelu, 2013). Micro testing is the examination of the material by looking at the surface structure of the etching section which has been etched with 400 time magnification (Sharma et al., 2013). In this test will be known the existence of material crack.

2.8. Testing the chemical composition

Testing the chemical composition conducted to determine the content of any existing in each material and to be used as a comparism one of the material. And if these materials given the heat treatment is the chemical composition of the material will be changed or remain.

2.9. Research Methods

This research display data from secondary data of the material wear out. As well as the primary data the research is the material in doing test The next two data will be compared so it can be found the results. The first step is the identification of a problem, book study, data validation, data analysis, and withdrawal conclusion.

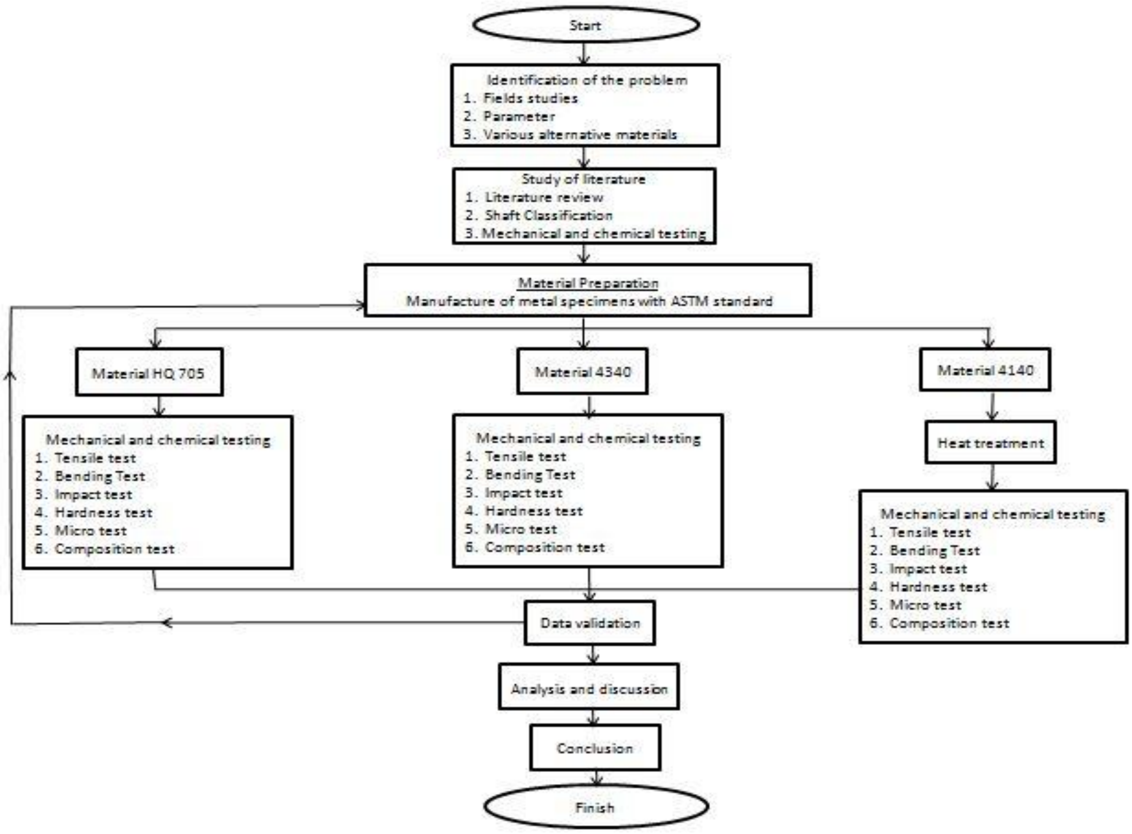

Fig. 2 Flowchart diagram of research

2.10. Analysis of Variance (ANOVA)

In this research, the data processing is done by comparing the data of tensile test and then compare the value of ultimate tensile strength (UTS), curve stress, impact, and hardness.

Data analyzing using ANOVA, is needed as a first steep to be able to see the difference value of each material variation test the following is an observation table with a single factor data analysis process (one way anova) *software* IBM SPSS *Statistics v16*.

With assumption:

a. If $F_{count} < F_{table}$, then H_o accepted and H_1 rejected, which means the variation of the test material after material preparation process can not affect the mechanical properties of the material.

b. If $F_{count} > F_{table}$, then H_o rejected dan H_1 accepted, which means the variation of the test material after the material preparation process can affect the mechanical properties of the material.

2.11. Experimental calculation of test specimens

a. Data collection.

The data supporting both primary and secondary data, used to compile this research are as follows:

Primary data

Data research conducted by doing procedure, varying the material aalternative and the test one of the material is given heat treatment on material 4140.

Secondary data

Data test result material wear out used as a reference and comparism in the selection of material to be tested, Reference and theory Associated with this research can be obtained through journals, books, and others.

b. Data specimens

Specimens used in this research the material based on the type of material, composition of the material and tensile strength of these materials. As for the material obtained: the HQ 705 from PT. Tira Austenit Surabaya while the other material that is: 4340 dan 4140 from PT. Assab Surabaya.

c. Equipment used.

Equipment used to research, among others testing machine tensile, teting machine bend, test equipment impact, test equipment hardness, test equipment micro, testing machine composition, testing machine metallography, lathe, grinding, miserly, calipers, glasses and gloves.

d. Planning.

e. Testing Phase.

3. RESULT.

In this section the results show from this chapter discusses the results of research and perform the processing of data obtained from the results of testing the material alternative as a replacement tail shaft that experienced wear on the ship. So get the results from data processing which include:

Primary data:

3.1. Tensile Test

Table. 1 Material prior to tensile test

No.	Variation	Material	D (mm)	Ao (mm^2)	Lo (mm)
1	Material HQ 705	A1	12,6	124,62	50
		A2	12,7	126,61	50
		A3	12,8	128,61	50
		Total	**38,1**	**379,84**	**150**
		Average	**12,7**	**126,61**	**50**
2	Material 4340	B1	12,5	122,65	50
		B2	12,6	124,62	50
		B3	12,6	124,62	50
		Total	**37,7**	**371,89**	**150**
		Average	**12,56**	**123,96**	**50**
3	Material 4140	C1	12,5	122,65	50
		C2	12,5	122,65	50
		C3	12,5	122,65	50
		Total	**37,5**	**367,95**	**150**
		Average	**12,5**	**122,65**	**50**

D = diameter, Lo = *Gauge Length*

In table 1 is the dimensions of the material test before tensile testing which will be conducted in Labinkimat using tensile testing machine automatically. After obtained the size of the of the ddimensions of the beginning of the material before testing of each material, testing will be made as much as 9 times consisting of 3 material HQ 705, material 4340 and 3 material 4140. From the tensile test obtained data used to compare each material test with material tail shafts who wear out on the ship or compare between material HQ 705, 4340 and 4140. So later terms of tensile test it can be concluded material closest of data ship wear out even material test has the results tensile better.

3.2. Bending Test

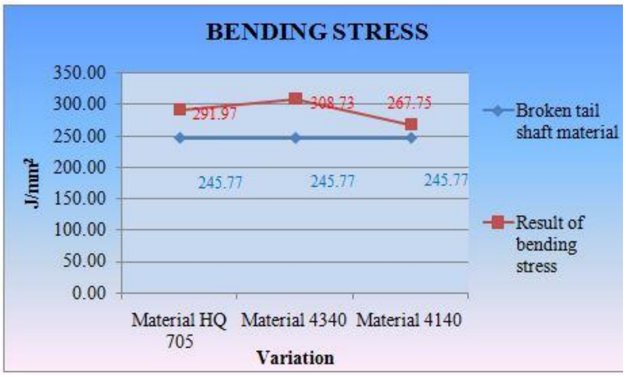

Fig 3. Graph of the bending stress

In Figure 3 can be seen various results of the curvature of each material, where the HQ 705 material produces a curved stress of 291.97, 4340 material produces a curved value of 308.73, 4140 material produces a curved value of 267.75 and the largest curvature value contained on 4340 material of 308.73.

3.3. Impact Test

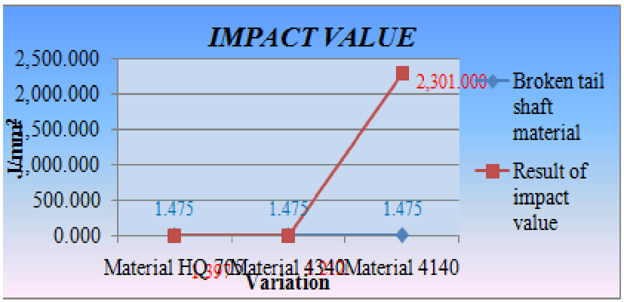

Fig. 4 Impact value graph

In Figure 4 can be seen the various results of the impact value of each material, where the material HQ 705 produce impact value of 1.397 J / mm2, 4340 material results in an impact value of 1,212 J / mm2, 4140 material produces an impact value of 2.301 J / mm2 and value the biggest impact value is found on 4140 material of 2,301 J / mm2. From the results of the test, the impact value of each material varies, the HQ material 705 and 4340 are below the value of the tail shaft material under the wear and tear. While the material 4140 is above the value of tail shaft material that experienced wear on the ship.

3.4. Hardness Test

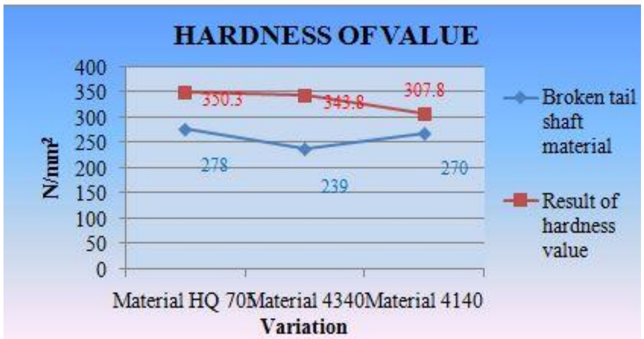

Fig 5. Hardness of value graph

In Figure 5 we can see the hardness values of each material, where the HQ 705 material yields a hardness value of 350.3 N / mm2, the 4340 material yields a hardness value of 343.8 N / mm2, 4140 material yields a hardness value of 307.8 N / mm2 and the largest hardness value is found in 4140 material of 350.3 N / mm2. From the test results obtained, the hardness value of each material is above the hardness value of tail shaft material that experienced wear on the ship.

3.5. Micro Test

Fig. 6 Results of microstructure test

In Figure 6 is a test result of HQ 705 material, 4340 material and 4140 material with 400 times magnification. On the surface of the material there is a content of pearlite or ferrite where the content of ferrite more than the pearlite content indicates when the material is soft.

3.6. Chemical Composition Test

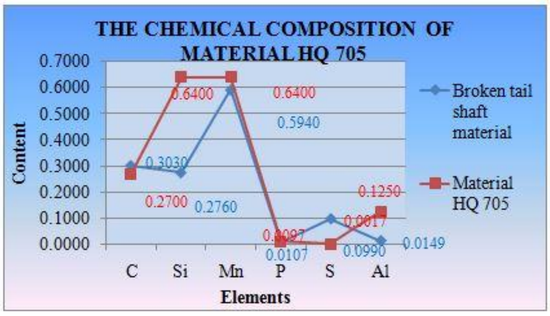

Fig. 7 Graph of chemical composition of HQ 705 material

In Figure 7 can be the result of testing of chemical composition and some of the main elements used the basic reference for material selection. In the carbon element, the phosphorus and sulfur materials of HQ 705 are under the chemical composition of wear-worn tail shaft material. But other elements such as silicon, manganese and aluminum are above the composition of the comparative material.

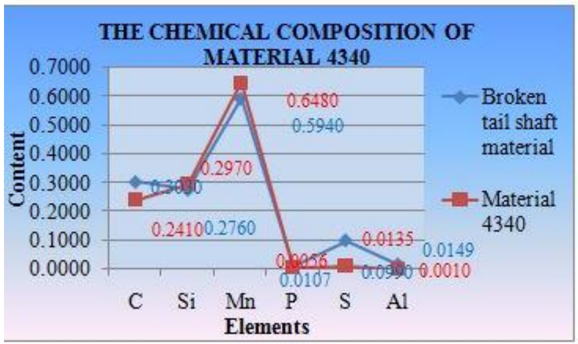

Fig. 8 Graph of chemical composition of material 4340

In Figure 8 can be the result of testing of chemical composition and some of the main elements used the basic reference for material selection. In the element carbon, phosphorus and sulfur 4340 materials are under the chemical composition of wear-resistant tail shaft material. But other elements such as silicon, manganese and aluminum are above the composition of the comparative material.

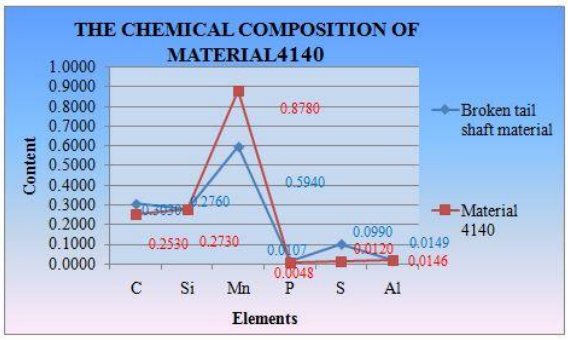

Fig. 9 Graph of chemical composition of material 4140

In Figure 9 can be the result of testing of chemical composition and some of the main elements used the basic reference for material selection. Judging from the above graphic image on the 4140 material only the manganese elements are on top of the tail shaft material that is wearing, the rest is underneath. This may happen because previously the material is given heat treatment.

3.7. Results of Data Engineering Analysis of Variance (ANOVA)

3.7.1. The result of tensile test variant analysis *(tensile test)*

At this stage is the stage of data processing taken from data analysis for Ultimate Tensile Strength (UTS).

Table. 2 Anova data one-way ultimate tensile strength

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	8733,318	2	4366,659	4,991	0,053
Within Groups	5249,110	6	874,852		
Total	13982,428	8			

From Table 2 it can be known that the F_{count} each calculation result gets the value of 4.991, known F_{Table} = 5.14 with the df of the numerator 2 and the df denominator 6 of the odds of 0.95 (1-α) where α = 0.05. It turns $F_{count} < F_{Table}$ then Ho is accepted and H1 is rejected which means variation of test material after material preparation process can not affect material mechanical properties due to significant probality (0.0053)> 0.005.

3.7.2. The result of bending test variant analysis (bending test)

At this stage is the stage of data processing taken from data analysis for curved stress

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Table 3. Anova data one-way curve stress

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2547,686	2	1273,843	1473,578	0,000
Within Groups	5,187	6	,864		
Total	2552,873	8			

From Table 3 it can be known that the F_{count} on each calculation result gets the value of 1473,578, known F_{Table} = 5.14 with the df of the numerator 2 and the df denominator 6 of the odds of 0.95 (1-α) where α = 0.05. It turns $F_{count} > F_{Table}$ then Ho is rejected and H1 is accepted which means the variation of test material after material preparation process can affect material mechanical properties but not significant because probality (0,000) <0.005.

3.7.3. The results of the test variant of the impact test

At this stage is the stage of data processing taken from data analysis for Impact Value.

Table. 4 Anova one-way Impact value data

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2,000	2	1,000	444,366	0,000
Within Groups	,014	6	,002		
Total	2,014	8			

From Table 4 it can be known that F_{count} on each calculation result get value equal to 44,366, known F_{Table} = 5,14 with df of numerator 2 and df denominator 6 from probability 0,95 (1-α) where α = 0,05. It turns out that $F_{count} > F_{Table}$ then Ho is rejected and H1 accepted which means variation of test material after material preparation process can affect material mechanical properties but not significant because probality (0,000) <0,005.

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Table. 5 Anova data one-way hardness

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3141,236	2	1570,618	258,656	0,000
Within Groups	36,433	6	6,072		
Total	3177,669	8			

3.7.4. Result of analysis of hardness test variant (hardness test).

At this stage is the stage of data processing taken from data analysis for the value of hardness From Table 5 it can be known that the F_{count} on each calculation result gets a value of 258,656, known F_{Table} = 5.14 with the df of numerator 2 and df denominator 6 of the odds of 0.95 (1-α) where α = 0.05. It turns $F_{count} > F_{Table}$ then Ho is rejected and H1 is accepted which means variation of test material after material preparation process can affect material mechanical properties but not significant because probality (0,000) <0,005.

3.8. The data of the tail shaft test material which become the reference as the comparative data of the wearing material is as follows:

3.8.1. Tensile test results (*tensile test*), UTM Shimadzu, Cap. 1000 kNi

Table. 6 Result of tensile test material wearing wear

No.	Test parameters	I	II	III	Test results average
1.	*Yield point force* (kN)	100,594	103,500	101,137	101,744
2.	*Yield point stress* (MPa)	819,712	843,394	824,143	829,08
3.	*Max force* (kN)	116,813	117,281	116,838	116,977
4.	*Max Stress*/UTS (MPa)	951,874	955,694	952,078	953,215
5.	*Max strain/elongation* (%)	19,925	17,187	24,119	20,410
6.	*Breaking force* (kN)	71,594	49,844	74,000	65,146

In Table 6 is the result of tensile test (tensile test) material of propeller shaft which is wear and used for basic comparator. The tests were conducted at the Chemical and Materials Master Laboratory (LABINKIMAT) under the auspices of the Navy that has been accredited by KAN.

3.8.2. Result of bending test, UTM Tokyokoki Seizosho, Cap. 30 kNi

Table. 7 Result of bending test material

No.	Test parameters	I	II	III	Test results average
1.	Max force, P_{max} (kg)	3625	3650	3600	3625
2.	Curved stress, τ (kg/mm^2)	245,77	247,77	244,08	245,77

In Table 7 is the result of bending test propeller shaft material that experienced wear and used for basic comparators. The tests were conducted at the Chemical and Materials Master Laboratory (LABINKIMAT) under the auspices of the Navy that has been accredited by KAN.

3.8.3. Result of impact test, Tokyokoki Seizosho, Cap. 30 kgm

Table. 8 Result of impact test material

No.	Impact Value, HI	I	II	III	Test results average
1.	*Specimen tail shaft*	0,789	1,805	1,831	1,475

In Table 8 is the result of an impact test propeller shaft material that experienced wear and used for basic comparators. The tests were conducted at the Chemical and Materials Master Laboratory (LABINKIMAT) under the auspices of the Navy that has been accredited by KAN.

3.8.3. Result of impact test, Tokyokoki Seizosho, Cap. 30 kgm

Table. 8 Result of impact test material

No.	Impact Value, HI	I	II	III	Test results average
1.	*Specimen tail shaft*	0,789	1,805	1,831	1,475

In Table 8 is the result of an impact test propeller shaft material that experienced wear and used for basic comparators. The tests were conducted at the Chemical and Materials Master Laboratory (LABINKIMAT) under the auspices of the Navy that has been accredited by KAN.

3.8.4. Result of hardness test, Brinell Hardness (HB)

Table. 9 Result of hardness test material

No.	Specimen test point	I	II	III	Test results average
1.	A	277	273	283	278
2.	B	236	237	245	239
3.	C	262	274	273	270

In Table 9 is the result of hardness test (hardness test) material propeller shaft that experienced wear and used for basic comparators. The tests were conducted at the Chemical and Materials Master Laboratory (LABINKIMAT) under the auspices of the Navy that have been accredited by KAN

3.8.9. Result of chemical test, Foundry-master Pro

Table. 10 Result of chemical test material

Testing	Fe	C	Si	Mn	P	S	Cr	Mo
1	95,2	0,309	0,278	0,595	0,0111	0,0120	0,900	0,441
2	95,2	0,303	0,274	0,594	0,0106	0,0092	0,907	0,430
3	95,2	0,297	0,276	0,592	0,0105	0,0084	0,0891	0,428
Average	**95,2**	**0,303**	**0,276**	**0,594**	**0,0107**	**0,099**	**0,900**	**0,433**
Testing	**Ni**	**Al**	**Co**	**Cu**	**Nb**	**Ti**	**V**	**W**
1	1,92	0,0156	0,0339	0,132	0,0015	0,0018	0,104	<0,0050
2	1,96	0,0150	0,0333	0,133	<0,0010	0,0015	0,102	<0,0050
3	1,97	0,0143	0,0334	0,133	0,0012	0,0017	0,101	<0,0050
Average	**1,95**	**0,0149**	**0,0335**	**0,133**	**0,0012**	**0,0017**	**0,102**	**<0,0050**
Testing	**Pb**	**Sn**	**B**	**Ca**	**Zr**	**Zn**	**Bi**	**As**
1	0,0050	0,0083	0,0007	0,0008	<0,0010	0,0035	<0,0010	0,0097
2	0,0050	0,0081	0,0006	0,0007	<0,0010	0,0031	<0,0010	0,0097
3	0,0050	0,0077	0,0006	0,0006	<0,0010	0,0033	<0,0010	0,0094
Average	**0,0050**	**0,0080**	**0,0006**	**0,0007**	**<0,0010**	**0,0033**	**<0,0010**	**0,0096**
Testing	**N**	**Se**	**Sb**	**Ta**				
1	0,0109	0,0063	0,0022	0,0245				
2	0,0082	0,0057	0,0032	0,0270				
3	0,0090	0,0062	0,0012	0,0258				
Average	**0,0094**	**0,0061**	**0,0022**	**0,0258**				

Table 10 is the result of chemical test material propeller shaft that experienced wear and used for basic comparators. The tests were conducted at the Chemical and Materials Master Laboratory (LABINKIMAT) under the auspices of the Navy that has been accredited by KAN.

4. CONCLUSION.

a. From the results of testing data and data analysis that has been done, the results of suitable alternative material as replacement of worn-out tail shaft is HQ 705 material with physical properties of microstructure of surface structure dominated by ferrite phase indicating the material is soft and mechanical properties of tensile testing, bending testing, hardness testing, and chemical testing of HQ 705 material has a high value.

b. All three alternative materials are suitable and can be used instead of tail shafts that wear and tear. However it is more advisable to choose the HQ 705 material as the main choice.

c. The observation of ANOVA on tensile testing can not affect the material but on bending test, impact and hardness may effect but not significantly.

5. Reference.

Arasu, P.T., Dhanasekaran, R., Kumar, P.S. & Srinivasan, N., 2013. Effect of Hardness and Microstructure on En 353 Steel by Heat Treatment. *International Journal Of Engineering And Science* , 2(11), pp.1-5.

Boddapati, V., Rao, S.S., Sumanth, K. & Manideep, J., 2015. Design Of Marine Propulsion Shafting System For 53000 DWT Bulk Carrier. *International Journal of Mechanical Engineering and Robotic Research*, 4, pp.171-80.

Dinesh, A.S. & Mani, G.V.N., 2016. Modeling and Analysis of a Shaft Blade for its Strength. *International Journal of Science and Research (IJSR)* , 5(2), pp.1412-15.

GanboZhang, YaoZhao, TianyunLi & XiangZhu, 2014. Propeller Excitation of Longitudinal Vibration Characteristics of Marine Propulsion Shafting System. *Hindawi Publishing Corporation*, 2014, pp.1-19.

Ghazi, S.S. & Mashloosh, D.K.M., 2015. Influence of Heat Treatment on Resistance of Wear and Mechanical Properties of Die Steel Kind D3. *American Journal of Scientific And Industrial Research*, pp.33-40.

Harish, M., J.V.Gugan & P.Periysamy, 2015. Vibration Analysis On A Propeller Shaft. *National Journal on Advances in Building Sciences & Mechanics*, 6, pp.13-16.

Jalali, H. & Ahmadian, H., 2015. Model identification and dynamic analysis of ship propulsion shaft lines. *Journal of Theoretical and Applied Vibration and Acoustics* , pp.85-95.

Khan, M., Mateen, M.A. & Shankar, D.V.R., 2013. Design and Development of Composite/ Hybrid Propeller Shaft. *International Journal of Science and Research (IJSR)* , 2(11), pp.385-90.

Kuroiwa, R. et al., 2007. Reliability Improvement of Stern Tube Bearing Considering Propeller Shaft Forces during Ship Turning. *Mitsubishi Heavy Industries, Ltd.*, 44, pp.1-5.

Momoh, I.M. et al., 2013. Investigating the Mechanical Properties of Post Weld Heat Treated 0.33%C Low Alloy Steel. *International Journal of Science and Technology*, 2, pp.433-37.

Murawski, L., 2005. shaft line alignment analysis taking ship construction flexibility and deformations into consideration. *elsevier*, pp.62-84.

Murugan, V.K. & Mathews, D.P.K., 2013. Effect of tempering behavior on heat treated medium carbon. *International Journal of Innovative Research in Science, Engineering and Technology* , 2(4), pp.945-50.

Pan, J., Farag, N., Lin, T. & Juniper, R., 2002. Propeller Induced Structural Vibration Through The Thrust Bearing. In *Anual conference of the Australian Acoustical Society*. adelaide, 2002.

Qamar, S.Z., 2009. Effect Of Heat Treatment On Mechanical Properties Of H11 Tool Steel. *Journal Of Achievement In Materials And Manufacturing Engineering*, 35(2), pp.115-20.

Raj, S.S. & Reddy, D.P.R., 2011. Performance evaluation of composite marine propeller using L8 orthogonal array. *International Journal of Engineering Science and Technology (IJEST)*, 3, pp.7998- 8003.

Roldo, L., Komar, I. & Vulić, N., 2013. Design and Materials Selection for Environmentally Friendly Ship Propulsion System. *Journal of Mechanical Engineering*, pp.25-31.

Seidu, S.O. & Kutelu, B.J., 2013. Influence of Heat Treatment on the Microstructure and Hardness Property of Inoculated Grey Cast Iron. *International Journal of Engineering and Technology*, 3, pp.888-92.

Sharma, S.S. et al., 2013. Effect of Heat Treatment on Mechanical Properties of AISI

4147 Spring Steel. In *International Conference on Mechanical, Automotive and Materials Engineering*. Singapore, 2013.

Taketani, T., Kimura, K., Ando, S. & Yamamoto, K., 2013. Study on Performance of a Ship Propeller Using a Composite Material. In *Third International Symposium on Marine Propulsors*. Launceston, 2013.

Tanwer, A.K., 2014. Effect of Various Heat Treatment Processes on Mechanical Properties of Mild Steel and Stainless Steel. *American International Journal of Research in Science, Technology, Engineering & Mathematics* , pp.57-61.

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STUDY OF WATER JET PROPULSION SYSTEM DESIGN FOR FAST PATROL BOAT (FPB-60)

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ABSTRACT

(FPB-60) is a type of patrol boat built by shipyard in Indonesia to strengthen the needs ofwater territorial.However, the 20 years age caused a decrease in performance of the vessel. The method used was the harvard guldammer method to calculate water jet system parameters at a maximum velocity of 35 knots such as inlet diameter and nossel diameter, pump power, pump type used and other parameters to obtain Overall Propulsive Coefficient at that speed. In the calculation of water jet propulsion system design, the amount of capacity generated water jet pump system obtained was 4.15 m^3 / s with flow velocity on the nozzle/jet of 28.8 m/s. Based on the value of specific swabs of suction (Nss) of 6205.49, the pump for the water jet propulsion system had considered fulfilled the cavitation limit requirement so that it could be used for (FPB-60).

KEYWORDS : Vessel Resistance, Water Jet, Power, FPB.

1. INTRODUCTION.

(FPB-60) is a type of patrol boat built by a shipyard in Indonesia to strengthen the needs of water territorial. However, the 20 years age cause a decrease in performance of the vessel. Based on these demands, it is necessary to have a ship that has good, safe acceleration and maneuverability, and has a low boat loadso that it can be operated in deep or shallow waters (Susanto.et.al. 2017).

With the use of a water jet propulsion system, the vessel can be cultivated to have a smaller load compared to ships that use propellers so that with an increase in thrust generated by the engine it will be able to produce higher vessel speed (Herdzik 2013).

This paper have many supporting its research, for example paper with title An Approximate Method For Calculation of Mean Statistical Value of Ship Service Speed on a Given Shipping Line, Useful in Preliminary Design Stage (Żelazny 2015).Experimental Investigation on Stern-Boat Deployment System and Operability For Korean Coast Guard Ship (Chun.et.al. 2013). Performance of VLCC Ship with Podded Propulsion System and Rudder (Amin 2014). Introduction to Naval Architecture (Tupper 1975). Basic Ship Theory (Tupper 2001). Practical Ship Design (Watson 1998). Ship Resistance and Propulsion : Practical Estimation of Ship Propulsive Power (Anthony F. Molland 2011). Practical Ship Hydrodynamics (Bertram 2000). Effect of Fluid Density on Ship Hull Resistance and Powering (Samson 2015). Ship Design and Contruction (D'arcalengelo 1969). Resistance Propulsion and Steering of Ship (WPA Van Lamerren 1984). Predictive Analysis of Bare-Hull Resistance of a 25,000 Dwt Tanker Vessel (Adumene 2015). Resistance and Propulsion of Ships (Harvald 1992). Hydrodynamic of Ship Propellers (Andersen 1994). Ship Design for Efficiency and Economy (Bertram 1998). Design of Propulsion Systems for High-Speed Craft (Bartee 1975). Amethod of Calculation of Ship Resistance on Calm Water Useful at Preliminary Stages of Ship Design (Zelazny 2014). Increase of Ship Fuel Consumption Due to the Added Resistance in Waves (Degiuli.et.al. 2017).

An Inventigation Into The Resistance Components of Converting a Traditional Monohull Fishing Vessel Into Catamaran Form (Samuel 2015). Simulation of a Free Surface Flow over a Container Vessel Using CFD (Atreyapurapu.et.al 2014). Empirical Prediction of Resistance of Fishing Vessels (Kleppesto 2015). Designing Constraints in Evaluation of Ship Propulsion Power (Charchalis 2013). Coefficients of Propeller-hull Interaction in Propulsion System of Inland Waterway Vessels with Stern Tunnels (Tabaczek 2014). Cost optimization of marine fuels consumption as important factor of control ship's sulfur and nitrogen oxides emissions (Kowalski 2013). Numerical Investigation of the Influence of Water Depth on Ship Resistance (Premchand 2015). The Wageningen Propeller Series (Kuiper 1992). Principles of Naval Architecture Second Revision (Lewis 1988). Marine Propulsion (Sladky 1976).

In this paper, we used harvard guldammer method to calculate water jet system parameters at maximum velocity of 35 knots such as inlet diameter and nossel diameter, pump power, pump type used and other parameters to obtain the Overall Propulsive Coefficient at that speed (Kim 1966). With this paper, it was expected that the water jet propulsion system could be used as an alternative for patrol boats to be built and operated in accordance with their duties.

This Paper is organized as follows. Section 2 is the review about basic ship theory. Section 3 were description of result and research discussion. Finally, the conclusion of this paper is presented in section 4.

2. RESEARCH METHODOLOGY.

2.1. Propulsion System of The Ship

The ship propulsion system, which is the exact matching between prime mover (diesel engine, gas turbine, steam turbine) and propeller from ship. Matching completion is not only seen from the engine or propeller point of view, but both are an integrated problem (Etter 1975).

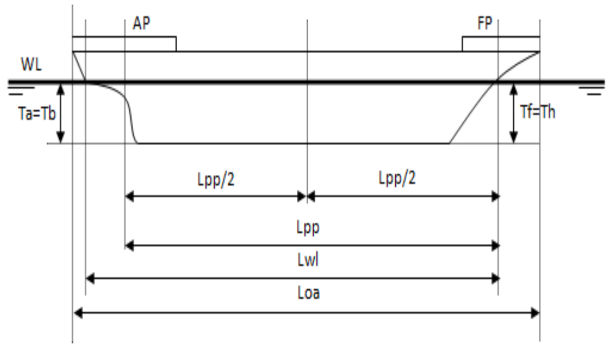

Fig. 1 Longitudinal Shape of The Vessel

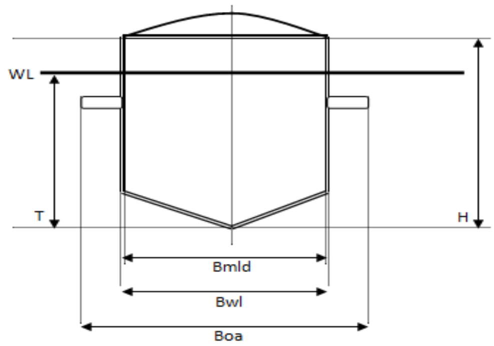

Fig. 2 Cross-sectional Shape of The Vessel

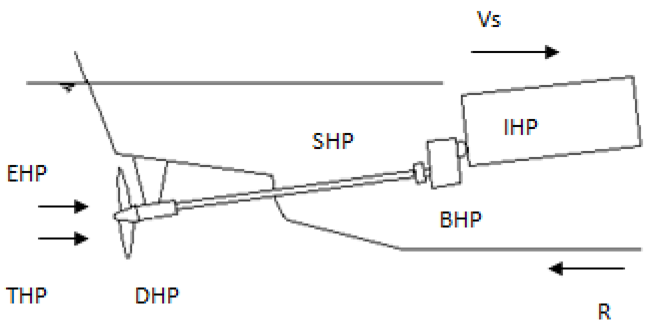

Fig. 3 Propulsion System of The Vessel

Nomenclature

After Perpendicular (AP)
Fore Perpendicular (FP)
Length between perpendicular (Lpp)
Length on the water line (Lwl)
Length Overall (Loa)
Breadth moulded (B/Bmld)

Draft/draught (T)
Dept (H)
Freeboard (F)
Centre line (CL)
Speed of The Ship (Vs)
Ship Resistance (R)
Effective Horse Power (EHP)
Thrust Horse Power (THP)
Delivery Horse Power (DHP)
Shaft Horse Power (SHP)
Brake Horse Power (BHP)

2.2. Water Jet Propulsion on Fast Patrol Boat

The water jet propulsion system has been used as a booster for fast boats over three hundred years ago, but its use is widely knocked on its low propulsive efficiency when compared to ship propulsion systems that use conventional propellers.

The ship with water jet propulsion is a ship which used water jet system as the propellerin its operation in the water media so that the ship can move in accordance with the speed of the desired ship. Ships that use water jet propulsion system is a system consisting of bare hull system and water jet system (Etter 1975).

Bare hull system is a shipbuilding body with no water jet installed. However, in the calculation of weight and the position of center of gravity should be the weight of the ship in a state of operation at sea, so it must be included along with the weight of water entering through the water jet system (entrained water).

The water jet propulsion system generally consists of a pump and a ducting systemsystem. The pump system serves to convert mechanical power into hydraulic power. While the channel system serves to direct the flow rate from the environment to the pump and from the pump to return to the environment.

The water jet propulsion system is widely used primarily for high-speed vessels, because based on studies that have been conducted, it wasshowed that the water jet propulsion system has a feature that has nothing to do with its propulsive efficiency. Some of the features that the water jet propulsion system possesses are described bellow:

a. The absence of propellers and steering outside the vessel is very advantageous because it reduces the total resistance occurring on the vessel and allows the operation of vessels for shallow waters.
b. Have good acceleration ability.
c. Have good shipmotion when the vessel speed is relatively low.
d. Have the advantage when the movement of the ship at a relatively high speed ship.
e. Placement of impeller inside ship body will be able to reduce vibration and noise level on ship.
f. At a relatively high velocity of the vessel, propulsive efficiency can be maintained high enough to be comparable to the propeller propulsion system.

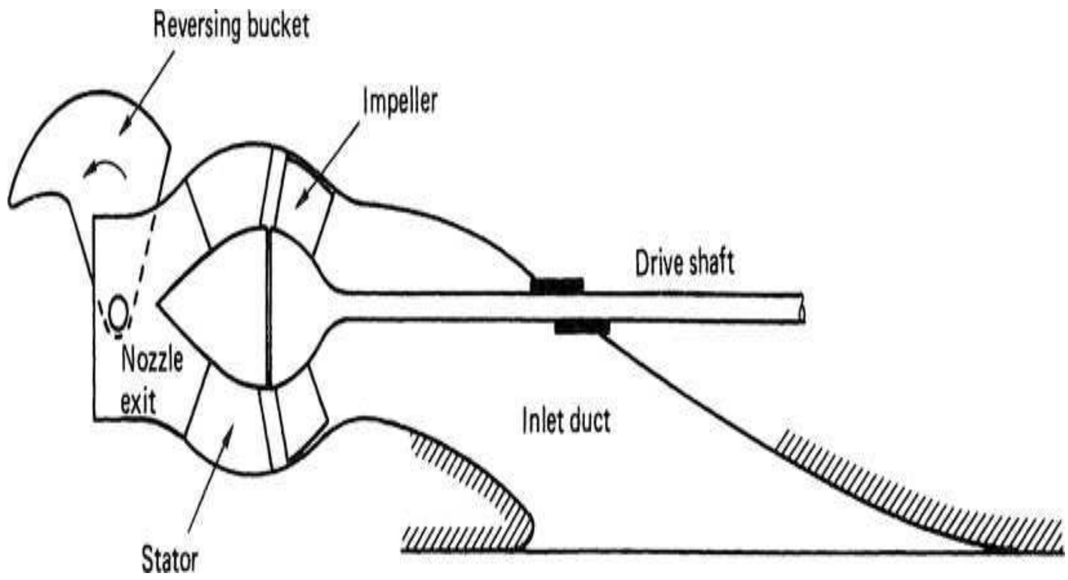

Fig. 4 Water jet System Configuration

2.3. Cavitation Requirements

Cavitation is a symptom of fluid evaporation that is flowing because the pressure is reduced to below the saturation pressure so that the steam bubble would be form and interfere with the work of the pump.

The evaporation of these liquids can occur inside the pump or channel due to high flow velocity (turbulent flow) which can cause the pumped fluid temperature to be higher. At the pump, the cavitation problem often occurs on the suction side when the pump suction pressure is too low or under it saturation pressure (Barrass 2004).

If the pump is cavitated, it will create noise and vibration that will eventually lead to a decrease in performance of the pump. In order for the pump to be safe against cavitation problems, the pump must have a specific suction rotation price which is below the cavitation limit of the pump. The specific rotation price of the suction will be greatly influenced by the magnitude of the Net Positive Suction Head (NPSH) of the pump used.

2.4. Method of Research.

The planning of the water jet propulsion system is based on the following matters

a. The ship data used was Fast Patrol Boats (FPB-60) to be built

b. Calculation of required power and total resistance used Harvarld Guldhamer method.

c. The planning of the water jet propulsion system started by taking the Overall Propulsive Coefficient (OPCo) as a first step to calculate the parameters of the water jet propulsion system until the OPC was obtained in accordance with the predefined OPCo. Thereafter, calculations of the cavitation requirements of the channel system and the propulsor pump were used.

3. RESULT AND DISCUSSION.

3.1 Vessel Data

The data from Fast Patrol Boats (FPB-60) to be used as calculations in the planning of water jet propulsion system were as follows:

a.	LOA	:	60 m
b.	LWL	:	55 m
c.	Breadth (B)	:	8,10 m
d.	Draft (T)	:	2,46 m
e.	Height (H_2)	:	4,86 m

f. Block Coefficient (Cb) : 0,350

g. Velocity (Vs) : 35 knot

3.2. Resistance Calculation

The magnitude of the resistance on the ship at the planned vessel velocity of 35 knots or 17.99m / s was:

a. Frictional Resistance : 82, 463 KN

b. Residual Resistance : 1,16 KN

c. Wind Resistance : 3,686 KN

d. Additional Resistance : 12,22 KN

So the total total resistance that occurs on the ship was 99.53 KN.

3.3. EHP, BHP and SHP Calculation

Based on the total resistance, the amount of effective thrust required to be able to move the ship in accordance with the planned speed could be calculated as follows:

$$\begin{aligned} EHP &= RT \times Vs \\ &= 99{,}53 \times 17{,}99 \\ &= 1790{,}55 \text{ KW} \end{aligned}$$

This plan was assumed to be in an ideal state so that the amount of thrust required was equal to the amount of total resistance that occurred. The water jet propulsion system was planned to use two pumps of propulsor so that the amount of thrust per pump was 49,765 KN. By taking the initial OPC price of 0.57, the amount of BHP could be calculated as follows:

$$\begin{aligned} BHP &= \left(\frac{T_h}{z}\right) \times \frac{Vs}{OPC} \\ &= 49{,}765 \times \frac{17{,}99}{0{,}57} \\ &= 1570{,}65 \text{ KW} \end{aligned}$$

In this water jet system,it was planned that the pump impeller would be driven by a motor with direct clutch transmission, with transmission efficiency between 0.96 - 0.99 per pump. In this planning, the value was 0.96 so the amount of SHP could be calculated as follows:

$$\begin{aligned} SHP &= \eta_T \times BHP \\ &= 0{,}96 \times 1570{,}65 \\ &= 1507{,}82 \text{ KW} \end{aligned}$$

3.4. Discussion

3.4.1. Dimension and Water Jet System Parameter Calculation

As shown in the figure below, based the amount of thrust per SHP in the unit (lbf / HP), the amount of power density (SHP / Di^2) in units (HP / cm^2) could be known.

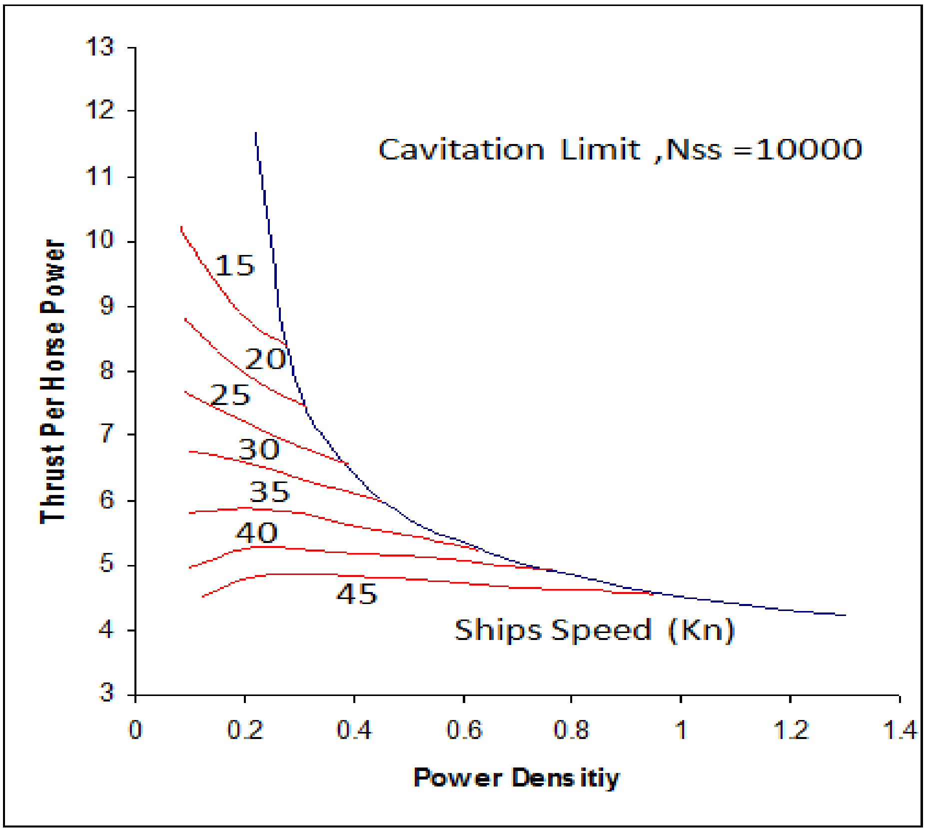

Fig. 5 Chart of Water jet System Inlet Dimension

The amount of thrust per SHP was 5.48 so based on the picture above, the amount of power density at 0.475 was obtained.

From power density, the main dimensions of water jet system could be calculated as follows:

- Inlet Diameter : 0,6682 m
- Inlet Area : 0,350 m2
- Nossel diameter : 0,430 m
- Nossel Area : 0,145 m2

By taking the fraction of the current flow value of 0.05, we could get the inlet speed as follows:

:

Vi = (1 – w) x Vs

= (1 – 0,05) x 17,99

= 17, 09 m/s

So the amount of speed on the outlet or nozzle (Vj) could be obtained by:

$$Vj = 0{,}5 \times \left(Vi + \sqrt{\left(Vi^2 + \frac{4.T}{\rho.An} \right)} \right)$$

$$= 0{,}5 \times \left(17{,}09 + \sqrt{\left(17{,}09^2 + \frac{4 \times 49765}{1024{,}63 \times 0{,}144} \right)} \right)$$

$$= 28.8 \ \frac{m}{s}$$

The amount of flow capacity in the jet / nozzle:

Q_J = Vj x An

= 28,8 x 0,145

= 4,15 m^3/s

The comparison of ship speed and flow velocity through the jet could be expressed by:

$$\mu = \frac{Vj}{Vs}$$

$$= \frac{28,8}{17,99}$$

$$= 0,625$$

The amount of ideal jet efficiency (ηj_{ideal}) :

$$\eta_j = \frac{2.\mu}{1+\mu}$$

$$= \frac{2 \times 0,625}{1+0,625}$$

$$= 0,769$$

For the planning of the water jet propulsion system, it was recommended that the value of inlet loss coefficient (ψ) was set between 16% - 20%. In this calculation, the value of inlet loss was 18%, because the water jet system used a flush inlet type and the vessel operated in a relatively clean area of water.

Meanwhile, the value of loss coefficient (ζ) was recommended between 1% - 4%. In the calculations for actual jet efficiency, a value of 2% was chosen because the losses on the nozzle were relatively smaller compared to their inlet channels. So, the actual (ηj_{aktual}) jet efficiency cost for the water jet system could be obtained by:

$$\eta j_{aktual} = \frac{1}{1-w} \times \frac{2.\mu.(1-\mu)}{(1+\psi)-(1-\zeta).\mu^2 + \frac{2.g.hj}{Vj^2}}$$

$$= \frac{1}{1-0,05} \times \frac{2 \times 0,769 \times (1-0,769)}{(1+0,02)-(1-0,18)\times 0,769^2 + \frac{2\times 9,8 \times 0,881}{28,8^2}}$$

$$= 0,675$$

In the calculation of the overall propulsion efficiency (OPC), it was assumed that the pump efficiency was 0.89 and the relative rotative efficiency was 0.98. So, the overall propulsion efficiency (OPC) could be obtained by:

$$OPC = \eta j_{aktual} \times \eta_P \times \eta_r \times \eta_T$$

$$= 0,675 \times 0,89 \times 0,98 \times 0,96$$

$$= 0,573 \approx 0,57$$

Based the calculation of Overall Propulsive Coefficient (OPC),an equal value to the previous forecast was obtained so that the calculation could be continued.

3.4.2 Calculation of Pump Characteristic:

a. Pump Rotation

$$N = K \times SHP^{(1/3)}$$

$$= 69 \times 2020,45^{(1/3)}$$

$$= 873,66 \approx 874 \text{ Rpm}$$

b. Specific Rotation

The flow capacity (Qj) obtained from the previous calculation was 4.15 (m3 / s) = 146.44 (ft3 / s) converted into gallon units per minute (GPM) to be obtained at 65731.06 GPM. The amount of price for pump Head could be calculated as follows:

$$H = \frac{V_j^2}{2g} - \frac{V_i^2}{2g} + h_{LT}$$

$$= \frac{28,8^2}{(2\times 9,8)} - \frac{17,09^2}{(2\times 9,8)} + 5,828$$

$$= 33,25 \text{ m} = 109,06 \text{ ft}$$

So the value of pump specific rotation could be calculated as follows:

$$Ns = N \times \frac{\sqrt{Q_j}}{H^{0,75}}$$

$$= \frac{874 \times \sqrt{65731,06}}{109,06^{0,75}}$$

$= \quad 6639{,}69$

Based on the specific rotation value of the pumps obtained above, the type of pump to be used that corresponds to the specific value of the round was the type of mixed flow pump with a specific rotation between 4000 <Ns <10000

c. Suction Specific Rotation

The value of NPSH could be calculated as follows:

$$\text{NPSH} = \frac{\eta_{j.ideal} \times Vj^2}{2g} - hj$$

$$= \frac{0{,}769 \times 28{,}8^2}{2 \times 9{,}8} - 0{,}881$$

$$= 31{,}66 \text{ m} = 103{,}84 \text{ ft}$$

Specific rotation value of suction could be calculated as follows:

$$\text{Nss} = \frac{N\sqrt{Q_j}}{NPSH^{0{,}75}}$$

$$= \frac{874 \times \sqrt{65731{,}06}}{103{,}84^{0{,}75}}$$

$$= 6888{,}48$$

Based on the image of the Operation Zone of the Mixed Flow Pump below, the planned operating zone of the water jet pump system was located in zone I or continuous operation zone, which was separated by zone II by Nss = 12000 line as the cavitation boundary.

This means that the pump for the planned water jet system met the allowable cavitation requirements so it was safe to use continuously.

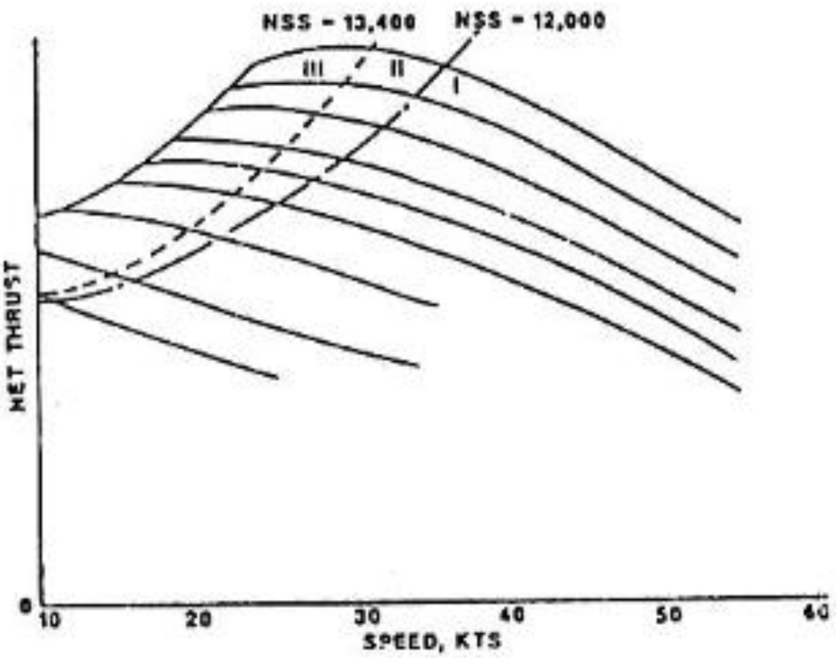

Fig. 6 Mix Flowed Pump Operation Zone

4. CONCLUSION

Based on the calculations,it required propulsor pump drive with power of 1571 KW and round 874 RPM per pump to obtain the maximum planned speed. Based on the result of specific rotation of 6639,69 then the type of pump used in accordance with the specific rotation size is Mixed Flow Pump (4000 <Ns <10000). The thrust force generated by the water jet propulsion system was highly dependent on the amount of flow capacity generated by the pump used. The larger the capacity produced by the pump with a constant nozzle diameter, the nozzle flow rate will also be greater so that the resulting thrust would also be greater. In the planning of water jet propulsion system is obtained the amount of capacity generated water jet pump system is 4.15 m3 / s with flow velocity on the nozzle / jet of 28.8 m / s. From the value of specific swabs of suction (Nss) obtained that is equal to 6205.49 then the pump for the water jet propulsion system has fulfilled the cavitation limit requirements so that it can be used continuously (continuous).

In this water jet propulsion system plan, the amount of capacity generated by water jet pump system was obtainedat 4.15 m^3/s with flow velocity on the nozzle / jet of 28.8 m/s. Based on the value of specific rotation of suction (Nss) obtained at 6205.49,it could be concluded that the pump for the water jet propulsion system had fulfilled the cavitation limit requirements so that it could be used continuously.

5. ACKNOWLEDGEMENT

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REFERENCE

Adumene, NSAS 2015, 'Predictive Analysis of Bare-Hull Resistance of a 25,000 Dwt Tanker Vessel', *International Journal of Engineering and Technology*, pp. 194-198.

Amin, JKAA 2014, 'Performance of VLCC Ship with Podded Propulsion System and Rudder', *International Society of Ocean, Mechanical and Aerospace Scientists and Engineers*, pp. 1-7.

Andersen, JP 1994, *Hydrodynamic of Ship Propeller*, Elsevier, Cambridge.

Anthony F. Molland, SR 2011, *Ship Resistance and Propulsion*, Practical Estimation of Ship Propulsive Power, United Stated of America.

Atreyapurapu.et.al, K 2014, 'Simulation of a Free Surface Flow over a Container Vessel Using CFD', *International Journal of Engineering Trends and Technology*, pp. 334-339.

Barrass, C 2004, 'Ship Design and Performance for masters and Mates', *Elsevier*.

Bartee, DL 1975, 'Design of Propulsion Systems for Hidh-Speed Craft', *The Society of Naval Architects and Marine Engineers*, pp. 1-17.

Bertram, HSAV 1998, *Ship Design for Efficiency and Economy*, Butterworth-Heinemann, Great Britain.

Bertram, V 2000, *Practical Ship Hydrodynamic*, Great Britain, Inggris.

Charchalis, A 2013, 'Designing Constraints in Evaluation of Ship Propulsion Power', *Journal of KONES Powertrain and transport*, pp. 1-6.

Chun.et.al., HH 2013, 'Experimental investigation on stern-boat deployment system and operability for Korean coast guard ship', *International Journal Naval Architecture Ocean Engineering*, pp. 488-503.

D'arcalengelo, AM 1969, *Ship Design and Contruction*, Professor of Naval Architecture and Marine Engineering University of Machigan, Michigan.

Degiuli.et.al., N 2017, 'Increase of Ship Fuel Consumption Due to the Added Resistance in Waves', *Journal of Sustainable Development of Energy, Water and Environment Systems*, pp. 1-14.

Etter, RAB&RJ 1975, 'Selection of Propulsion Systems for High Speed Advanced Marine Vehicles ', *SNAME*.

Etter, RJ 1976, *Water Jet Propulsion – An Interview*, The Winter Annual Meeting of The American Society of Marine Engineers, New York.

Harvald, SA 1992, *Resistance and Propulsion of Ships*, John Wiley and Sons, New York.

Herdzik, J 2013, 'Problems of propulsion systems and main engines choice for offshore support vessels', *Scientific Journals Zeszyty Naukowe*, vol 2, no. 1733-8670, pp. 45-50.

Jeng-Horng Chen, C-CC 2006, 'A Moving PIV System For Ship Model Test in Towing Tank', *Journal Ocean Engineering*, pp. 2025-2046.

Joe Longo, FS 2005, 'Uncertainty Assessment For Towing Tank Tests With Example For Surface Combatant DTMB Model 5415', *Journal of Ship Research*, pp. 55-68.

Kim, HC 1966, 'Hydrodinamic Aspect of Internal Pump Jet', *Marine Technology*.

Kleppesto, K 2015, 'Empirical Prediction of Resistance of Fishing Vessels', *NTNU Trondheim Norwegion University of Science And Technology*, pp. 1-87.

Kowalski, A 2013, 'Cost optimization of marine fuels consumption as important factor of control ship's sulfur and nitrogen oxides emissions', *Scientific Journals*, pp. 94-99.

Kuiper, G 1992, *The Wageningen Propeller Series*, MARIN, Netherland.

Lewis, EV 1988, *Principles of Naval Architecture Second Revision*, The Society of Naval Architecs and Marine Engineers, New Jersey.

M. Reichel, AMANLL 2014, 'Trim Optimisation - Theory and Practice', *the International Journal on Marine Navigation and Safety of Sea Transportation*, pp. 387-392.

Mohamad Pauzi Abdul Ghani, MNAR 2008, 'The Prediction of Wake Wash in The Towing Tank', *Jurnal Mekanika*, pp. 129-140.

Premchand, PK 2015, 'Numerical Investigation of the Influence of Water Depth on Ship Resistance ', *International Journal of Computer Applications* , pp. 1-8.

Samson, DIFAN 2015, 'Effect of Fluid Density On Ship Hull Resistance and Powering', *International Journal of Engineering Research and General Science*, pp. 615-630.

Samuel, MI 2015, 'An Inventigation Into The Resistance Components of Converting a Traditional Monohull Fishing Vessel Into Catamaran Form', *International Journal of Technology*, pp. 1-10.

Sladky, J 1976, *Marine Propulsion*, The Winter Annual Meeting of The American Society of Marine Engineers, New York.

Susanto.et.al., AD 2017, 'Analysis of The Propulsion System Towards The Speed Reduction of Vessels Type PC-43', *International Journal of Engineering Research and Application*, pp. 8-15.

Tabaczek, JK 2014, 'Coefficients of Propeller-hull Interaction in Propulsion System of Inland Waterway Vessels with Stern Tunnels', *International Journal on Marine Navigation and Safety of Sea Transportation*, pp. 1-8.

Tupper, E 1975, *Introduction to Naval Architecture*, Great Britain, Inggris.

Tupper, KR 2001, *Basic Ship Theory*, Great Britain, Inggris.

Watson, DGM 1998, *Practical Ship Design*, Elsevier Science Ltd, Netherlands.

WPA Van Lamerren, TL 1984, *Resistance Propulsion and Steering of Ship*, Harleem Holland, Holland.

Zelazny, K 2014, 'Amethod of Calculation of Ship Resistance on Calm Water Useful at Preliminary Stages of Ship Design', *Scientific Journal Maritime University of Szuczecin*, pp. 125-130.

Żelazny, K 2015, 'An Approximate Method For Calculation of Mean Statistical Value of Ship Service Speed On a Given Shipping Line , Useful In Preliminary Design Stage', *Polish Maritime Research*, pp. 28-35.

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AN INVESTIGATION OF ZINC ANODE PERFORMANCE FOR SACP ON INDONESIAN WARSHIP UNDERWATER STRUCTURES

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ABSTRACT

Today's majority of Indonesian Warship (KRI) uses Zinc as Sacrificial Anode for corrosion control, but quality of zinc is under expectation. The aim of paper is to investigation of Zinc Anode Performance on underwater structure of KRI using chemical composition test and corrosion potential measurement test. This paper uses three speciments of zinc anode as a comparison. The result of dry chemical composition test showed that speciment A have 99,8% (Zn), 0,121% (Al), 0,0141% (Cd), 0,0004% (Cu), 0,002% (Fe), 0,0087% (Pb), 0,0007% (Si). Speciment B showed that 99,9% (Zn), 0,0045% (Al), 0,0001% (Cd), 0,0026 % (Cu), 0,002% (Fe), 0,0111% (Pb), 0,0005% (Si). Speciment C showed that 99,6% (Zn), 0,102% (Al), 0,0023% (Cd), 0,077 % (Cu), 0,0272% (Fe), 0,042% (Pb), 0,0008% (Si). The result of wet chemical composition test showed that speciment A have 1,4502% (Zn), 0,163% (Al), 0,00311% (Cd), 0,0000276 % (Cu), 0,00005% (Fe), 0,000056% (Pb). Speciment B showed that 1,4723% (Zn), 0,0096% (Al), 0,0002% (Cd), 0,000018 % (Cu), 0,0016% (Fe), 0,00007% (Pb). Speciment C showed that 1,456% (Zn), 0,0896% (Al), 0,00065% (Cd), 0,005 % (Cu), 0,0156% (Fe), 0,00428% (Pb). The result of corrosion potential test showed that 1,005V for speciment A, 0,977V for speciment B, 0,994V for speciment C. Zinc with Mild steel A showed 0,83V for speciment A, 0,87V for speciment B, 0,829V for speciment C. Based of chemical composition test, speciment A and B is accomplished from US Military Specifications standard, but speciment C doesn't accomplish. Based of corrosion potential measurement test, all of speciment can used for sacrifice anode.

KEYWORDS : *Cathodic Protection, Zinc Anode, Composition Test, Corrosion Potential Test, Indonesian Warship.*

1. INTRODUCTION.

Indonesian Warship (KRI) is the main component from Indonesian Navy (TNI AL) to secure maritime area. At sea, KRI have many activities for Maritime Security and Defence such as basic training, warfare alert and operation (Susilo et al. 2017). Largely, KRI made from metal material which easy to corrosion attacked, particulary on underwater structure. So that, the underwater structure of warship needs protection from corrosion. Corrosion can be defined as the deterioration of material's properties due to its interaction with its environment (Al-Sultani & Nabat 2012). Corrosion is a malicious chemical or electrochemical reaction between the metal surface and the surrounding environment (Javadi, J.Javidan & Salimi 2104). Since, seawater has significant effect on marine vessels and offshore steel structures because it is highly corrosive media, which leads to the formation of different types of corrosion cells such as dissimilar metal corrosion cells and differential aeration cells (Rogers 1974). There are three primary reasons for concern about and the study of corrosion-safety, economics, and conservation (Emami 2012).

Different methods are used for corrosion protection of steel in corrosive solution (Panah & Ajani 2016). Basically, there are five methods of corrosion control such as change to a more suitable material, modification to the environment, use of protective coating, design modification to the system or component, and the application of cathodic or anodic protection (Roberge 1999).

Cathodic Protection (CP) is a proven method of controlling corrosion in reinforced concrete through the application of a small Direct Current (DC) (Nguyen et al. 2012). The method has widely used in many areas such as for storage tanks, offshore structures, platforms and ship hulls (Hafizh et al. 2015). There are two types of applying cathodic protection system, namely Sacrificial Anode Cathodic Protection (SACP) and Impressed Current Cathodic Protection (ICCP) (Al-Himdani, Mahdi & Khuder 2005).

Majority of KRI used Zinc as Sacrifice Anode for corrosion control on underwater structure. Today's, the quality of Zinc Anode on KRI is under expectated. The aim of this paper is to present an investigation of Zinc Anode performance on underwater structure of KRI. There a two method for evaluating performance of Zinc Anode, one is chemical composition and another is based on corrosion potential measurement test (Mahasiripan, Tangtermsirikul & Sancharoen 2014). Boundary of problem in this paper is Zinc as sacrificial anode applied in US Military Specification Standard, Zinc divided by 3 speciments as a comparison.

The inscriptive benefit from this paper is a literature for Indonesia Navy about corrosion control on KRI underwater Structure. Second, it uses for academic contribution to Indonesian Naval Technology College.

To support the research, this paper has many literatures. Literature of paper about corrosion control likes Numerically Analysis of Corrosion Resistance and Control Plate (Kumar, Rajalingam & G.R.Kannan 2014). Corrosion Protection System in Offshore Structure (Ivanov 2016). Synergic effect of Thiomalic acid and Zinc ions in Corrosion control of Carbon Steel in Aqueous Solution (Ramesh & Periasamy 2014). Study on Corrosion Properties of plasma Nitried Pure Aluminium (Yazdani, Soltanieh & Aghajani 2009). An Investigation on the Performance of an Imidazoline Based Commercial Corrosion Inhibitor on CO2 Corrosion of Gas-well Tubing steel by EIS Technique (Khavasfar, Moayed & Attar 2007).

Paper literature about cathodic protection such as Efficiency of Corrosion Inhibitors on Cathodic Protection System (Briggs & Eseonu 2014). Cathodic Protection of Steel in Concrete Using Conductive Polymer Overlays (A.S.S.Sekar, V.Saraswathy & G.T.Parthiban 2007). Interaction Between Cathodic Protection and Microbially Influenced Corrosion (Masli 2011).

Paper literature explains about Sacrificial Anode (SACP) is The effect of Cathodic Protection System by Means of Zinc Sacrifial Anode on Pier in Korea (Jeong & Jin 2014). Numerical Analysis Result of The Cathodic Protection for The Underground Steel Pipe by Anode Installation Method (Jeong et al. 2014). Impact of Galvanic Anode Dissolution on Metal Trace Element Concentrations in Marine Waters (Deborde et al. 2015). Electrocoagulation of Textile Wastewater with Fe Sacrificial Anode (Ajjam & Ghanim 2012). Sacrificial Protection Method During Disinfection to Avoid Corrosion (Rehman, Amin & Abbasm 2014)

This paper is organized as follows. Section 2 reviews the methods and materials of this paper. Section 3 gives result and discussion. Finally, in section 4 presents this paper conclusion.

2. MATERIAL/METHODOLOGY.

2.1. Sacrificial Anode.

Sacrificial anode is the main component of Cathodic protection system used to protect form corrosion. Sacrificial anodes have become a standard practice for the protection of vessels and offshore hull structures against corrosion (Baere et al. 2013). Sacrificial anodes are made in various shape using alloys of zinc, magnesium and alumunium (Loto & Popoola 2011). Sacrifical zinc anodes is used to protect bare steel in commercial and military vessels, in hot waters, water storage tanks and steel reinforcing bars in concrete structurres located in marine environment (McCafferty 2010). The underwater structure of ship is protected by painting for the main protection and zinc as sacrifial anode used to control the rate of dissolution in seawater (Talbot & Talbot 1998).

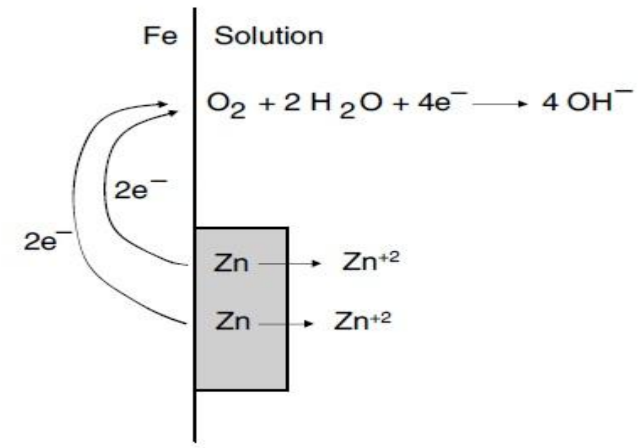


Fig. 1. Process of Sacrificial Anode (Roberge 1999).

In the sacrificial anode method, electrical potential is created by attaching a dissimilar metal in electrolyte, when different metals are coupled together, the anode material will release electrons and protect the cathode from corrosion (Hafizh et al. 2015). The electrode potential of low alloy steel in seawater is approximately -0,6 V vs SCE. The electrode potential of zinc is -1,0 V, thus when zinc is coupled to steel zinc will be the anode and steel will be the cathode.

The advantages are associated with sacrificial anode CP systems (Roberge 1999):

a. No external power sources required.
b. Ease of installation.
c. Unlikely cathodic interference in other structures.
d. Low-maintenance systems.
e. System is essentially self-regulating.
f. Relatively low risk of overprotection.
g. Relatively uniform potential distribution

These limitations that have been identified for ICCP systems (Roberge 1999):

a. Limited current and power output.
b. High-resistivity environments or large structures may require excessive number of electrodes..
c. Anodes may have to be replaced frequently under high current demand.
d. Anodes can increase structural weight if directly attached to a structure.

2.2. Zinc Anode.

Zinc anode are commonly available in weight from 2,27 – 113,4 kilograms (5 pounds to 250 pounds) in the form of plates, bars, and rods as shown in MIL-HDBK-1004/10. Zinc is also available as ribbon anodes in 16-millimeter by 22.2-millimeter (5/8-inch by 7/8-inch), 13-millimeter by 14.3-millimeter (1/2-inch by 9/16-inch), and 8.7-millimeter by 11.9-millimeter (11/32-inch by 15/32-inch) sizes, each with a 2.5-millimeter (1/10-inch) diameter galvanized steel wire core (Basham et al. 2003). The electrical potential of zinc anodes is approximately -1.10 volts DC to copper/copper sulfate in soil. In some fresh waters, the potential can reverse at temperatures above 58.3 ºC (140 ºF); consequently, zinc should not be used in those cases (Basham et al. 2003).

Table 1. Chemical Composition of Zinc Anode (Fontana 1987)

ELEMENT	STANDARD ALLOY	SEAWATER ALLOY
Aluminum	0.005% max	0.10% - 0.50%
Cadmium	0.003% max	0.03% - 0.15%
Iron	0.00014% max	0.005% max
Lead	0.003% max	0.006% max
Copper	-	0.005% max
Silicon	-	0.125% max
Zinc	Remainder	Remainder

Table 2. Chemical Composition with U.S Military specification (NACE 2002)

Element	Weight Content %	
	MIL-A-18001 (ASTM B-418 Type I)	ASTM B-418 Type II
Al	0.1-0.5	0.005 max
Cd	0.02-0.07	0.003 max
Fe	0.005 max	0.0014 max
Pb	0.006 max	0.003 max
Cu	0.005 max	0.002 max
Zinc	Remainder	Remainder

2.3. Method of Research.

This paper shows analysis performance of Zinc Anode on underwater structure of KRI, for evaluating performance of Zinc Anode, this paper used two method, one is chemical composition and another is based on corrosion potential measurement test. The first phase is identification of the problem, library studies, and steps of experiment.

2.3.1 Flowchart Diagram.

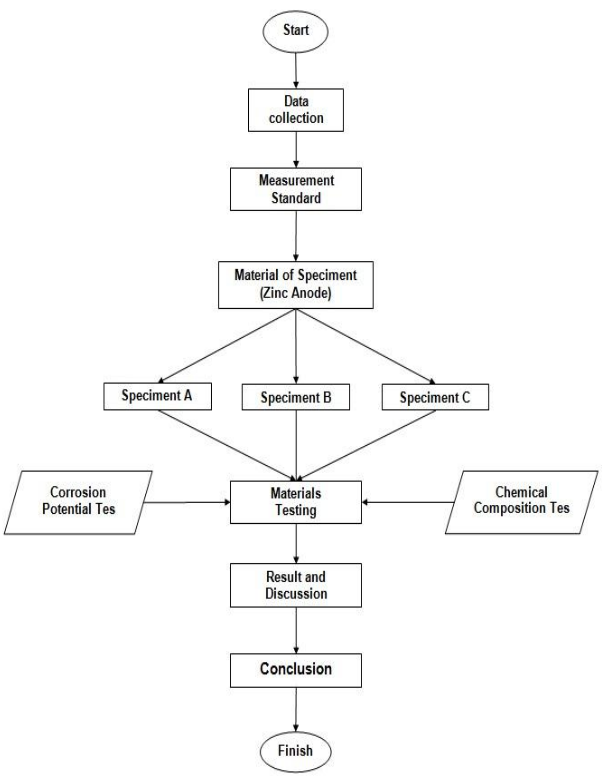


Fig. 2. Flowchart Diagram of

2.3.2 Data Collection.

a. Materials speciment.

1) Speciment A : Zinc made from Naval Laboratory.

2) Speciment B : Pure Zinc anode 99,99%.

3) Speciment C : Zinc anode from domestic market.

4) NaCl 3,5%.

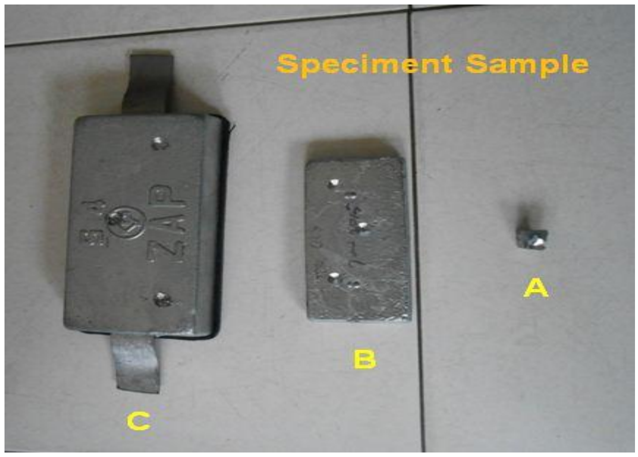


Fig. 3. Speciment Sample.

b. Tools :

1) Metal Plate, Mild steel Grade A.

2) Referensial Anode.

3) Multitester.

4) Inductively Couple Plasma (IPC) for wet composition test.

5) Foundry Master Pro for dry composition test.

Fig. 4. Foundry Master Pro

This machine contains a solid state spark source, a vacum system, an optical system and output system. The sample was positioned on the spark stand for chemical composition analysis (Cassinath 2013).

Fig. 5. Inductively Couple Plasma

ICP is an effective method of measuring multiple trace metals involves using an inductively coupled plasma-atomic emission spectrometer (Ryan & Clark 2010). The fundamental characteristic of this process is that each element emits energy at specific wavelengths peculiar to its chemical character (Kumar, I. & Ajitha 2014). ICP instrument employs argon plasma (ICP) as the ionization source and a mass spectrometer (MS), usually with a quadrupole mass filter, to separate the ions produced (A.A & W.L.O 2011)

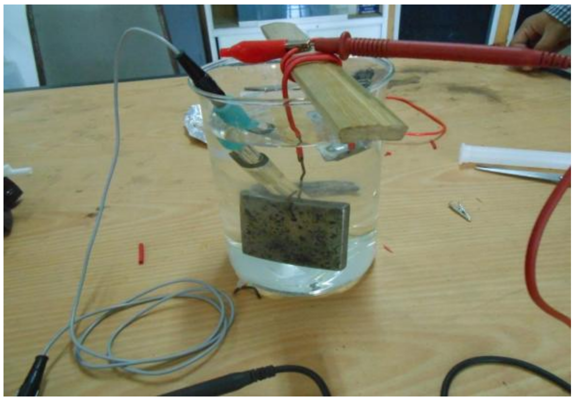


Fig. 6. Potential Corrosion Test.

Corrosion potential test is measured as a potential difference against a reference electrode at different points on a structure and is used to determine the likehood of reinforcement corrosion (Trejo, Reinschimdt & Halmen 2009). The numerical value of the measured potential difference between the steel in concrete and the reference electrode will depend in the type of reference electrode used and on the corrosion condition of the steel in concrete (Andrade et al. 2003).

3. RESULT AND DISCUSSION.

3.1 Result of Dry Composition Test.

Table 3. Result of Chemical Composition (Dry Test).

Element	Zinc Anode (%) Weight			U.S Standard
	Speciment A	Speciment B	Speciment C	(Mil-A-18001-H)
Zn	99,8	99,9	99,6	Remainder
Al	0,121	0,0045	0,102	0,1-0,5
Cd	0,0141	0,0001	0,0023	0,025-0,15
Cu	<0,0004	0,0026	0,0777	Max 0,005
Fe	<0,002	<0,002	0,0272	Max 0,005
Pb	0,0087	0,0111	0,0422	Max 0,006
Si	0,0007	0,0005	0,0008	Max 0,015

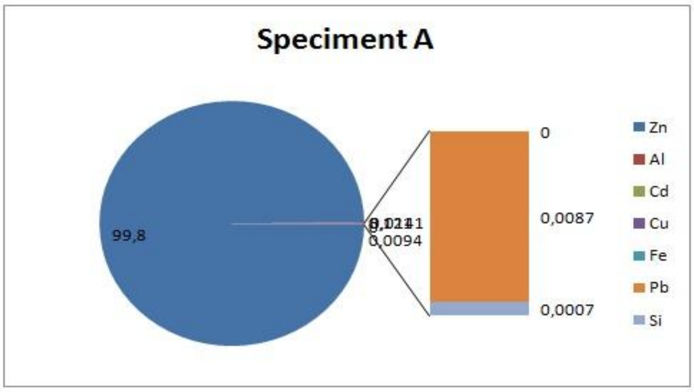


Fig. 7. Composition of Speciment A

The result of dry chemical composition test showed that speciment A have 99,8% (Zn), 0,121% (Al), 0,0141% (Cd), 0,0004% (Cu), 0,0020% (Fe), 0,0087% (Pb), 0,0007% (Si).

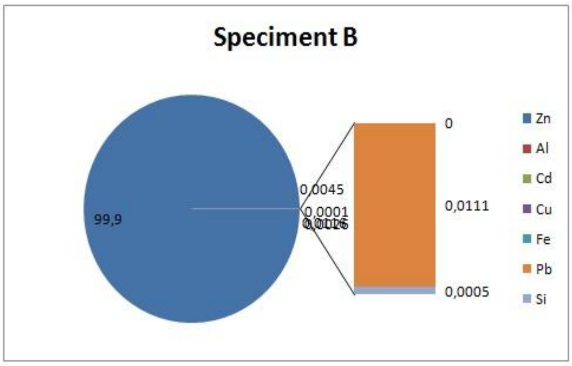


Fig. 8. Composition of Speciment B

Speciment B showed that 99,9% (Zn), 0,0045% (Al), 0,0001% (Cd), 0,0026 % (Cu), 0,0020% (Fe), 0,0111% (Pb), 0,0005% (Si).

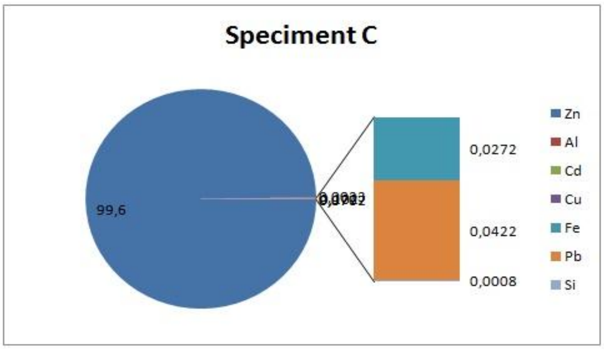


Fig. 9. Composition of Speciment C

Speciment C showed that 99,6% (Zn), 0,102% (Al), 0,0023% (Cd), 0,077 % (Cu), 0,0272% (Fe), 0,042% (Pb), 0,0008% (Si).

3.2 Result of Wet Composition Test.

Table 4. Result of Chemical Composition (Wet Test)

Element	Zinc Anode (%) Weight			U.S Standard
	Speciment A	Speciment B	Speciment C	(Mil-A-18001-H)
Zn	1,4502	1,4723	1,456	Remainder
Al	0,163	0,0096	0,0896	0,1-0,5
Cd	0,00311	0,0002	0,00065	0,025-0,15
Cu	0,0000276	0,000018	0,005	Max 0,005
Fe	0,00005	0,0016	0,0156	Max 0,005
Pb	0,000056	0,00007	0,00428	Max 0,006
Si	-	-	-	Max 0,015

The result of wet chemical composition test showed that speciment A have 1,4502% (Zn), 0,163% (Al), 0,00311% (Cd), 0,0000276 % (Cu), 0,00005% (Fe), 0,000056% (Pb).

Speciment B showed that 1,4723% (Zn), 0,0096% (Al), 0,0002% (Cd), 0,000018 % (Cu), 0,0016% (Fe), 0,00007% (Pb).

Speciment C showed that 1,456% (Zn), 0,0896% (Al), 0,00065% (Cd), 0,005 % (Cu), 0,0156% (Fe), 0,00428% (Pb).

3.3 Result of Corrosion Potential Test.

Table 5. Result of Corrosion Potential

	Element	Potential (V)
1	Speciment A	-1,005
2	Speciment B	-0,977
3	Speciment C	-0,994
4	Fe Mild Steal	-0,463
5	Speciment A	-0,83
6	Speciment B	-0,87
7	Speciment C	-0,829

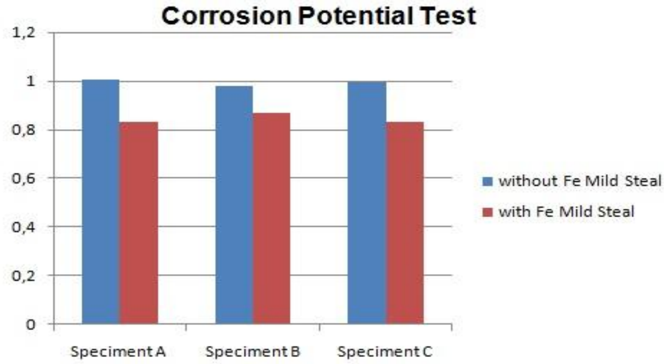


Fig. 10. Result of Corrosion Potential Test.

The result of corrosion potential test without Mild Steel showed that 1,005V for speciment A, 0,977V for speciment B, 0,994V for speciment C. Zinc with Mild steel A showed 0,83V for speciment A, 0,87V for speciment B, 0,829V for speciment C.

3.4 Comparison of Element Composition.

3.4.1 Zinc (Zn) Element

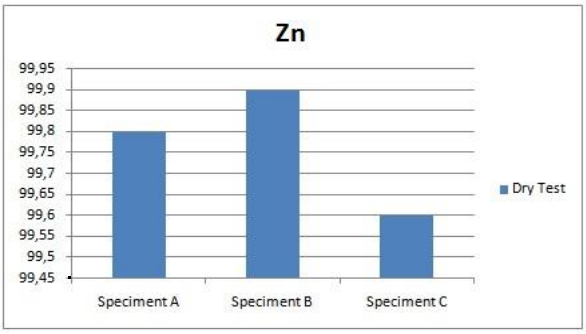


Fig. 11. Zinc Element.

Base of theoritic graphics for Zinc (Zn) element (fig.11), showed that specimen A has 99,8%, speciment B has 99,9%, speciment C has 99,6%. Speciment B has highest value in Zinc element and speciment C has lowest.

3.4.2 Aluminium (Al) Element.

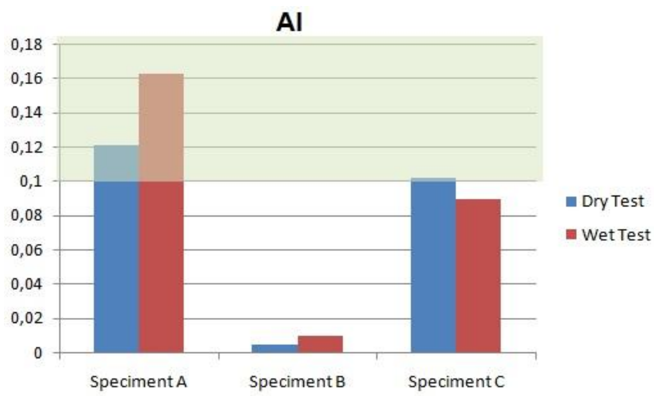


Fig. 12. Aluminium Element

Base of theoritic graphics for Aluminium (Al) element (fig. 12), showed that specimen A has 0,121% in dry test and 0,163% in wet test. Speciment B has 0,0045% in dry test and 0,0096% in wet test. Speciment C has 0,102% in dry test and 0,0896% in wet test. Speciment B has highest value in Zinc element and speciment C has lowest. Based of grey parameters, speciment A in category for dry and wet composition test.

3.4.3 Cadmium (Cd) Element.

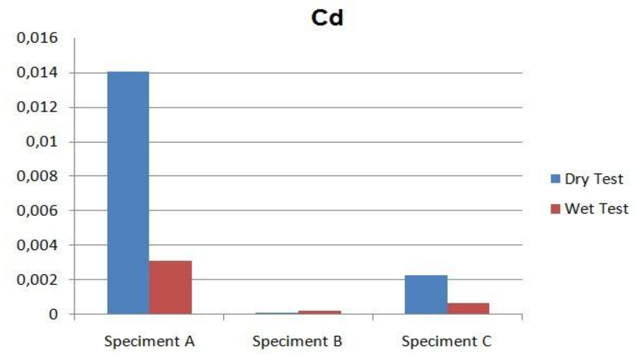


Fig. 13. Cadmium Element

Base of theoritic graphics for Cadmium (Cd) element (fig. 13), showed that specimen A has 0,141% in dry test and 0,00311% in wet test. Speciment B has 0,0001% in dry test and 0,0002% in wet test. Speciment C has 0,0023% in dry test and 0,00065% in wet test. All speciment is not in category.

3.4.4 Copper (Cu) Element.

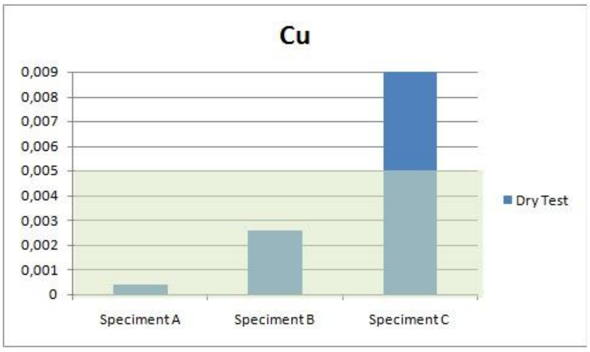


Fig. 14. Copper Element (dry test)

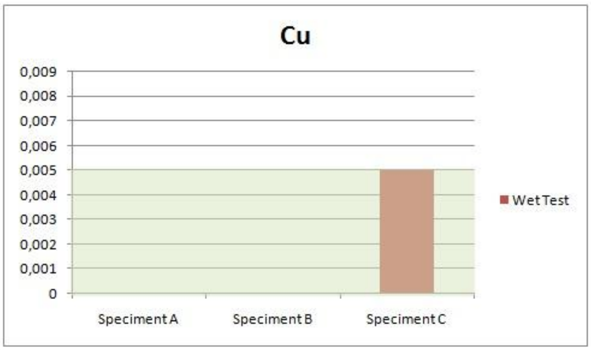
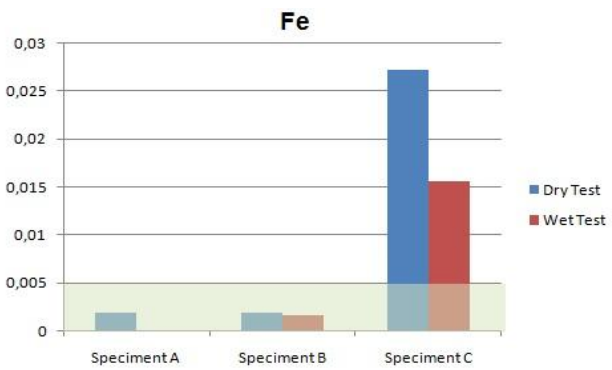


Fig. 15. Copper Element (wet test)

Base of theoritic graphics for Copper (Cu) element (fig. 14,15), showed that in dry test specimen A has 0,0004%, Speciment B has 0,0026%, Speciment C has 0,0777%. In wet test, specimen A has 0,0000276%, Speciment B has 0,000018%, Speciment C has 0,005%. In dry test, Speciment A and B include in category, but Speciment C not in category. In wet test, All of Speciment include in category.

3.4.5 Ferrum (Fe) Element.



· **Fig. 16**. Ferrum Element

Base of theoritic graphics for Ferrum (Fe) element (fig. 16), showed that specimen A has 0,002% in dry test and 0,00005% in wet test. Speciment B has 0,002% in dry test and 0,0016% in wet test. Speciment C has 0,0272% in dry test and 0,0156% in wet test. Speciment A and B include in category, Speciment C not in category

3.4.6 Plumbum (Pb) Element.

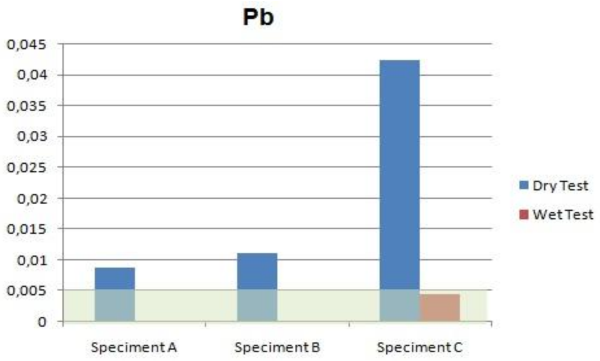


Fig. 17. Plumbum Element

Base of theoritic graphics for Plumbum (Pb) element (fig. 17), showed that specimen A has 0,0087% in dry test and 0,000056% in wet test. Speciment B has 0,0111% in dry test and 0,00007% in wet test. Speciment C has 0,0422% in dry test and 0,00428% in wet test. In dry test, all of speciment not in category, but in wet test all of speciment include in category.

4. CONCLUSION.

a. The result of dry chemical composition test showed that speciment A have 99,8% (Zn), 0,121% (Al), 0,0141% (Cd), 0,0004% (Cu), 0,002% (Fe), 0,0087% (Pb), 0,0007% (Si). Speciment B showed that 99,9% (Zn), 0,0045% (Al), 0,0001% (Cd), 0,0026 % (Cu), 0,002% (Fe), 0,0111% (Pb), 0,0005% (Si). Speciment C showed that 99,6% (Zn), 0,102% (Al), 0,0023% (Cd), 0,077 % (Cu), 0,0272% (Fe), 0,042% (Pb), 0,0008% (Si).

b. The result of wet chemical composition test showed that speciment A have 1,4502% (Zn), 0,163% (Al), 0,00311% (Cd), 0,0000276 % (Cu), 0,00005% (Fe), 0,000056% (Pb). Speciment B showed that 1,4723% (Zn), 0,0096% (Al), 0,0002% (Cd), 0,000018 % (Cu), 0,0016% (Fe), 0,00007% (Pb). Speciment C showed that 1,456% (Zn), 0,0896% (Al), 0,00065% (Cd), 0,005 % (Cu), 0,0156% (Fe), 0,00428% (Pb).

c. The result of corrosion potential test without Mild steel showed that 1,005V for speciment A, 0,977V for speciment B, 0,994V for speciment C. Zinc with Mild steel A showed 0,83V for speciment A, 0,87V for speciment B, 0,829V for speciment C

d. Based of chemical composition test, speciment A and B is accomplished from US Military Specifications standard, but speciment C doesn't accomplish.

e. Based of corrosion potential measurement test, all of speciment can used for sacrifice anode.

5. ACKNOWLEDEMENT.

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REFERENCES.

A.A, W & W.L.O, J 2011, 'Overview of An Inductively Coupled Plasma (ICP) System ', *International Journal of Chemical Research*, pp. 41-48.

A.S.S.Sekar, V.Saraswathy & G.T.Parthiban 2007, 'Cathodic Protection of Steel in Concrete Using Conductive Polymer Overlays', *International Journal of Electrochemical Science*, pp. 872-882.

Ajjam, SK & Ghanim, AN 2012, 'Electrocoagulation of Textile Wastewater with Fe Sacrificial Anode ', vol 12.

Al-Himdani, FF, Mahdi, WI & Khuder, AWH 2005, 'Corrosion Protection of Coated Steel Pipeline Structures using CP Technique', *Journal of Engineering and Development*.

Al-Sultani, KF. & Nabat, JN 2012, 'Protect of Underground Oil Pipelines by Using (Al-Sn-Zn) as Sacrificial Anode in Al-Qasim Region', *Journal of American Science*, pp. 158-165.

Andrade, C, Gulikers, J, Polder, R & Raupach, M 2003, 'Half-cell potential measurements – Potential mapping on reinforced concrete structures ', *RILEM*, pp. 461-471.

Baere, KD, Verstraelen, H, Rigo, P, Passel, SV, Lenaerts, S & Potters, G 2013, 'Reducing the cost of ballast tank corrosion: an economic modeling approach', vol 32.

Basham, DL, Wright, JW, Ferguson, K & Moy, GW 2003, *Operation and Maintenance : Cathodic Protection*, UFC.

Briggs, T & Eseonu, YM 2014, 'Efficiency of Corrosion Inhibitors on Cathodic Protection System', *International Journal of Engineering Trends and Technology (IJETT)*.

Cassinath, Z 2013, *Development of Twin Screw Rheo Extrusion Technology*, Brunel Centre for Advanced Solidification Technology (BCAST).

Deborde, J, Refait, P, Bustamante, P & Caplat, C 2015, 'Impact of Galvanic Anode Dissolution on Metal Trace Element Concentrations in Marine Waters', vol 226.

Emami, MRS 2012, 'An Experimental and Theoritical Investigation of Corrosion Mechanism in a Metallic Stack', *Iranian Journal of Materials Science & Engineering*, vol 9, no. 3, pp. 58-66.

Fontana, MG 1987, *Corrosion Engineering*, McGraw Hill,Inc, Singapore.

Hafizh, MM, Sunhaji, A, Norhayati, S & Noriyati, S 2015, 'Performance Analysis of 99.5% Alumunium Alloy as a Sacrificial Anode', vol 11.

Ivanov, H 2016, *Corrosion Protection System in Offshore Structure*, University of Akron, Ohio.

Javadi, M, J.Javidan & Salimi, M 2104, 'Cathodic Protection of an underground Pipeline by Photovoltaic Power System using Intelligent Method', *International Journal of Renewable Energy Research*, pp. 267-274.

Jeong, JA, Choo, YG, Jin, CK & Park, KW 2014, 'Numerical Analysis Result of The Cathodic Protection for The Underground Steel Pipe by Anode Installation Method', vol 38.

Jeong, JA & Jin, CK 2014, 'The effect of Cathodic Protection System by Means of Zinc Sacrifial Anode on Pier in Korea', *Journal of the Korean Society of Marine Engineering*, pp. 1206-1211.

Khavasfar, A, Moayed, MH & Attar, MM 2007, 'An Investigation on the Performance of an Imidazoline Based Commercial Corrosion Inhibitor on CO2 Corrosion of Gas-well Tubing steel by EIS Technique ', *Iranian Journal of Materials Science and Engineering*, vol 4, no. 3, pp. 1-8.

Kumar, GM, I., N & Ajitha, AMVU 2014, 'Inductively Coupled Plasma Atomic Emission Spectroscopy : An Overview', *International Journal of Pharmaceutical Research & Analysis*, pp. 470-477.

Kumar, S, Rajalingam, K & G.R.Kannan 2014, 'Numerically Analysis of Corrosion Resistance and Control Plate'.

Loto, CA & Popoola, API 2011, 'Effect of Anode and Size Variation on The Cathodic Protection of Mild Steel in Sea Water and Sulphuric Acid ', vol 6.

Mahasiripan, A, Tangtermsirikul, S & Sancharoen, P 2014, 'A study of Different Sacrificial Anode Materials to Protect Corrosion of Reinforcing Steel in Concrete', vol 19, no. 4.

Masli, AB 2011, *Interaction Between Cathodic Protection and Microbially Influenced Corrosion*, University of Manchester, Manchester.

McCafferty, E 2010, *Introduction to Corrosion Science*, Springer , New York.

NACE 2002, *NACE Corrosion Engineer's Reference Book*, NACE International The Corrosion Society, Houston.

Nguyen, CV, Lambert, P, Mangat, P, O'Flaherty, F & Jones, G 2012, 'The Performance of Carbon

Fibre Composites as ICCP Anodes for', *ISRN Corrosion*, p. 9.
Panah, MB & Ajani, N 2016, 'Synthesis and Study of Corrosion Performance of Epoxy Coating Containing Multi-walled Carbon Nanotube/Polyortho Aminophenol Nanocomposite', *Iranian Journal of Materials Science & Engineering* , vol 13, no. 1, pp. 1-10.
Ramesh, SPM & Periasamy, V 2014, 'Synergic effect of Thiomalic acid and Zinc ions in Corrosion control of Carbon Steel in Aqueous Solution', *Research Journal of Chemical Sciences*, pp. 41-49.
Rehman, A, Amin, F & Abbasm, M 2014, 'Sacrificial Protection Method During Disinfection to Avoid Corrosion', vol 34.
Roberge, PR 1999, *Handbook of Corrosion Engineering*, Mc Graw Hill Company, Highstown, United State.
Rogers, TH 1974, *Marine Corrosion, Science and technology*, George, London.
Ryan, J & Clark, ML 2010, 'Trace metal determination in tobacco and cigarette ash by inductively coupled plasma-atomic emission spectroscopy', *Concordia College Journal of Analytical Chemistry 1*, pp. 34-41.
Susilo, AK, Ahmadi, Suharyo, OS & Pratisna, P 2017, 'Applied of Impressed Current Cathodic Protection Design for Fuel Pipeline Network at Naval Base', *International Journal of Materials Science & Engineering* , vol 14, no. 2, pp. 41-52.
Talbot, D & Talbot, J 1998, *Corrosion Science and Technology*, CRC Press, Florida.
Trejo, D, Reinschimdt, K & Halmen, CI 2009, *Corrosion Performance Tests For Reinforcing Steel in Concrete : Technical Report*, Texas Transportation Institute, Texas.
Yazdani, A, Soltanieh, M & Aghajani, H 2009, 'Study on Corrosion Properties of plasma Nitried Pure Aluminium', *Iranian Journal of Materials Science and Engineering*, vol 6, no. 4.

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STUDY OF BRIDGE REINFORCEMENT CONCRETE DESTRUCTION TECHNIQUES USING TNT AND C_4 EXPLOSIVES TO OPTIMIZE THE POWER OF EXPLOSIVES

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ABSTRACT

Explosive technology is the fracturing of materials by using a number of calculations from the explosion so that the volume of breakable material can be determined. This study is to find out how the 30 cm diameter bone bridge concrete technique and how the explosive strength difference of explosive TNI and C4 at the same weight to the concrete of the bridge. The method used is literature study and field experiments. The results of this study were obtained for effective and efficient blasting of concrete and resulted in an optimum explosion with several steps: calculating concrete strength by Core Drill test, calculating the amount of current required, calculating the amount of C4 and TNT explosives required. The explosive strength difference of explosive TNI and C4 at the same weight to the concrete with the value of fc = 229.31 kg / cm2 Core Drill test. C4 explosives have more complete destructive power compared to TNT and the number of effective explosives required to destroy the concrete with the strength of fc = 229.31 kg / cm2 is 122 g.

Keywords: Concrete Power, TNT and C_4 explosive, Tamping Factor

1. INTRODUCTION

Explosive technology is the material fracturing process by using calculations from the explosion. So that the volume of breakable material can be determined. In this research, the study of reinforced concrete technique by using effective and efficient explosive of TNT and C4 to optimize the explosive power was performed. The objective of this study was to know the destruction technique of 30 cm diameter reinforced concrete. So they could be completely destroyed using TNT and C4 explosives, and to know the difference in the explosive power of TNT and C4 on the same weight of concrete bridge. As for the method used was literature study and field experiments. Explosive technology is the material fracturing process by using calculations from the explosion so that the volume of breakable material can be determined. Originally, black power was widely used to detonate materials, however there have been many developments in the use of: explosives, detonators, delay techniques and the mechanism of rock breaking with explosive (Jovisevic, et al., 2007).

Reinforced concrete is an excellent composite structure for use in building construction.There are various benefits of reinforced concrete structures resulting from the merging of two materials, namely concrete (PC + fine aggregate + rough aggregate + additive) and steel as reinforcement. We've already known that the superiority of the concrete is the high compressive strength, while the reinforcing steel is excellent for withstanding tensile and shear forces (Ilangovana, et al., 2008). The merger between concrete and reinforcing materials allows the construction agent to acquire new materials with the ability to withstand compressive, tensile, and shear forces so that the overall structure of the building becomes stronger and safer (Neville, 2011).

Therefore, the new finding in building material by adding reinforcing steel to strengthen the concrete is useful to overcome the shortcoming of concrete material. The reinforcing steel should use deformed bar steel (Shende, et al., 2012). While plain bar can only be used for spiral and tendon reinforcement, except for certain cases. However, to get the concrete strength above 35 or 40 Mpa required a very careful concrete mix design and full attention to detail such as mixing, placement, and maintenance. This requirement led to greater relative cost increases. The tensile strength of the concrete was not directly proportional to the ultimate strength of the fc '. Nevertheless, this tensile strength was estimated to be directly proportional to the square root of fc '. This tensile strength was difficult to measure with direct axial tensile loads due to the difficulty of holding test specimens to avoid stress concentrations and the difficulty of straightening the loads. As a result, two indirect tests were created to calculate the tensile strength of the concrete (Schuman & John Tucker, 1943) (Yao, et al., 2017). Both were modulus test collapse and cylindrical cleavage test.

Concrete tensile strength during flexure was important when we were reviewing cracks and deflections in beams (Khalil & R., 2013). For this purpose, we had been using the tensile strength obtained from the modulus-collapse test. The collapse modulus was usually calculated by burdening a square concrete beam (with simple support of 6m gap from asphalt) without the reinforcement and the size was 15 cm x 15 cm x 75 cm. It was performed until it collapses with a centralized load equal to 1/3 of the points on the beam corresponding to those mentioned in ASTM C-78. These loads continued to be increased until the collapse occured due to cracks in the tilted beam. The collapse modulus fr was determined later from the bending formula. The voltage determined in this way was not very accurate because we assume the concrete was in a perfectly elastic state with a voltage proportional to the distance from the neutral axis (Lee, et al., 2014).

In measuring bomb strength, there are five points to consider, the first is VOD (velocity of detonation), the second is strength, the third is sensitivity, the fourth is density, and the fifth is time saving (Bansal, et al., 2016). For military, VOD is usually large and the average is more than 4500 m/sec, has poor sensitivity, heavy beat, with higher type. The further the power, the stronger the explosive power. The TNT vapor is about 6,800 meters per minute. While the ANFO or Ammonium Nitrate has the power of 3000 meters per second and the RDX power reaches 8,000 meters per second (Al-Zuhairi & Qasim, 2016).

The benefit of this study is to know the 30 cm diameter bone bridge concrete technique and how the explosive strength difference of TNI and C4 explosive at the same weight to the concrete bridge and to know the amount of explosive C4 and TNT needed for breakable material can be determined.

In this paper, the Material and Methodology used would be described in Section 2, Research Results and Discussion in Section 3, last chapter Conclusions in Section 4.

2. MATERIAL AND METHODOLOGY

2.1. Reinforced Concrete

Concrete is a building material made of cement (Portland cement or other hydraulic cement), sand or fine aggregate, gravel or coarse agregate, water and with or without additives. The concrete compressive strength for planning is determined by the compressive strength of the concrete at 28 days. Although now we can produce concrete with a compressive strength of over 100 MPa, the compressive strength of concrete commonly used in planning ranges from 20 to 40 MPa. Concrete has a high compressive strength but has a low tensile strength, ranging from 8% to 15% of its compressive strength (Shang, et al., 2012) (Kristiawan, 2006).

Deep knowledge about reinforced concrete properties is essential before the design of reinforced concrete structures begins (Rai & Joshi, 2014). Some of the properties of reinforced concrete are:

a. Compresive Strenght

The concrete compressive strength (f'c) was performed by conducting a concrete cylinder test with a diameter of 150 mm and a height of 300 mm for 28 days with a certain loading rate. During this 28-day period, the concrete cylinder was usually placed in a room with a fixed temperature and 100% humidity. Although there was a concrete with a maximum strength of 28 days from 17 MPa to 70 -140 Mpa, most concrete had a strength in the range of 20 MPa to 48 MPa. For general applications, 20 Mpa and 25 Mpa of concrete were used, while for prestressed concrete was 35 Mpa and 40 Mpa. For certain applications, such as for columns on the lower floors of a high-rise building, concrete with strength up to 60 Mpa had been used and could be provided by ready-mix concrete manufacturers. The values of concrete compressive strength as obtained from the test results were strongly influenced by the size and shape of the test element and the manner of loading. In many countries, the test specimens used were cubes containing 200 mm. For the same concrete, the test of the cylinders with the size 150 mm x 300 mm only produced a compressive strength of 80% of the value obtained from the cubic concrete test. The concrete strength could switch from 20 MPa concrete to 35 Mpa concrete without the need to add excessive amount of labor and cement. The approximate increase of material cost to get such power increase was 15% to 20%. The stress-strain curves in the following image showed the achievement results from compression tests on a number of 28-day standard test cylinders of various strength.

1) The curve was almost straight when the load was increased from zero to approximately 1/3 - 2/3 of the concrete maximum strength
2) Above this curve, the concrete behavior was nonlinear. The nonlinearity of the concrete stress-strain curve at this higher tension led to some problems when the structural analysis of the concrete constructs was performed. It was due to the construction behavior that will also be nonlinear at higher tension.
3) One important thing to note wass the fact that no matter how large the concrete strength was, all concrete wiould reach its peak strength at a about 0.002 of strecth.
4) The concrete did not have a definite melting point, otherwise the concrete curve would remain smooth until it reached the point of rupture at about 0.003 to 0.004 of stretch.

b. Static Modulus of Elasticity

Concrete does not have a definite elastic modulus. Its value varies depending on the concrete strength, the age of concrete, the type of loading, and the characteristics and comparison of cement and aggregate. In addition, there are several definitions of the modulus of elasticity:

1) The initial modulus is the slope of the stress-strain diagram at the origin of the curve.

2) The tangent modulus is the slope of one tangent to the curve at a certain point along the curve, for example at 50% of the maximum strength of the concrete.

3) The slope of a line drawn from the point of the curve origin to a point on the curve somewhere between 25% to 50% of its maximum compressive force is called the Secant Modulus.

4) The other modulus, called apparent modulus or long-term modulus, is determined using the stresses and strain obtained after the load is given for a certain time.

5) The ACI regulation states that the formula for calculating the concrete modulus of elasticity with weight of concrete (wc) ranges from 1500-2500 kg/m^3.

6) Where: wc is weight of concrete (kg/m^3), fc' is concrete quality (Mpa), and Ec is modulus of elasticity (Mpa)

c. Dinamic Modulus of Elasticity

The dynamic modulus of elasticity, corresponding with various small instantaneous strains, is usually obtained from the sonic test. The value is usually 20% -40% greater than the static elasticity modulus value and approximately equal to the initial value of modulus. This dynamic modulus of elasticity is usually used in structural analysis with seismic or impact loads.

d. Poisson Ratio

When a concrete receives a compressive load, the cylinder is not only reduced in height but also expands in the lateral direction. The comparison of lateral expansion with this longitudinal approach is called the Poisson's ratio (Poisson's ratio). The values range from 0.11 for high quality concrete and 0.21 for low quality concrete, with an average value of 0.16. There seems to be no direct relationship between this ratio value with values of water-cement ratio, length of treatment, aggregate size, and so on. In most reinforced concrete designs, the effect of this poisson ratio is not particularly noticed. However, the ratio effect must be taken into account when we analyze and design arc dams, tunnels, and other indefinite static structures.

e. Tensile Strenght

Concrete tensile strength varies between 8% to 15% of the compressive strength. The main reason for this small tensile strength is the fact that the concrete is filled with fine cracks. These cracks have no major effect when the concrete receives the compressive load because the compressive load causes the crack closing and allows the occurrence of chanelling pressure. This obviously does not occur when the beam receives load. Although usually neglected in design calculations, tensile strength remains as an important property that affects the concrete size and how big the cracks occur. Since concrete tensile strength is not large, little effort is made to calculate the tensile elasticity modulus of the concrete. However, based on this limited information, it is estimated that the value of the tensile modulus of elasticity is equal to the modulus of elasticity of the press. The concrete is not assumed to withstand the tensile stress that occurs on a flexible bar and the steel that holds it. The reason is that the concrete will crack at such tensile strain so that the low voltages present in the steel will cause an uneconomical use of it.

f. Shear Strenght

The test to obtain a completely pure shear collapse without being affected by other stresses was very difficult. Consequently, concrete shear strength testing over the years always resulted in melting values located between 1/3 to 4/5 of its maximum compressive strength.

g. Stress-Strain Curve

The stress-strain relationship of concrete needed to be known to derive the analytical and design equations as well as the procedures on the concrete structure.

h. Column

The column definition according to SNI-T15-1991-03 is a component of a building structure whose main task is to support a vertical axial load with a high, unsupported height at least three times the smallest lateral dimension. Columns are vertical composite rods of frames structures that carry loads from both the main beam and the small beam. The column continues the load from the upper elevation to the lower elevation until it reaches the ground through the foundation.

The collapse of a column is a critical condition that can cause the collapse of the floor and the total collapse of the entire structure. The column is a structure that supports the load from the roof, the beam and its own weight is passed to the foundation. The structure of the column receives a large vertical load, in addition it must be able to withstand horizontal loads even torque due to the influence of the eccentricity of loading. Things to note are the height of the planning column, the quality of concrete, steel used and the eccentricity of loading that occurs.

i. Beam

A beam is a part of a structure that serves as a vertical and horizontal load support. The vertical loads are dead loads and live loads received by floor plates, the weight of the beams and the weight of the above insulating wall. While the horizontal wind load and earthquake load. Beams are an important part of building structures and the aim is carrying a tranversal load that can be either flexural, shear or torque loads. Therefore, the effeicient, economical and safe beam planning is essential for a building structure, especially high-rise structures or large-scale structures

2.2. C4 Explosive

Any new explosives can explode in case of collisions, friction, or elevated temperatures. In case of friction, the explosive will turn into another more stable substance followed by a high pressure that produces a violent explosion or spark. Apparently, the assembly of explosives is not too difficult, since almost all objects can produce chemical reactions that produce explosions. Moreover, currently explosives are easily found in mining or exploration industries, along with the stone miners and fishermen (Rarata & Smętek, 2016).

One of the high explosive categories is emulsion, which is a mixture of ammonium nitrate + almunium + sulfur. Ammonium nitrate is the most probable and easily formulated commercial explosive. Other materials are PETN, RDX, and Semtex (which are a mixture of RDX and PETN, originally from Czech, Eastern Europe, and usually used by terrorists) (Verkouteren, 2007). These results are subsequently coded into C, C2, C3, and C4. All of them use RDX. The difference is the presence of plasticizer and sometimes combined with TNT and PETN. C4 has the largest RDX, so it has the most damaging power. TNT, RDX, PETN, and C4 (which are a combination of RDX + PTEN + TNT) are classified as military exsplosive (Cross, 2014). C4 bombs are plastic bombs, high explosive, very sensitive, used only for military purposes (for example, for the purposes of blowing bridges). The shape is solid, can be like a small stick or square and can be detonated using a timer, remote control, key contacts, and so on, produced in America and Europe.C4 is prone to vibration, prone to light, and prone to darkness. It is often used for military duties destruction and only used by special forces.

The explosive in C4 is RDX (cyclonite or cyclotrimethylene-trinitramine), which is 91% of C4 weight like many plastic explosives and the binder is usually polyisobutylene (2.1%). The plasticizer is diethylhexyl (5.3%) sebacate or dioctyl. Other plasticizers used are dioctyl adipate (DOA). The chemical material of 2,3-dimethyl-2,3-dinitrobutane is used to help explosives detection and identify its source. A small amount of SAE 10 non-detergent motor oil (1.6%) is also added. C4 is produced by combining the recorded material with the material dissolved in the solvent (Belmas & Plotard, 1995). The solvent then evaporates and the mixture is dry and filtered. The last material is solid off-white which is similar to clay. Because the C4 bomb has several advantages, namely: This bomb can be easily formed into any desired shape, C4 is very stable and insensitive to physical shocks, thus the blasting can only occur due to a combination of extreme heat and shock waves. C4 can not be detonated by a shot or by dropping it to a hard surface. C4 also does not explode when burned or exposed to microwave radiation (Campeau, et al., 2008).

2.3. TNT Explosives

TNT as a chemical structure is actually an abbreviation of Trinitrotoluene, which is an aromatic organic chemical compound with the structure formula of C_6H_2 (NO_2) $3CH_3$ compound, commonly written under the name 2,4,6 – Trinitrotoluene (Figure 1). Where, 2,4,6 are points, where NO2 is attached with carbon in the aromatic cycle (Pitz & Westbrook, 2005) (Qasim, et al., 2007).

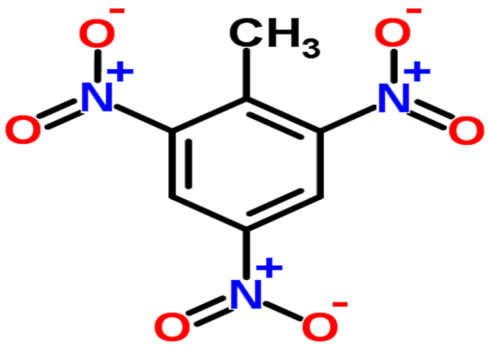

Fig. 1 Structure Formula of TNT

TNT has IUPAC (International Union of Pure and Apllied Chemical) name as 2-methyl-1,3,5 - Trinitrobenzene. This compound has a molecular weight of 227.13 grams / mol, in accordance with the total number of atomic weights that constitute it. TNT is mostly used as an explosive and in the military industry, because its use is quite easy and safe. For example, the possibility of spontaneous or accidental explosions is very small, due to high melting point and not too sensitive to shocks (Carper, et al., 1982)

Physical and Chemical Properties in physical form: TNT in normal condition is a pale yellow, crystalline. Odor: odorless. Molecular Weight: 227,13 grams/mol. Melting Point: 80 ^{0} C. Boiling Point: 240 ^{0} C. Density: 1, 6 ± 1 gram/cm_3 Water solubility: 130 mg / L at 20 ^{0} C (soluble in water). Easy soluble inside: ether, acetone, benzene, and pyridin Vapor Pressure: 0.0002 mmHg at 20 ^{0} C. Explosion Data Detonation Speed: 6900 m / s (first shock rate shortly after an explosion. Sensitivity to shock: No reaction up to shock of 15 Newton.meter Sensitivity to Friction: No reaction to frictional force 353 Newton Reaction - Synthesis.

2.4 Research Conceptual Framework

A study is a systematic process and based on the information obtained, a flow sheet it can be compiled as follows figure 2.

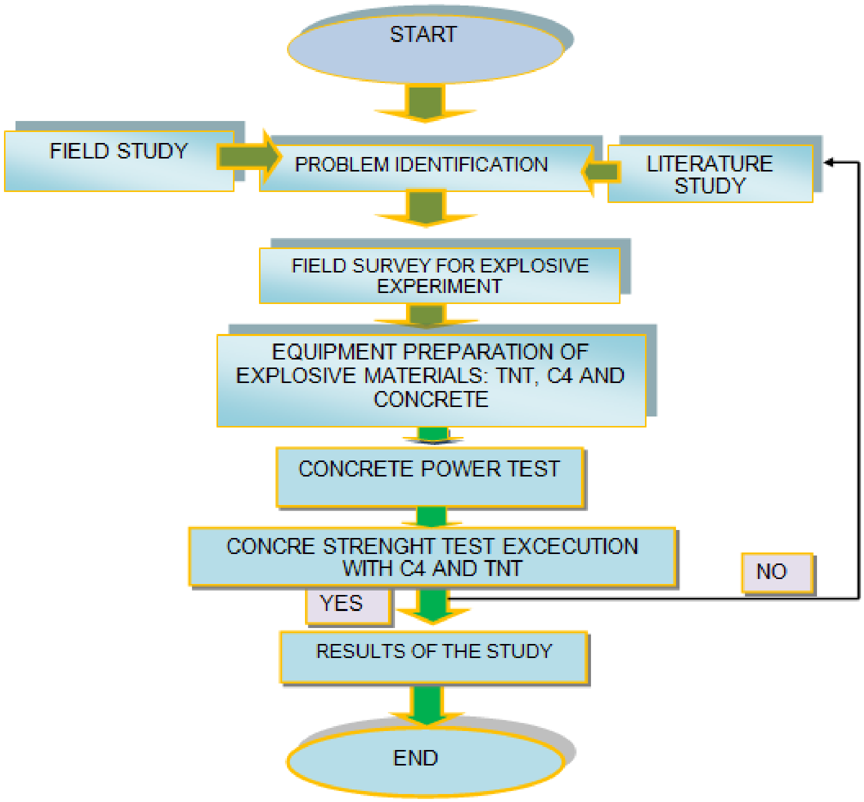

Fig. 2 Flow Chart and Stage of Research Plan

3. RESEARCH RESULTS AND DISCUSSION

3.1. Value Of Various Material

The explosive strength (K) data and Tamping value of this data affected the position where the explosive was placed on the material detenoted (Al-Homoud, 2005). The value of the explosive coefficient can be seen in the following table 1.

Table. 1 The Value Of Combustion Coefficient (C) On Various Material.

Building Thickness (m)	Hole Depth (m)	Coefficient Value (C)			
		Brick Building	Stone	Concrete	Reinforced Concrete
0,50	0,35	1,20	1,46	1,58	1,70
0,60	0,40	1,18	1,22	1,32	1,70
0,75	0,50	0,86	1	1,08	1,12
0,90	0,60	0,65	0,76	0,81	0,87
1-1,2	0,65-0,80	0,58	0,65	0,70	0,76
1,3-1,5	0,85-100	0,50	0,58	0,63	0,68
1,5-1,7	1,05-1,15	0,45	0,54	0,58	0,62
1,8-2	1.20-1,40	0,43	0,52	0,54	0,56

The tamping factor (C) is the coefficient value depending on the location of the fill and the type of tamping that is used. The value of tamping in a Demolition can be seen in the tamping image as shown below.

3.2. The Data of Concrete

Concrete data for Demolision Performance tested in ITS Core Drill Laboratory in table 2.

Table 2. Test Result of Concrete dP Core Drill Laboratory

No	Description	Unit	Core 1	Core 2
1	Press Load	kg	16550	11400
2	Cross-Sectional Area	Cm2	69,40	69,40
3	Sillinder core	Kg/cm2	238,48	164,27
4	Compresive Strength	Kg/cm2	229,31	157,95

3.3. The Measurement of TNT and C_4 Utilization

The destroying of the concrete was using the following formula: P = R3KC. That formula aimed to determine the number of C4 reuquired for the destruction of concrete bridge, with 0.50 cm thick and 0.50 cm wide, means K = 1.58, R = 0.35 C (Tamping) = 1.8

$P = R^3KC,$

$= 0,35^3.1,58. 1,8.$

$= 0,122$ kg

=122 gr explosives.

Based on the explosive experiments data using explosives with the amount oof 100, gr, 200 gr and 300 gr, explosion results of several explosive weight and concrete strength of fc 229.31 kg / cm3 could be obtained ands presented in the data as follows table 3-4 and figure 3.

Table. 3 Explosion Resultf of C_4 from several weight

NO	WEIGHT OF C_4 EXPLOSIVE	CONCRETE STRENGHT fc kg/cm3	EXPLOSION RESULTS
1	100 gr	229,31	Split into 15 parts
2	100 gr	229,31	Split into 16 parts
3	100 gr	229,31	Split into 16 parts
4	100 gr	229,31	Split into 17 parts
5	200 gr	229,31	Split into 100 parts
6	200 gr	229,31	Split into 120 parts
7	200 gr	229,31	Split into 125 parts
8	200 gr	229,31	Terbelah 100 bagian
9	300 gr	229,31	Destroyed with no residue = 500
10	300 gr	229,31	Destroyed with no residue = 500
11	300 gr	229,31	Destroyed with no residue = 500
12	300 gr	229,31	Destroyed with no residue = 500

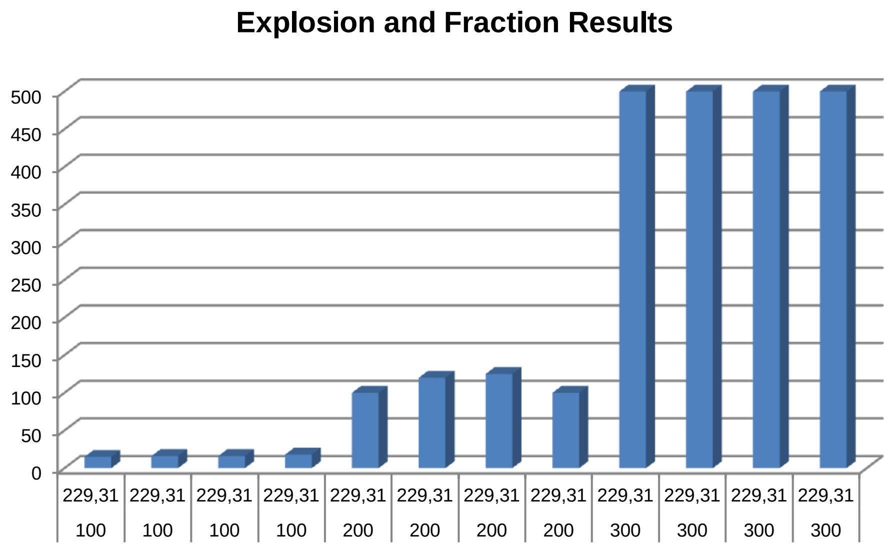

Fig. 3 Column Graph Explosive Mass And Concrete Strength With Explosion Results

Table. 4 TNT Explosion Result from several weights

NO	WEIGHT OF TNT EXPLOSIVE	CONCRETE STRENGHT fc kg/cm3	EXPLOSION RESULTS
1	100 gr	229,31	Split into 9 parts
2	100 gr	229,31	Split into 10 parts
3	100 gr	229,31	Split into 10 parts
4	100 gr	229,31	Split into 11 parts
5	200 gr	229,31	70 flakes
6	200 gr	229,31	75 flakes
7	200 gr	229,31	72 flakes
8	200 gr	229,31	71 flakes
9	300 gr	229,31	Destroyed with combustion residue
10	300 gr	229,31	Destroyed with combustion residue
11	300 gr	229,31	Destroyed with combustion residue
12	300 gr	229,31	Destroyed with combustion residue

4. CONCLUSION

a. The effective and efficient technique of concrete detonating can be done in several steps, namely:

1). The calculation of the concrete strength that will be detonated through the laboratory test is performed to find out the value of fc Core Drill test or by calculating the K strength of the concrete detonated through the correlation table of material strength along with the tamping value.

2) Calculating the amount of current required to detonate the detonator with the following formula E = IR, E = Voltage / Voltage in volt, I = Current in ampere R = Resistance in Ohm.

3). Calculating the amount of C4 and TNT explosives required by using the following formula P = R3. K.C. (P = Number of Explosive needed, R = correlation value of material thickness that is distinguished according to table 4.1, K is strength or coefficient value according to table 4.1, C = tamping factor)

b. The difference of explosive strength between TNI and C4 at the same weight to the concrete with the value of fc = 229.31 kg / cm2 Core Drill test. C4 explosives have more complete destructive power compared to TNT and the number of effective explosives required to destroy concrete with the strength of fc = 229.31 kg/cm2 is 122 g.

5. **References**

Al-Homoud, M. S., 2005. Performance Characteristics and Practical Applications of Common Building Thermal Insulation Materials. *Journal of Building and Environment,* 40(3), pp. 353-366.

Al-Zuhairi, A. H. A. & Qasim, A. J., 2016 . Response Of R.C. Barriers Subjected To Tnt Explosion Blast Loading. *Applied Research Journal ,* 2(3), pp. 125-133.

Bansal, A., Girdhar, A., Tomar, K. & Sehgal, S., 2016. Explosion Intensity Measurement using Piezo Element. *International Research Journal of Engineering and Technology (IRJET),* 4(1), pp. 165-168.

Belmas, R. & Plotard, J.-P., 1995. Physical Origin of Hot Spots in Pressed Explosive Compositions. *Journal De Physique,* Volume 5, pp. 61-86.

Campeau, L.-C.et al., 2008. C2, C5, and C4 Azole N-Oxide Direct Arylation Including Room-Temperature Reactions. *Journal of American Chemical Society,* 130(11), p. 3276–3277.

Carper, W. R., Davis, L. P. & Extine, M. W., 1982. Molecular structure of 2,4,6-trinitrotoluene. *The Journal of Physical Chemistry,* 86(4), p. 459–462.

Cross, K., 2014. Best Practice for Commercial Explosive Ordnance Disposal (EOD) in Great Britain. *The Journal of The Institute of Explosives Engineers,* pp. 8-11.

Ilangovana, R., Mahendrana, N. & Nagamanib, K., 2008. Strength And Durability Properties Of Concrete Containing Quarry Rock Dust As Fine Aggregate. *ARPN Journal of Engineering and Applied Sciences,* Volume 3, pp. 20-26.

Jovisevic, V., Sokovic, M. & Kosec, B., 2007. Introduction Of Explosive Cladding Technology For The Manufacturing Of Hydraulic Cylinders. *Metalurgija,* 46(4), pp. 273-276.

Khalil, W. I. & R., T. Y., 2013. Flexural Strength Of Fibrous Ultra High Performance Reinforced Concrete Beams. *ARPN Journal of Engineering and Applied Sciences,* Volume 8, pp. 200-214.

Kristiawan, S. A., 2006. Strength, Shrinkage and Creep of Concrete in Tension and Compression. *Civil Engineering Dimension,* 8(2), p. 73–80.

Lee, S.-H., Hong, K.-N., Park, J.-K. & Ko, J., 2014. Influence of Aggregate Coated with Modified Sulfur on the Properties of Cement Concrete. *Materials,* Volume 7, pp. 4739-4754.

Neville, A. M., 2011. *Properties of concrete.* London : British Library Cataloguing in Publication Data.

Pitz, W. J. & Westbrook, C. K., 2005. A Detailed Chemical Kinetic Model for TNT. *Lawrence Livermore National Laboratory,* pp. 1-8.

Qasim, M. M. et al., 2007. Structural Characteristics and Reactivity Relationships of Nitroaromatic and Nitramine Explosives – A Review of Our Computational Chemistry and Spectroscopic Research. *International Journal of Molecular Sciences,* Volume 8, pp. 1234-1264.

Rai, A. & Joshi, D. Y., 2014. Applications and Properties of Fibre Reinforced Concrete. *Int. Journal of Engineering Research and Applications,* 4(5), pp. 123-131.

Rarata, G. & Smętek, J., 2016. Explosives based on hydrogen peroxide - A historical review and novel applications. *High-Energetic Materials,* Volume 8, p. 56 − 62.

Schuman, L. & John Tucker, J., 1943. Tensile and Other Properties of Concretes Made With Various Types of Cements. *National Bureau of Standards,* Volume 31, pp. 107-124.

Shang, H.-S., Yi, T.-H. & Yang, L.-S., 2012. Experimental Study on the Compressive Strength of Big Mobility Concrete with Nondestructive Testing Method. *Advances in Materials Science and Engineering,* pp. 1-6.

Shende, A., Pande, A. & Pathan, M. G., 2012. Experimental Study on Steel Fiber Reinforced Concrete for M-40 Grade. *International Refereed Journal of Engineering and Science (IRJES) ,* Volume 1, pp. 43-48.

Verkouteren, J. R., 2007. Particle Characteristics of Trace High Explosives: RDX and PETN. *Journal of Forensic Sciences,* 52(2), pp. 335-340.

Yao, W., Jiang, S., Fei, W. & Cai, T., 2017. Correlation between the Compressive, Tensile Strength of Old Concrete under Marine Environment and Prediction of Long-Term Strength. *Advances in Materials Science and Engineering,* pp.1-12.

FIELD III
POLICY & STRATEGY

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ROHINGYA REFUGEES AND POLICIES OF INDONESIAN GOVERNMENTS IN SOCIO ECONOMIC, AND SECURITY PROBLEMS OF THE REPUBLIC OF INDONESIA

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ABSTRACT

This paper intends to explain Indonesian policy in handling Rohingya refugees in Indonesia. This paper uses the normative legal method of tracking the provisions of international legislation such as conventions, statutes, protocols and declarations. Then presented descriptively by providing interpretation and description with regard to research problems that the authors review. This paper outlines three important points about Indonesian policy to handle Rohingya refugees in Indonesia. First, the Government of Indonesia made a new policy by adjusting existing regulations regarding refugee issues and working with the international community in solving the problem of spiritual refugees. Second, the impact for Indonesia itself as a temporary shelter for spiritual refugees on the socio-economic aspect. Third, the impact for Indonesia itself as a temporary shelter for spiritual evacuation of the Indonesian republic.

KEYWORDS : Rohingya Refugees, Indonesian Policy, Socioeconomic, Security.

1. INTRODUCTION

Indonesia is a maritime country with more than 17,508 islands stretching from Sabang to Merauke. Indonesia's position is geographically located in a strategic area. Indonesia lies between the two continents of Asia and Australia, and is located between the two Indian Ocean and Pacific Oceans, making Indonesia a shipping lane used by refugees to reach the destination country. Indonesia is not the main destination country for refugees from the Asian Continent. However, due to its strategic position, Indonesia became one of the transit countries for refugees across borders, especially from the Indo-Chinese mainland before they continued their journey to the destination country.

Ethnic Rohingya is one of the ethnic groups living in Myanmar is Muslim, but they are not recognized as citizens and experienced discrimination by the government of Myanmar. Ethnic Rohingyas live in the Arakan region that is also inhabited by ethnic Rakhine, but the relationship between the two is not harmonious. In May 2012, conflict broke out between ethnic Rohingya and ethnic Rakhine. Monks and Rakhine ethnic people demonstrated "No Rohingyas", killed ethnic Rohingyas, damaged buildings of worship, and damaged shelters. The conflict resulted in more than 70 people dying, more than 3,000 damaged buildings, and nearly 60,000 people homeless and forced to flee to Malaysia, Thailand and Indonesia (www.rohingya.org, 2017).

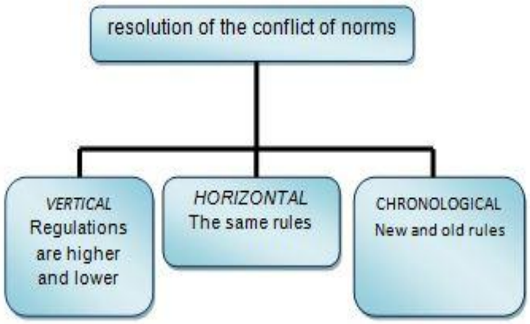
The Rohingya refugees are out of Myanmar because they feel it is no longer safe to live in their own country. Rohingya is a minority Muslim community in northern Arakan, west of Myanmar. They are perceived as stateless people and are not fully recognized by citizenship by the government of Myanmar. The Rohingyas are regarded as temporary residents and are not entitled to full citizenship rights. Myanmar's junta not only intimidates them, but has raided anti-Islam among Buddhist Rakhine and Burmese peoples as a campaign against the ethnic Muslim Rohinggya. The movement was successful and finally Rohinggya faced discrimination by the democratic movement of Myanmar. As stated in Constitution 1945, 'Just and civilized humanity' is one of the foundations of the state of Indonesia to participate in assisting the handling of refugees across borders. Indonesia has an obligation to assist refugees on the basis of humanity and respect for international rules. Prior to the Rohingya refugee case, Indonesia has succeded in handling cases of cross-border refugees, namely the 1975 Vietnamese refugee case and East Timor refugees in 1999. According to the 1945 Constitution article 28 G of Clause 2 stating that, "Everyone has the right to be free from torture or degrading treatment of human dignity and entitled to political asylum from other countries ". This is the basis of Indonesian law to protect the refugees across borders in Indonesia. Everyone's word in the sentence means that there is no limitation on anyone to get legal protection from Indonesia regardless of citizenship status (Anggrainy, 2014).

This humanitarian attitude is evidenced by the participation of Indonesia in addressing the problem of refugees in the region. The Indonesian government also volunteered to accommodate and prepare temporary shelters for Rohingya refugees. However, the refugees residing in the shelter can not stay for long, the government has given them time limits to stay in immigration detention centers. After the time limit has been set, the Government of Indonesia will no longer provide protection to the refugees. The humanitarian assistance provided by the Government of Indonesia to Rohingya refugees in Aceh has awakened the world's eyes to participate in helping to address the humanitarian crisis. The funding intended to meet the temporary needs of Rohingya refugees in Aceh has been accepted by the Government of Indonesia from the United States, Qatar, the United Nations, and several other countries. However, the funding does not seem to be able to solve the problem in real time. The main problem faced by these refugees is how to obtain clear citizenship and human rights status so that they can live properly.

These refugees come to Indonesia through several stages from 2012 to 2015. They come by using very simple fishing boats and with limited food supplies. Many of those who failed in the middle of the journey due to hunger and sinking ship because it is old and overload (Nuswanto, 2013). According to Heri Aryanto, Director of the Rohingya-Arakan Information and Advocacy Center (PIARA), he noted that not all Rohingya refugee arrivals to Indonesia originated from Myanmar and went directly to Indonesia. On his arrival in Indonesia, the Rohingya refugees were stranded in several areas in Indonesia such as Aceh, Medan, Riau Islands, to Banyuwangi, East Java. Conditions that are very concerning because of hunger make them forced to surrender to the Indonesian security and immigration authorities who are expected to provide adequate food and drink. In addition to Indonesia's strategic geographic location, the weakness of the Indonesian government's security and oversight system (especially in the border areas) is also one of the biggest factors that make the refugees and immigrants to stop in Indonesia. The presence of Rohingya refugees themselves can bring adverse impacts on the Indonesian people when it comes to demographics (demography), as well as socioeconomic that will indirectly affect the increasing crime rate in Indonesia, especially Aceh region. Indonesia is one of 17 observer countries in the International Organization for Migration (IOM) board since 1999 (IOM, 2014). Indonesia, which in fact is not an IOM member country has contributed a lot in handling Rohingya migration in Aceh. One of them is by making residential houses (detention) and temporary camps to accommodate the refugees. In addition, Indonesia also has many volunteers from various districts who are tasked with assisting and providing basic materials for the refugees.

2. METHODOLOGY

The type of research used is normative research, namely research that examines the provisions in legislation in order to examine the consistency and synchronization of the application of legislation in fact Soerjono (Soekanto, 2001). Sources of data used in this study are secondary data consisting of primary legal materials and secondary legal materials.



Data collection methods used in this study using two ways, namely; Literature study, by finding and finding the primary legal materials in the form of legislation related to the research conducted, searching and finding secondary legal materials in the form of legal opinions and non-law, then identify the secondary data obtained about the role of Indonesian government policy in solving the problem of spiritual refugees to the socioeconomic and security aspects of the republic of Indonesia. The data obtained were analyzed by using normative legal research method that is tracing to international law such as convention, statute, protocol or declaration. Then presented descriptively by providing interpretation and description with regard to research problems that the authors review. Thinking process is the last step in this research, that is to draw a conclusion. The process of thinking in this paper using deductive analysis that is based on a general proposition that the truth has been known and believed and ended in a special conclusion.

3. RESULT AND DISCUSSION

3.1. Rohingya Refugees

The Government of Indonesia has a definition of refugees as set forth in the Law on Disaster Management in Chapter I article 1 number 20 "Refugees are persons or groups of people who are forced or forced out of their homes for an uncertain period of time as a result of adverse impacts of disasters(Law of the Republic of Indonesia on Disaster Management : 2007) : (1) Natural disasters are disasters caused by events or series of events caused by nature such as earthquakes, tsunamis, volcanoes, floods, droughts, hurricanes, and landslides. (2) Non-natural disasters are disasters caused by events or series of non-natural events that include failing technology, failing modernization, epidemics, and disease outbreaks. (3) Social disaster is a disaster caused by events or series of human-caused events that include social conflicts between groups or between communities, and terror. The above law also explains the handling of refugees listed in Article 1 paragraph (3) refers to the handling of refugees is "The handling of refugees as referred to in paragraph (1) covers the efforts of humanitarian service and protection of refugees arising from the conflict. Both social and political events that occur in a region, including prevention, emergency response, shelter, displacement and refugee relocation (Law of the Republic of Indonesia on Disaster Management : 2007). Ethnic Rohingya is one of the ethnic groups living in Myanmar is Muslim, but they are not recognized as citizens and experienced discrimination by the government of Myanmar. Indonesia is one of the countries that provide shelters and facilities that are quite good compared to other countries, in the context of handling Rohingya refugees This is evidenced by the complete facilities and infrastructure supporting the daily needs of the refugees. Such as the availability of places of worship, schools, and clinics / hospitals to the hall where the refugees can socialize with other refugees and local residents. Rohingya ethnic problems that initially domestic

Myanmar problem, eventually raised a Regional issue when ethnic Rohinggya stranded and evacuate other countries, so that it can disrupt the security of the country near and adjacent to Myanmar. Rohingya refugees are a common problem because the Rohingya refugees are burdening and becoming new problems in their stranded country. Since then, racial riots in Rakhine have expanded to the burning of villages and ethnic Rohingya extermination. With the increasing pressure of the Rohingyas, they are forced to seek refuge outside Myanmar. Bangladesh which is the nearest country and has historical relation with the ethnic Rohingnya become the main purpose. However, Bangladesh itself is not willing to accommodate them on the grounds of not able. So many Rohingya refugees to Bangladesh are repatriated once they arrive in Bangladesh. After ethnic Rohinggya get expulsion from Myanmar and refusal in Bangladesh, not a few ethnic Muslim spirits who finally run and seek asylum in Indonesia because Indonesia is one of the largest Muslim countries in Southeast Asia in hopes they will get protection in Indonesia. Indonesia became one of the Rohingyas' goals as Indonesia is a predominantly Muslim country expected to be a safe haven for Rohingyas.

3.2. Policies of Indonesian Governments

Indonesia as one of the host countries of Rohingya refugees has a series of legal rules governing refugees. However, the existing legal rules in Indonesia have not been fully addressed to address these refugee issues. One of the regulations concerning refugees owned by Indonesia is contained in Law no. 39 of 1999 on Human Rights, the law reads: "Everyone has the right to seek asylum for political protection from other countries". However, in Law Number 37 Year 1999 concerning Policy Relations of the Government of Indonesia Foreign Affairs states that to handle refugee cases must be through Presidential Decree (Keppres). Prior to the issuance of Presidential Regulation of the Republic of Indonesia number 25 of 2016, the following will be discussed Indonesian government policies or laws that are closely related to the problem of illegal immigrants as the basis. Indonesian legislation that is closely linked to illegal immigration issues is Law No. 9 of 1992 on Immigration and Human Rights Instruments in the 1945 Constitution. Prior to the enactment of the Immigration Act, there are many regulations regulating immigration matters in Indonesia . Both the colonial legacy of the Dutch East Indies and the government of the Republic of Indonesia after the Proclamation of Independence August 17, 1945. All existing rules were declared no longer valid with the enactment of Immigration Law on March 31, 1992 as published in the State Gazette of 1992 Number 33. The Immigration Act does not provide a definition about what is meant by illegal immigrants. What exists is the definition of immigration, so that the traffic of persons entering or leaving the territory of the Republic of Indonesia and the supervision of foreigners in the territory of the Republic of Indonesia, as set forth in article 1 number 1 of the Immigration Law. While the Foreigner is a person not a citizen of the Republic of Indonesia (Article 1 point 6). By looking at this definition, clearly visible link between illegal immigrants with the Immigration Act, because illegal immigrants in this writing are foreigners who are in the territory of Indonesia. The following are the articles in the Immigration Law relating to illegal immigrants (Law of the Republic of Indonesia Number 24 on Disaster Management : 2007).

Under the Immigration Act, the Indonesian government places illegal immigrants in the Immigration Quarantine, in accordance with the provisions of article 44 of the Act. The Government also conducts surveillance of illegal immigrants under section 36 and to facilitate the journey of illegal immigrants, most of whom do not have valid travel documents, the Indonesian government issues travel letters as Passport for foreigners which is only given for one trip, in accordance with Article 35 Immigration Law. Meanwhile, the regulation and protection of human rights are also contained in Law No. 39 of 1999 on Human Rights, but relating to Dark Immigrants, especially articles 9, 11, 12, 21, 22, 26, 28, 29, 30, 33, 34, 35, 71 and 72. Articles 71 and 72 of Law No. 39 of 1999 on Human Rights regulate the obligations and responsibilities of governments to respect, protect, uphold and promote human rights including effective implementation steps in the field of law , political, economic, social, cultural defense and security of the state, and other fields regulated in national law as well as ratified international law (Sri Badini Amidjojo, 2004). The above policy is perfected by Presidential Regulation No. 125 of 2016 was signed by President Joko Widodo, issued late December 2016.

Indonesia which is one of the ASEAN member countries has a clear position to maintain the stability of national security from various regional security threats. In its handling, in connection with the Rohingya refugee issue, there is a dilemma that prevents ASEAN countries from working together to end the problem. The obstacle comes from one of the agreements that form the basis of ASEAN member countries. The Agreement has become the foundation of the organization and is recorded in the ASEAN Charter. The basic principle adopted by ASEAN is the principle of non-interventionism. On the other hand, the attitude shown by the UN has become more proactive. The United Nations has sent its envoys to the Arakan region of Myanmar to urgently urge the Government of Myanmar to resolve the problems immediately. However, until now the United Nations has not given warning and strong sanctions against the Government of Myanmar on the issue of Rohingya. The UN should have sent a security and peacekeeping mission to Myanmar, but that has not happened until now (Susetyo, 2013). The Government of Indonesia has worked closely with UNHCR and IOM to establish a Joint Verification Team (TVG / Team) to facilitate the determination of Rohingya refugee status. UNHCR is a child of a United Nations international organization specifically addressing refugee issues. UNHCR is collaborating with IOM to work together to discuss refugee issues around the world.

3.3. Socio-Economic Impact of the Republic of Indonesia

In Indonesia, until early 2017, at least 959 settled and spread in several regions in the archipelago, from Aceh, Medan, Makassar to Jakarta. The Human Rights Working Group (HRWG) with SUAKA, a civil society network working on the protection of refugee rights in Indonesia has mapped out five fundamental issues experienced by refugees in Indonesia, as well as its description (Yudhistira Dwi:2017):

a. Educational Issues.

HRWG Executive Director, Muhammad Hafiz explained, hundreds of spiritual children in Indonesia have difficulty access to education. Indeed, a number of public schools in some areas have expressed their attitude to accept some of their spiritual children as students, but still, the large number of spiritually displaced children is incapable of accommodating schools in Indonesia. In addition to not all schools have stated the same attitude - to receive the spirits, HRWG and SUAKA also admitted to having difficulties regarding data collection related to spreading the location of the spirits children. Related to this issue, HRWG encourages the government to find a gap solution that can accommodate the fulfillment of the rights of the spirit child to attend school.

b. Health Problems.

In addition to educational issues, Rohingya refugees in Indonesia are also experiencing difficulties in accessing health services. A complicated administrative process is touted as a major problem. HRWG notes, in some cases, mothers of ethnic spirits even have difficulty in the process of their delivery.

c. Job Problems.

Work issues become one of the most complicated for the spirits in Indonesia. Their status as refugees makes it difficult for them to work. Moreover, Indonesia did not take part in ratifying the 1951 convention, so the government was not obliged to provide employment for the refugees. As a result, the Rohingya refugees in Indonesia can only depend entirely on the assistance of the International Organization for Migration (IMO). In addition, HRWG notes the large number of refugees who actually become illegal workers to cover the necessities of life such as clothing and telephone credit.

d. The issue of the Right to Family.

Related to this, HRWG noted many findings of mixed marriage between refugees and local communities. Unfortunately, the marriage is not officially registered because civil law does not recognize mixed marriages with refugees.

e. Legal Umbrella Problems

Among the various problems that have been described, the legal umbrella problem becomes one of the most basic issues. HRWG encourages the government to immediately form a legal umbrella to oversee the various issues of refugees. Umbrella law, based on humanitarian considerations and oriented to the fulfillment of the rights of life of refugees as human beings.

f. Economic Problems.

Every month Rohingya Refugees get help from IOM which amounts to approximately 1.2 million per person per month(Winner Nabia:2015). All of its logistical health needs and needs are at the heart of UNHCR or IOM.

3.4. The Security Impact of the Republic of Indonesia

Rohingya refugees are a problem and a dilemma for the Indonesian government, until now Rohingya refugees are in quarantine of Medan Immigration and some are in Aceh region. As known to Indonesian refugees stranded in Indonesia in 2015 because they were expelled to the sea by Malaysia and Thailand. Conditions (refugees) are now very good and just waiting for completion of documents to move to countries such as the United States (US), Canada, Australia, and others, where the government of Indonesia to receive refugees for transit in the country for humanitarian reasons. The United Nations and the international community categorize Rohingya refugees as one of the most suffering groups at the moment. The arrival of Rohingya refugees to Indonesia for securitization actors can have a negative impact on the stability of state security and public security. The threat or existential threat constructed by government actors is the impact on national security and state sovereignty.

TNI as securitization has an important duty to maintain the security and sovereignty of Indonesian Republic. The TNI's action to expel refugee ships attempting to enter the Indonesian territory is an anticipatory measure of the possibility of an exsitential threat constructed by refugees. Entry of foreign citizens to the territory of Indonesia without official documents from the UN or country of origin is a form of violation of law of the Republic of Indonesia and which of course can threaten the sovereignty of the state. Particularly from UNHCR, IOM, international human rights and national human rights protection institutions such as Kontras, this group considers that Rohingya refugees are the ones who need help. They deny that the arrival of Rohingya refugees to Indonesia will threaten the stability of security.

UNHCR Indonesia Representative Thomas Vargas firmly stated that Rohingya refugees will not have a negative impact, even these refugees can also contribute positively to Indonesia. Criticism and national and international pressure continue to come to Indonesia. TNI actions and statements refusing Rohingya refugees are in fact not accepted by the public. The Community Group seeks to brainwash people and policy makers that Rohingya refugees are not a threat but a suffering group that needs the help and generosity of the Indonesian people. The government continues to evaluate the TNI's policy of refusing to accept the Rohingya refugees. After the policy evaluation of TNI, Ministry of Foreign Affairs and vice president states that Indonesia will receive and assist Rohingya refugees for one year on condition that there is assistance from related parties such as UNHCR, IOM mainly concerning funding and the process of establishing the status and return of Rohingya refugees to the home country or third country who are willing to accept.

The pattern of government policy change that originally refused Rohingya refugees and then received for one year indicated that the previous policy process was unworkable and unacceptable to the public. Community efforts on the issue of refugee refugees Rohingya categorized successfully, because diplomatic efforts between UNHCR with the Indonesian government led to a policy of receiving Rohingya refugees in Indonesia for one year with help from international organizations and the international community. Because Rohingya refugees are a shared responsibility. Cooperation is mostly done by the Ministry of Justice and Human Rights through the Directorate General of Immigration, the Regional Office of Law and Human Rights with the Regional Police as well as the Embassy of the Representative State Representatives related to the emphasis on the number of smuggling and trafficking. The function of the police in the structure of community life is as a protector of society, law enforcement and has a special responsibility to maintain public order and deal with crime both in the form of transnational crime and the prevention of transnational crime. This is in accordance with Law no. 2 of 2002 on the Police of the Republic of Indonesia(Law no. 2 Article 5 paragraph : 2002).

Based on the roles and responsibilities of the security guard, the Indonesian republic police have tasks that include a number of actions that are pre-emptive (preventative), preventive (prevention), and repressive (coping) in accordance with the police function in a universal context .The pre-emptive tasks are directed to create conditions conducive to caramen observe or detect early, such as criminogenic correlative factors that are potentially the cause, incentive, and opportunities for disturbance of public order and security. Preventive tasks more lead to prevent the occurrence of disturbances of security and order through the presence of police in the community. While repressive tasks are on legal action if the security and order disturbance is already happening in order to restore the situation conducive (Dinda.Lock.Cit : 2007).

4. CONCLUSION

Ethnic Rohingya is one of the ethnic groups living in Myanmar is Muslim, but they are not recognized as citizens and experienced discrimination by the government of Myanmar. Indonesia is one of the countries that provide shelter and facilities that are quite good compared to other countries. Rohingya refugees are a common problem because the Rohingya refugees are burdening and becoming a new problem in their stranded country especially

Indonesia. Since then, racial riots in Rakhine have expanded to the burning of villages and ethnic Rohingya extermination. With the increasing pressure of the Rohingyas, they are forced to seek refuge outside Myanmar. Indonesia can only temporarily accommodate and provide the basic facilities and needs of the refugees during their stay in Aceh, then the rest will be processed and followed up by UNHCR, all of their health logistics needs and needs will be covered by UNHCR or IOM.

The guarantee of legal protection for all refugees within the territory of Indonesia shall also be set forth in Presidential Decree of the Republic of Indonesia no. 3 of 2001 on the National Coordinating Agency for Disaster Management and Refugee Management which contains that whatever the reasons and background of the evacuation, the government should immediately seek and handle it quickly, accurately, integrated and coordinated through prevention, rescue, rehabilitation and reconstruction activities. As a country with a 'just and civilized humanity' base, Indonesia only helps victims on a humanitarian basis by accommodating them until the burden of refugees becomes lighter. Indonesia imposes restrictions on residence time to refugees from Rohingya existing in Rudenim throughout Indonesia for 10 years. After the stipulated period of expiration, Indonesia is irresponsible and will not provide any further protection against refugees from across the border.

The resolution of this case involves not only ASEAN countries, but Indonesia also has to cooperate with other international communities that focus also on the same issues. Indonesia which is one of the host countries of Rohingya refugees in cooperation with ASEAN, UN and IOM to work together in handling the problem. The position of Indonesia and Myanmar as a member of ASEAN has encouraged Indonesia and other actors involved to immediately discuss the issue jointly in international forums (ASEAN). The security of the Unitary State of the Republic of Indonesia (NKRI) is handed over to the TNI and is being monitored as a police duty in the structure of community life as a community guard, law enforcement and has the responsibility to maintain public order and deal with crimes both in the form of transnational crime and the prevention of transnational crime.

REFERENCES

Dinda.Lock.Cit., (2007). Supervision and Implementation of Environmental Law: A Social Analysis. Jakarta: Yayasan Obor Indonesia. Page 54.

Indonesian Perspective, Vol. 2, No. 1 (January-June 2017): 1-17

International Federation of Human Rights League, 2000. "Burmese: Repression, Discrimination and Ethnic Cleansing in Arakan". Report, International Mission of Inquiry, No. 290/2, April 2000.

Kiragu, Esther, 2011. States of Denial: A Review of UNHCR's Response to the Protracted Situation of Stateless Rohingya Refugees in Bangladesh. Geneva: Policy Development and Evaluation Service United Nations High Commissioner for Refugees.

Law of the Republic of Indonesia Number 24 Year 2007 on Disaster Management. View at http://www.bnpb.go.id/uploads/migration/pubs/1.pdf accessed on 31 October 2017.

Immigrationlaw, http://www.imigrasi.go.id/index.php/produk-laws / laws are accessed November 1, 2017.

Presidential Regulation No. 8/2008 on the National Disaster Management Agency.http: //www.gitews.org/tsunamikit/en/E6/further_resources /national_level/presiden/respres%2008- 2008_% 20BNPB.pdf accessed on 2 November 2017 .

Republic of Indonesia (2000). Law of the Republic of Indonesia no. 26 of 2000 on Human Rights Courts. Jakarta.

Republic of Indonesia (1945). The Constitution of the Unitary State of the Republic of Indonesia Year 1945. Jakarta.

Republic of Indonesia (1998). MPR Decree Number XVII / MPR 1998 on the Universal Declaration of Human Rights (DUHAM). Jakarta.

Soerjono Soekanto, (2001). Normative Law Research: A Brief Review, Jakarta. Raja Grafindo Persada.

Sri Badini Amidjojo, S.H., M.H. (2004). Legal Protection of Refugees Under the 1951 Geneva Conventions, Jakarta: National Legal Development Board of the Ministry of Justice and Human Rights of the Republic of Indonesia. 37-38.

UNHR (2005). Introduction to International Protection,

UNHCR's Concerned Persons. Switzerland: United Nations High Commissioner for Refugees.

United Nations (1951). Convention Relating to the Status of Refugees 1951. New York: UNGA.

United Nations (1967). Protocol Relating to the Status of Refugees 1967. New York: UNGA.

United Nations (1969). Vienna Convention on the Law of Treaties. New York: UN General Secretariat.

Winner Nabila, (2015), Journal of Implementation of the Non Discrimination Principle for his Rohisan refugees. Surabaya: Unair, page 51.

Yudistira Dwi P, 2017, "The Problem of Rohingya Refugees in Indonesia Has Been Mapped". https://news.okezone.com/read/2017/09/04/337/1769032/problem-pengungsi-rohingya-di-indonesia-telah-dipetakan-ini-uraiannya. accessed November 2nd, 2017.

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Sustainability Analysis of Coastal Management in The Madura Strait

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ABSTRACT

Coastal area has a strategic value for the development of national economy and improving people's welfare. However, coastal area is also extremely vulnerable to environmental damage and destruction. Therefore, the need of sustainable management with regard to the dimension of ecological, economic, social and institutional is important. This research is aimed to overview the current condition of coastal area in the Madura strait and to formulate coastal management strategies in term of sustainable development. Multi Dimensional Scaling (MDS) method was used in this research. Five dimensions (ecology, economy, social, technology and institution) were measured. The results showed that in general, coastal management of Madura Strait was less to moderately sustainable. It means that coastal management of the area has given enough contribution for the community; however the condition of the environment should be supervised closely to provide continuous benefit for future economics of the region.

KEYWORDS : Coastal Management, Madura Strait, Multi Dimensional Scaling

1. INTRODUCTION

Integrated coastal management is a dynamic process that runs continuously, in making decisions about the use, development and protection of the territory and coastal and marine resources (Dahuri, et al., 2001). Due to its nature of open access regime, Bengen and Retraubun emphasize that coastal areas are particularly vulnerable to over-exploitation and environmental pressures such as pollution, erosion and sedimentation (Bengen & Retraubun, 2006). Therefore, it needs special strategies for integrated and sustainable coastal management.

Coastal management is considered to be sustainable if the development activities in economic, ecological and social politics, not only in the interests of a current moment, but more focus on sustainability for the future. Economically sustainable development means that an activity must be able to produce economic growth, maintenance capital, and maintain the use of resources and investments efficiently. Ecologically sustainable means that the activity should be able to carry on the integrity of the ecosystem, maintaining the carrying capacity of the environment and conservation of natural resources, including biological diversity. Meanwhile, the ongoing social and political development requires that an activity should be able to equalize the results of development, social mobility, social cohesion, community participation, community empowerment, social identity, and institutional development.

Madura Strait is a coastal area that became one of the centers of economic development in East Java, in particular the fisheries sector. Madura Strait area is ± 9,500 km2 and become a fishing ground for more than 92,480 fishermen with the number of fishing vessels of more than 9,000 units. Madura Strait fishery potential was 214,097 tons, but its production has reached 227, 427 tons in 2008 so that it has been experiencing over-fishing. Other researchers have also noted gradual decline of the Madura Strait coastal resources, for example the degradation of mangrove area (Hidayah & Wiyanto, 2014), water pollution, coral reef bleaching (Estradivari, et al., 2009) and land use conflict (Nehru, 2015).

According to those facts, it is important to evaluate effectiveness of current management policy as well as to formulate strategies towards sustainable development of the Madura Strait coastal area. There are three main indicators to measure the level of sustainability of coastal fisheries resources management, which are ecology, economic and social (Dahuri, et al., 2003). For a more complete analysis of sustainability, analysis of institutional and infrastructure should also be performed.

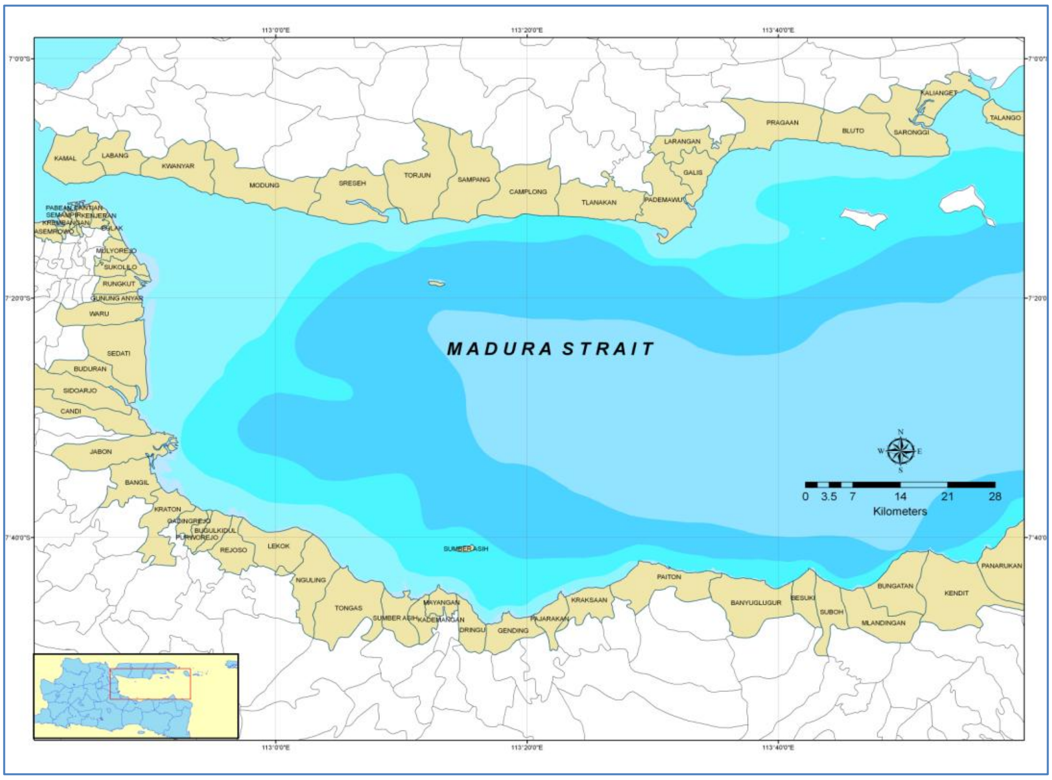

Fig.1 Study Area (Madura Strait)

2. METHODOLOGY

MDS is a multivariate statistical analysis that can be used as multiple variables to determine the position of an object based on similarity or dissimilarity (Kholil & Dewi, 2014). To perform the MDS analysis, several steps should be followed (Berhitu, et al., 2016). Firstly is to determine the attributes of each dimension based on the availability of data (primary or secondary data from previous study). The attributes are divided into five dimensions, namely ecology, economics, social, technology and institutions. Secondly is the valuation of each attribute in an ordinal scale based on sustainability criteria of each dimension. Each attribute of each dimension was conducted for the valuation based on the *scientific judgment* by the expert respondents according to the requirement. Ordinal scoring is given from the lowest (0) to the highest level (3). Finally is calculating the sustainability index and analyze the status of sustainability.

Data attributes used in this study were selected based on the availability of information that can be obtained from the character of coastal resources as well as reflect the level of sustainability of each dimensions. Data collection and the valuation of each attributes were conducted by reviewing previous studies of the study area, performing direct field measurement and deep interview with local experts including community's leader, non government organization, fishermen, government officials and other relevant key persons. Furthermore, Rap-Mad method was used to determine the level of sustainability of coastal management in Madura Strait. This method was developed from Rap-Fish which generally used to determine the level of sustainability or the development of the research object by modifying the dimensions and attributes in accordance with the aspects to be evaluated (Pitcher & Preikshot, 2000).

Measuring the level of suitability or fit (goodness of fit) in the above method is very important. Goodness of fit in MDS measures the accuracy or how well of a point to reflect the original data. Goodness of fit in MDS is determined by the value of the S-Stress resulting from the calculation of the S value. Low stress value indicates good of fit, while high-value S indicates otherwise. In Rap-Mad, a good model is shown with stress values smaller than 0.25 (S <0.25). Moreover, based on the valuation of each dimensions, sustainability status of coastal management in Madura Strait can be divided into four categories:

Table 1. Index Value and Sustainability Status (Hartisari, 2006)

Index Value	Sustainability Status
< 25%	Unsustainable
26%-50%	Less Sustainable
51%-75%	Moderately Sustainable
> 75%	Sustainable

3. RESULT AND DISCUSSION

3.1. Ecology Dimension

In order to determine the sustainability level of coastal management in the Madura Strait for ecology dimension, 14 attributes were measured. The results show that sustainability index value based on MDS analysis for ecology dimension is 49.50%. This index value is in the category of less sustainable. Figure 2 showed the level of sensitiveness or contribution of each attributes to the sustainability ecology dimension in the management of coastal area in the Madura Strait.

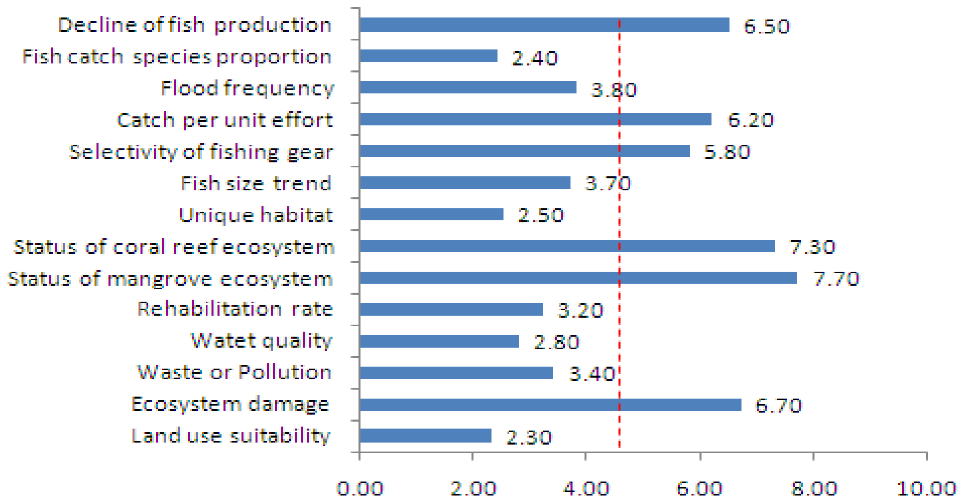

Fig. 2 Leverage Factor of Attributes in Ecology Dimension

As can be seen from Figure 2, there are 6 attributes that can be considered as sensitive and having a large contribution to the status of ecology dimension on coastal management in the Madura Strait. Most of them are related to the environment degradation such as coastal damage rate, status of mangroves and coral reefs ecosystem and the decline in fish catches. Previous studies confirmed this condition, for instance mangrove areas in the Madura Strait have been decreased from 5569 Ha in 2006 to approximately 5458 Ha in 2014 (Hidayah, et al., 2015). In addition, results from field observation on 20 dive sites also found that only 15% of coral ecosystems in the study area can be classified under good condition. Moreover, in term of fish catches production, Madura Strait has been experiencing over-exploitation of fish resources since 1997 (Muhsoni & Nuraini, 2006). Therefore based on the above results, it means that preventing further damage on coastal environment, providing continuous rehabilitation programs on coastal ecosystems and implementing considerable fair policies to control fish catches production should become priorities to increase sustainability level of coastal management in the Madura Strait.

3.2. Social Dimension

The results of MDS analysis on social show the value of sustainability index of 72.3, it indicates that this dimension is moderately sustainable. Nine attributes were measured to determine the social sustainability in coastal management of Madura Strait. The result is shown in Figure 3. Based on that, three attributes were identified to have strong influence in the level of social sustainability of coastal management.

Fig. 3 Leverage Factor of Attributes in Social Dimension

Three social attributes that need to be improved to increase the sustainability of coastal management in Madura Strait are local knowledge in coastal management, community empowerment and level of education. Increasing local knowledge of sustainable resource management could be done by introducing best practices as early as possible. There is a significant correlation between the levels of coastal damage and community role. It can be argued that the lack of local knowledge is one of the causes. Therefore, community members should been given understanding about the importance of sustainability concepts in exploiting costal resources to ensure that no further damage happen to their areas. Moreover, this concept could also be introduced formally in school's curriculum in a proportional way.

Community empowerment is imperative to improve local economy. At the same time, it can be used as an instrument to raise awareness to ensure environmental-friendly exploitation of natural resources. It actually has been run by the government through various community empowerment programs such as CCEE (Coastal Community Economic Empowerment) and NCEP (National Community Empowerment Program). However, according to field observation's results, those programs have failed to provide coastal communities with productive ventures due to some issues. The main issues were uncertain continuity of the programs and difficulties to seek funding or loan from industries and banking.

3.3. Economic Dimension

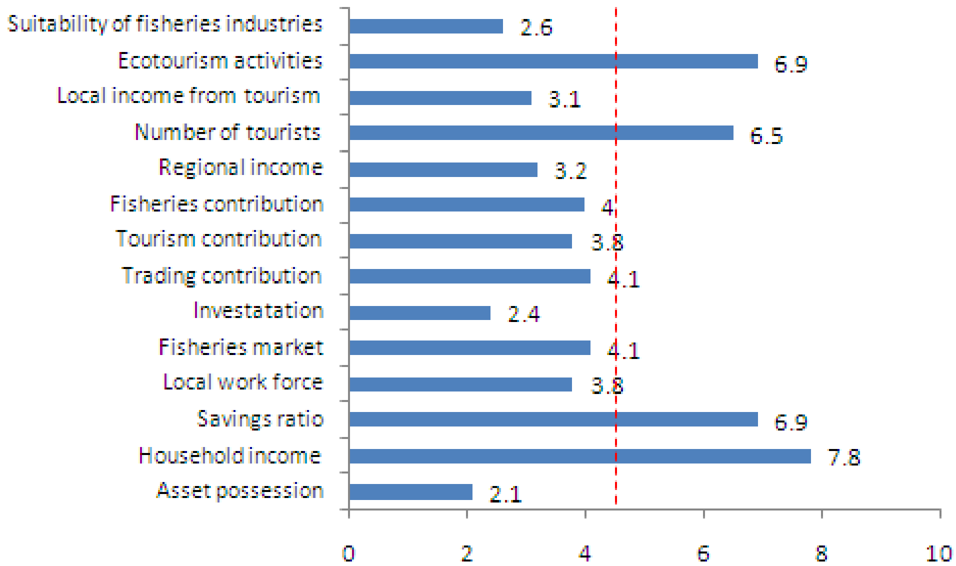

Fig. 4 Leverage Factor of Attributes in Economic Dimension

MDS analysis of economic dimension of coastal management in Madura Strait confirms the sustainability index of 65.7%. This value can be categorized as moderately sustainable. Further analysis of 14 economic attributes explains that leverage factors in this dimension mainly come from 4 contributing attributes; they are household income, savings ratio, number of tourists and eco-tourism activities. The results means that to increase sustainability of coastal development in Madura Strait coastal area, it is necessary to focus on how to increase fisheries house hold's income as well as promote eco-tourism on the area.

In general, household income of coastal communities in Madura Strait derived from fisheries and is very different from other types of businesses such as trade or farmers. Fishing activities are full of uncertainties, speculative and highly depending on the climate. In fact, during western wind seasons most of the fishermen must stop their activities at sea due to bad weather, consequently they loss their income. To overcome this situation, diversification of fisheries activities and providing venture capital assistance should be taken into account. Government could provide comprehensive programs for instance developing small scale industries towards intensive training on fish processing. Likewise, contribution of coastal eco-tourism to the GDP of East Java Province is insignificant. There are only several well managed coastal tourist destination in the area such as Wonorejo and Bee Jay mangrove's eco-tourism in Surabaya and Probolinggo along with Pasir Putih beach and diving sites in Situbondo. Government and Private Company's collaboration is important to improve eco-tourism activities in Madura Strait. Investment to find and develop new tourist destination in the area should be done in the near future. However, to ensure its sustainability, involving local communities during the process is necessary.

3.4. Technology Dimensions

Result from MDS analysis of technology dimension show that this dimension is less sustainable (sustainability index 48.8%). Figure 5 explain the leverage factors of each attributes. Among 9 attributes in this analysis, five of them are considered sensitive. Those attributes are the availability and the use of fish processing technology and IT support to assist fishermen communities. Small scale fish processing industries are common to be found around coastal regions including Madura Strait. They use traditional method to manufacture various kinds of fish processing products. As a means of preserving fish, traditional methods have certain limitations in capacity of production, hygiene, variation in products and packaging. That is why traditional fish products from coastal regions in Madura Strait are rarely sold abroad. The lack of business networks and limited access to obtain financial credit to develop their business are some of many factors that make small scale industries in fish processing are difficult to grow. Therefore government should improve ways to solve it, for example encouraging and facilitating local industries to comply with national food product standardization. In addition, it is also important for the government to bridge collaboration between modern and traditional fish processing industries in term of mutual partnership.

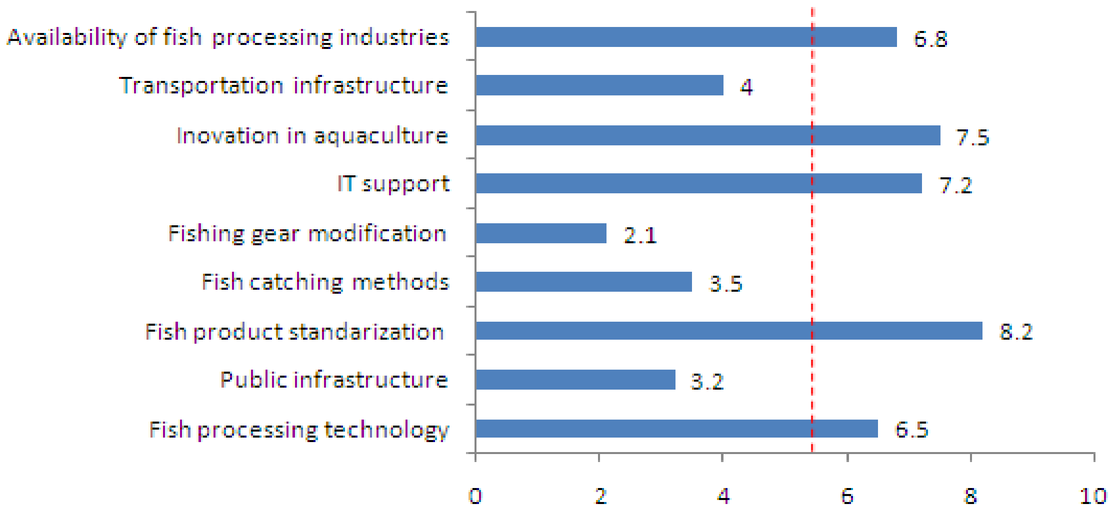

Fig. 5 Leverage Factor of Attributes in Technology Dimension

3.5. Institutional Dimension

Result of MDS analysis show the index value of 60.05%. It means that in term of institutional dimension, coastal management in Madura Strait can be categorized as moderately sustainable. Figure 6 above explains that 4 attributes are very influential. Most of them are related to legal frame work that control exploitation of marine and coastal resources. In general, the lack of law enforcement and low compliance with fisheries regulations are common cases when it comes to community's conflict in the coastal area. Many regulations have been created by the government to prevent coastal resources and habitats from severe damages caused by uncontrolled exploitation. However, cases like destructive fishing, illegal logging of mangroves vegetations and land use conversion are still happen frequently. It needs to understand that responsibility to monitor disobedience act not only belongs to government officials. Therefore, government should raise awareness among local community to cooperate in monitoring violation of the law at sea and coastal regions. It can be done by facilitating community groups with knowledge about monitoring and reporting procedures when they find violation against proper regulations. This policy is highly recommended because at the same time it can increase the role of fishermen organization. To emphasize the importance of legal frame work in coastal management, that regulatory instruments could provide legal protection and preservation of coastal resources in a sustainable way (Berhitu, et al., 2016).

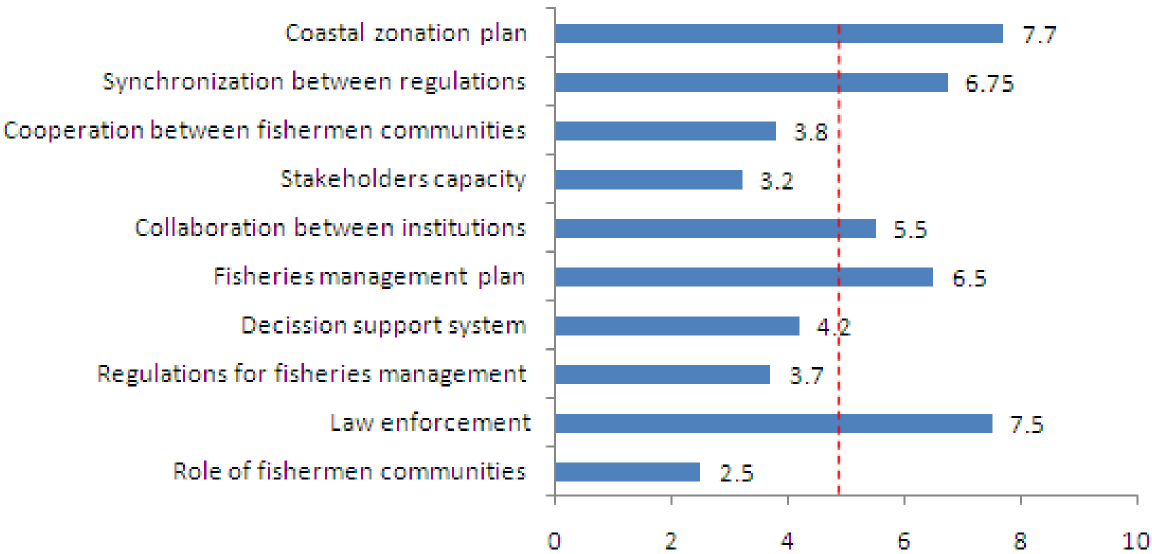

Fig. 6 Leverage Factor of Attributes in Institutional Dimension

3.6. Validity Test

Table. 1 Stress Value and R^2-value of MDS Rap-Mad Analysis

No	Parameter	Dimension of Ecology	Dimension of Economy	Dimension Social	Dimension Institutional	Dimension Technology
1	Value of stress	0,18	0,13	0,09	0,07	0,11
2	Value of R^2	83.02	93.15	96.11	96.23	92.10
3	Number of Iteration	3	2	2	3	5

Test of accuracy for MDS Rap-Mad analysis obtained coefficient of determination (R^2) between 83.02 and 96.23. According to Kavanagh (2001), R^2 value more than 80 can be categorized as good and fit. It means that result of MDS analysis can be used to describe the level of sustainability of coastal management in the Madura Strait. Moreover, the results also show stress value less than 2. Therefore, it can be argued that result of MDS analysis has a high accuracy to explain the sustainability in term of implementation of coastal management particularly in the region of Madura Strait.

3.7. Sustainability Status of Coastal Management in the Madura Strait

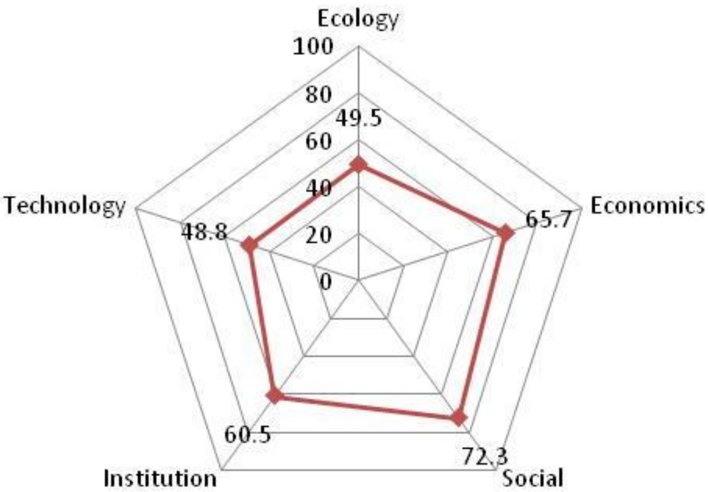

Fig. 7 Kites Diagram of Sustainability Analysis of Coastal Management in Madura Strait

Result of sustainability index value of 5 dimensions using MDS Rap-Mad method is described in Figure 7. It shows that ecology and technology dimensions are less sustainable, while the others can be categorized as moderately sustainable. Therefore, to increase the sustainability level of coastal management in the area, it should be focused on conservation and rehabilitation of coastal ecosystems as well as introducing the use of modern technology especially for small scale fish processing industries.

Nonetheless, further analysis explains that there are inter-dimensional correlation between low attributes values. The social dimension is closely related to the economic and ecology dimension. One of the crucial problems in the social and economic dimensions is education. Low education limit people to get a proper job, it means that they tend to experience poverty and under-development. The problem of poverty and low education level is what makes the cause of the inability of fishers and coastal communities to improve quality of life; therefore innovation in technology and knowledge transfer cannot be fulfilled. Lack of education for coastal communities can also lead to activities that can cause environmental damage. It can be argued that low level of sustainability index in ecology dimensions is related to it. Lack of information on how important is sustainability for the continuity of life in the future makes the communities carry out illegal or destructive exploitation of coastal resources.

Through education either formally or not, community should be encouraged to raise their awareness and play active role in conserving coastal resources. Government and NGO's could collaborate to implement it. Moreover, it is highly suggested that government must involve local communities in real actions such as replanting mangrove vegetations, regular beach clean-up, sea patrol and monitoring. With these actions, the community will feel ownership and ultimately preserve the coastal resources by their own.

Figure 7 also explain that the use of technology in supporting coastal management in Madura Strait is still low, particularly in fish processing industries. Due to limitation of technology in preservation and processing of fish makes the income of fishermen becomes stagnant. The use of traditional technology limits their competitiveness against superior producers. Therefore, it is important to suggest several policies that can be implemented by the government to overcome this problem. Firstly, through collaboration with universities and research institutions government could improve quality of products and providing assistance to create efficient small industries business plan. Secondly, government should focus on how to develop quality of human resources by initiating relevant training programs and certification expertise in fish processing. Finally, government should intensify promotion of local fish processing product as well as maintain its market distribution

4. CONCLUSION

The implementation of coastal management in Madura Strait can be explained using MDS Rap-Mad analysis. Five dimensions are measure. In general the results show that status of coastal management in Madura Strait can be classified into 2 categories; less sustainable (ecology and technology dimensions) and moderately sustainable (social, economy and technology dimensions). Result of validity test is R^2 between 83.02 and 96.23, whereas accuracy test value is less than 2. It means that the analysis is adequate to be uses to explain the level of sustainability of coastal management in the Madura Strait.

To increase the sustainability status of coastal management in the Madura Strait, eight attributes of ecology dimension and three attributes of technology dimension need to be improved proportionally. Moreover, to maintain sustainable exploitation of coastal resources in the area government should be encouraged to involve community to participate in planning, implementation, evaluation and monitor coastal management programs.

5. REFERENCES

Bengen, D. & Retraubun, A. &., 2006. *Menguak Realitas dan Urgensi Pengelolaan Berbasis Eko-Sosio Sistem Pulau-Pulau Kecil.* Bogor: Pusat Pembelajaran dan Pengembangan Pesisir Dan Laut.

Berhitu, P., Hutabarat, S., Supriharyono & Suprapto, 2016. MDS Analysis Approach to Evaluate Sustainability of Management of Ambon City Coastal Area. *Journal of Oceanography and Marine Research,* 4(1).

Dahuri, R., Rais, J., Ginting, S. & Sitepu, M., 2001. *Pengelolaan Sumberdaya Wilayah Pesisir & Lautan secara Terpadu.* Jakarta: PT Pradnya Paramitha.

Dahuri, R., Sitepu, M. & Dutton, I., 2003. *Building Integrated Coastal Management Capacity in Indonesia. Center for Coastal and Marine Resources Study.* Boor: Bogor Agriculture University.

Estradivari, Setyawan, E. & Yusri, S., 2009. *Terumbu Karang Jakarta (Pengamatan Jangka Panjang Terumbu Karang Kepulauan Seribu 2003-2007).* Jakarta: Yayasan Terumbu Karang Indonesia (TERANGI).

Hidayah, Z., Rosyid, D. & Armono, H., 2015. GIS Application in Monitoring Distribution of Mangrove Ecosystem of Southern Madura. *Journal of Ecology Environment and Conservation,* 21(1).

Hidayah, Z. & Wiyanto, D., 2014. Analisa Temporal Perubahan Luas Hutan MaNgrove di Kabupaten Sidoarjo Memanfaatkan Data Citra Satelit. *Jurnal Bumi Lestari,* 13(2).

Kholil & Dewi, I., 2014. The Use of MDS TO Analyze the Level of Sustainability of Fisheries

Resources in Thousand Island. *International Journal of Marine Science,* 4(27).

Muhsoni, F. & Nuraini, C., 2006. Kajian Tingkat Pemanfaatan Sumber Daya Ikan Di Perairan Selat Madura Dengan Menggunakan Metode Holistik Serta Analisis Ekonominya. *E-Journal UMM,* 13(1).

Nehru, M., 2015. *Analisis Perubahan Penggunaan Lahan Wilayah Pesisir Selat Madura dengan Sistem Informasi Geografis.* Madura: Jurusan Ilmu Kelautan. Universitas Trunojoyo.

Pitcher, T. & Preikshot, D., 2000. *Rapfish: A rapid appraisal technique to evaluate the sustainability status of fisheries.* Fisheries Research 49 (2001) ed. Canada: Fisheries Centre, University of British Columbia.

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THE ANTHROPOGENIC THREATS TO CORAL REEF ECOSYSTEM IN KARIMUNJAWA NATIONAL PARK INDONESIA : ITS STATUS AND MANAGEMENT

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ABSTRACT

In Indonesia, Karimunjawa was among one of the first areas to be recognized as being important for conservation and marine biodiversity protection. Most of its area was gazetted as a marine protected area in 2001 mainly due to its biodiversity of coral reef ecosystem. Like other protected areas in Indonesia, local community lives within its area. It directly creates human based problems and threats for the park that are mainly rooted in poverty. It is recorded that various destructive fishing methods, coral mining, bleaching and tourism impacts are the present and upcoming threats to coral reef ecosystem in the park. Evaluating the present management, some recommended improvements are provided for the management such as the development of co management, stronger law enforcement, community based monitoring and well communicated stakeholders. The general idea of the improvement is putting more socioeconomic considerations in park management to achieve success management.

KEYWORDS : Coral Reef Ecosystem, Karimunjawa, socioeconomic considerations.

1. INTRODUCTION

Basically, based on its origin, the threats to coral reef ecosystem can be categorized into two major groups: natural threats and anthropogenic threats (Hopley, 2000). Kleypas and Eakin list top five threats to coral reef in South East Asia, the most threatened region, are sedimentation, human population growth, over fishing, habitat destruction and law enforcement (Kleypas & Eakin, 2007). Therefore, most of them can be categorized as anthropogenic threats. This paper will illustrate a range of present and future anthropogenic threats in Karimunjawa National Park, a marine protected area in Indonesia, Some proposed improvements to address those threats are also provided.

2. Karimunjawa National Park overview

2.1. General description

Geographically, the Karimunjawa archipelago is situated from 5^{o}49' to 5^{o}57' South Latitude and from 110 ^{o} 04 to 110 ^{o} 40 East Longitude. The archipelago consists of 27 small islands. Most of them are uninhabited. In 1986, Ministry of Forestry, as a representative of the central government, declared 22 islands within the archipelago as a Strict Natural Reserve. Later on, in 1999 its status was changed into a national park named Karimunjawa National Park (KNP). The park's total area is 111,625 hectares (KNPA, 2004). In 2001, the park seawater area (110,625 hectares) was established as Marine Protected Area (MPA). Karimunjawa National Park Authority (KNPA) is the official central government agency that was appointed for the management.

Within the park, there are 8,842 people living in the four inhabited islands; Karimunjawa, Kemujan, Parang and Nyamuk Island (KNPA, 2005). The general characteristics of the local community are fisherman (more than 61%), having low level of education and a mixture of various tribes such as Javanese, Buginess and Madurese (KNPA, 2005) (KNPA, 2005). Figure 1 illustrates the map of Karimunjawa National Park.

2.2. The coral reef ecosystem

Ecologically, there area five different types of ecosystems in Karimunjawa National Park; coral reef, sea grass and sea weed ecosystems, mangrove forest, coastal forest and also the low land tropical rain forest. Coral reef ecosystem in KNP is mainly characterized as fringing reef. There are 63 genera of scleractinian corals and 3 non-scleractinian corals (KNPA, 2004). Furthermore, 2 species of marine turtle, 4 species of giant clams, 10 species of sea cucumbers and other marine organisms live in the reef ecosystem (KNPA, 2006).

Fig, 1 The map of Karimunjawa National Park (KNPA, 2004)

In 2003, the KNPA in cooperation with Wildlife Conservation Society-Indonesia program (WCS-IP) conducted the first comprehensive ecological research on coral reef ecosystem. The research mainly focused on coral cover, invertebrates, coral damage, discarded fishing gear and reef fishes. The following points are the summary of the research (Marnane, et al., 2003).

a. In 44 sampling sites, the coral cover generally ranged from 7% to 69%. In detail, in shallow areas coral cover ranged from 26.8% in Gosong Tengah to 86.2% in Seruni Island. Meanwhile, in deep areas coral cover ranged from 24.4% in Kecil Island to 92.9% in western part of Menjangan Island. Marnane et al also observed that western part of the archipelago was more degraded than the eastern part due to the seasonal monsoon and high human exploitation activities (Marnane, et al., 2003).

b. High density of giant clams (23 individu/100^2) and sea urchin that mainly dominated by *Diadema setosum* (27 individu/100^2) were found within the sampling site. The species of the giant clam are *Hippopus hippopus, Tridacna crocea, Tridacna maxima* and *Tridacna squamosa*. The highest abundance occurred in Seruni

Island (248 individu/100^2). In contrast, as a result of high extraction activity, sea cucumber density was very low (0.1 individu/100^2).

c. The average of recent coral damage in all sampling sites was 644 individu/100^2. Meanwhile, the commonest discarded fishing gear found during the research were fishing line (37%) followed by rope and anchors, traditional fish trap and fish net.

d. There are 342 reef fish species found in 44 sampling sites. The fish composition was dominated by family Pomacentridae (22%) followed by Labridae (15%), Chaetodontidae (8%), Scaridae (8%), Serranidae (7%) and others.

e. For fish biomass, family Scaridae and Pomacentridae contributed the highest proportion. The biomass ranged from 89.26 kg/hectares to 1096.58 kg/hectares.

2.3. The threats

KNPA has been identifying threats and problems occurring in its jurisdiction. Generally, the threats are categorized into four major groups; natural resources degradation, organizational, the lack of community awareness and the use pattern (KNPA, 2007). The threats and problems in KNP are presented in Figure 2. Meanwhile Marnane et al categorized the park as an area with medium level of threats if it is compared with high level pressure threats in Seribu National Park and relatively low pressure threats in Bali (Marnane, et al., 2003). This part will discuss the last group of threats that are related to the anthropogenic activities.

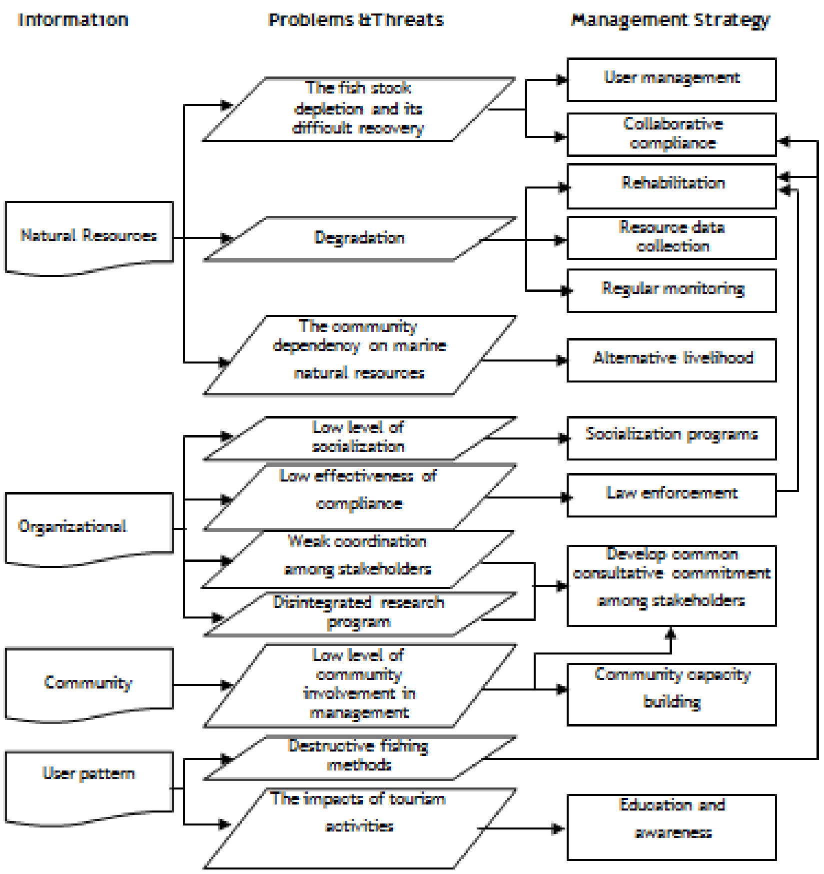

Fig. 2 The diagram of the threats and problems in Karimunjawa National Park (KNPA, 2007)

a. Muroami

In 2003, another research on ecological and socioeconomic impacts of muroami practices was conducted by KNPA and WCS-IP. Marnane et al in their report concluded some of these points (Marnane, et al., 2003) :

1) The history of muroami practices in Karimunjawa archipelago is unique. It was first introduced in early 1990s by the fishermen coming from Seribu Island areas. In 1996 the local fishermen rejected the practices. As a result from 1996 to 2001 the operations were stopped. Unfortunately, in 2000 the local government, Jepara Regency, established a fishing regulation allowing re-operation of muroami practices in Karimunjawa areas with some requirements. Some of the requirements are the owners, workers and boats for muroami operations must originally come from Karimunjawa areas (local community) and the operation should use larger mesh size (minimum 2 inch).

2) At the beginning of the new practices, the amounts of catchments were big. At least 2 tones were captured per week. The amounts were equal to AU$ 1,700. For the local fishermen, the values of the catchments were incredible. However, the more muroami operational occurred the lesser catchments captured.

3) The operational of muroami usually use 3 boats. Two boats will carry the nets, while another boat will be the storage. About 13 to18 people including 5-7 divers were involved in the operation the divers. The nets will be set within the reef ecosystems about 10-20 meter depth. Then the divers will drive the fish into the nets. Figure 3 illustrates the operational of muroami in KNP.

4) The muroami practices were widely distributed within the park. The distribution of muroami practices is presented in Figure 4.

5) The main target of muroami practice is *Caesio cunning* fish. The other fishes trapped in the nets will be shared among the workers. However, the research showed that *Caesio cunning* is only 27.61% while the bigger proportion (72.39%) is dominated by other fishes (Marnane, et al., 2003).

Fig. 3 The operational of muroami in KNP (Marnane, et al., 2003)

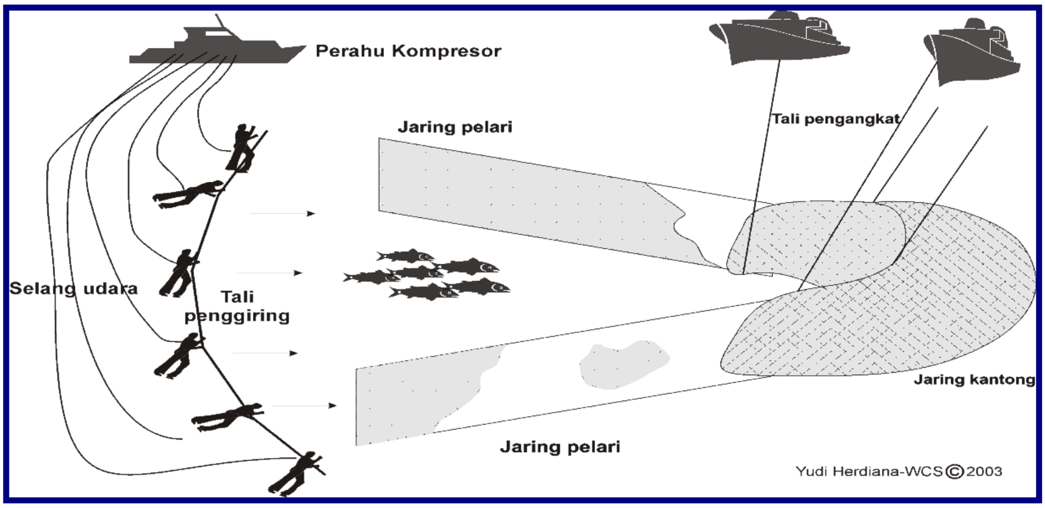

Fig 4. The operational of muroami in KNP
(Marnane, et al., 2003)

6) It is predicted that one operation will cover an area of 2.4 hectares. From this coverage area, it is then calculated that the fish biomass taken everyday ranged from 4.83 to 127.71 hectares kg/hectares or the average is 62.76 kg/hectares. The amount is relatively not too big. But if it was multiplied with the number of operators per day operations, it will be numerous.

7) The size of the catchments varied from 9 to 108 cm. based from the observation, the net's mesh size is not selective.

8) It is estimated that each muroami diver will create 11.6 cm^2 damages for 1 cm^2 of living coral. The damages caused by the following activities; divers stepping on coral, the net ropes stranded on the reef, the net rings broke the reef, and the nets used living corals as a net weighting.

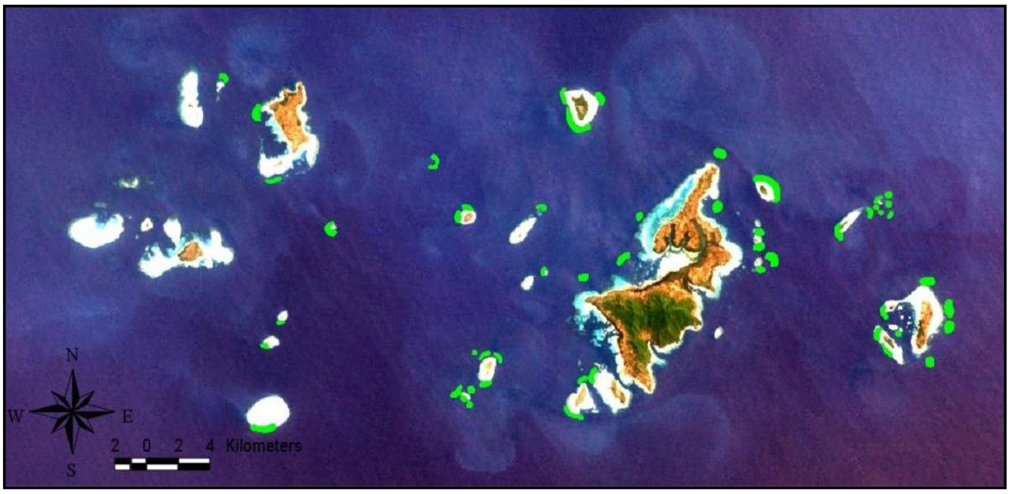

Fig 5. The distribution of muroami operations in KNP (green areas)
(Marnane, et al., 2003)

b. Other destructive fishing methods

Muroami practices are not the only destructive fishing methods occurring in this area. There are many others. However, their extents are not well quantified by the authority. Provided below are some of the practices:

1) Marnane *et al,* (2003) reported that based on their interview with the local community, sea cucumber gleaning activities are widely occurred within the park. The collections are not only in shallow water but also in depth water.

2) Anecdotal evidence showed the utilization of trawl and blast fishing by outsiders or local fishermen within the park area in early 1990s (KNPA, 2005).

3) In 2005, the park rangers recorded the utilization of cyanide to catch the aquarium fishes (*Amphiprion* sp). Nearly 140 fishes were smuggled in the ferry (KNPA, 2005).

That evidence showed an ice cap phenomenon. The real extent of the destructive activities might be bigger than it is predicted. Due to its relatively open area, fishermen can exploit the marine resources anywhere within KNP then directly leave heading directly to mainland.

c. Coral mining

Similarly, coral mining activities also not yet well quantified. Locl people mostly use the coral as housing materials. However, the park rangers observed the existence of these activities within the park (KNPA, 2005). Even though, the scale is very small (subsistence level) this activities is a serious threat for reef environments.

d. Bleaching

It is globally perceived that global warming is caused by the anthropogenic green house emission. The increase of sea water temperature is a direct effect of global warming. Bleaching is commonly known as the coral reefs' response to the increase of sea water temperature. In their observation, Taka Foundation had not found significant bleaching within the park. However, bleaching is recognized as a future threat for the coral reef ecosystems particularly in KNP (Foundation, 2006).

e. Impacts of tourism

In their planning both Jepara Regency government and Central Java Province government, as the local authorities, agreed to develop marine tourism activities in Karimunjawa areas (KNPA, 2005). It is believed that the tourism development will boost the local economic growth. In the other hand, its presence creates another threat for the existence of the coral reef ecosystem.

3. The management of Karimunjawa National Park

3.1. Present management

As a management authority, the KNPA has two main tasks; managing the park area and conserving the natural resources and the ecosystems based on established laws and regulations (KNPA, 2005). In its management plan, KNPA has listed its main management activities. Based on KNP's 2007 annual plan, there are 11 main activities (KNPA, 2006). They are:

a. Planning

b. The area management such as zoning socialization and the border signages.

c. The resources management such as inventory of flora and fauna.

d. The park utilization such as tourism and the fishing management.

e. Research.

f. Protection and compliance such as patrolling.

g. Organization capacity such as training for rangers.

h. Coordination with central and local government.

i. Infrastructure development.

j. The enhancement of local community participation.

k. Evaluation and monitoring.

Those management efforts have been conducted independently or in coordination with other bodies. In 2002, cooperation between KNPA and WCS-IP was signed. The underlying reason for the cooperation is the need to develop an integrated coral reef ecosystems management in KNP (Marnane, et al., 2003). Based on the cooperation agreements, two previous researches (ecological research and socioeconomic research including muroami observation) as the preliminary step for rezoning plan were designed.

3.2. Proposed improvements

From the present management, there are four potential points that can be considered to improve the park management. Each point will be discussed below:

a. Type of management

Socioeconomics factors play a great role in determining the successfulness of the resource managements (White, et al., 2002) (McClanahan, et al., 2006). "This is because social, economic and cultural factors influence whether individuals and communities create incentives to overexploit common property resources or, alternatively, cooperate to successfully manage them" (Cinner, et al., 2006) (Cinner, et al., 2005). Thus, to determine effective management strategy, it is important to understand how the local community's use pattern (Cinner, et al., 2005). Furthermore, high level of community involvement is identified as one of the key factor for the success of a MPA (Polnac, et al., 2001).

It is crucial to develop a management approach that will accommodate the needs for socioeconomics understanding and simultaneously enhance community involvement. In KNP, community involvement has just initially begun particularly during the previous rezoning program. In the rezoning process, the local community had their representatives who involved in designing the new zones. In addition, there were sets of public consultations to communicate the plans (KNPA, 2004). To maintain and enhance the community involvement, co-management offers a better approach. "Co-management, as a compromise between bottom up and centralized management, will engage resource users and governments officials in an equitable and transparent planning process that is formally recognized and sanctioned" (Christie & White, 2007). This management approach is successfully proven in Sumilon and Apo Island Philippines that relatively has similar characteristics with KNP. In those areas in Philippines, the government give more responsibilities to the local government and local community in managing their areas (Acala & Russ, 2006). Therefore it is suggested that coastal management in Indonesia should be switched using co- management approach.

b. Compliance

The effectiveness and sustainability of MPA is characterized by good compliance. However, in Indonesia, sometimes it is difficult to achieve good compliance within the park due to the limited funding and infrastructure. Combining compliance with other activities might be the solution. Wilkinson et al found that in Komodo National Park combination between monitoring and compliances had significantly reduced the blast fishing practices in the park (Wilkinson, et al., 2004). Having the rangers doing the coral reef monitoring will suppress the blast fishing operations. At the same time, the coral reef data that are important for management are gathered. Capacity building for the rangers and the park staffs are critical in developing this scheme.

c. Education and communication

There is a common agreement that education and communication on coral reefs are essentially important (Kleypas & Eakin, 2007). The target is not mainly the local community that living and using marine resources but also to the governments agencies and other stakeholders (Polnac, et al., 2001). A common understanding followed by legal support from the government agencies from national level to the lowest level will highly contribute to the successfulness of the coral reef management (White, et al., 2002). Meanwhile, sharing and learning the success story from other areas in Indonesia that successfully manage its marine resources can be a good way to promote awareness and stimulate the local community (Fauzi & Buchary, 2002).

d. Monitoring

The community involvement scheme should be brought into real forms. For the application of might be by adopting a community based monitoring program that was developed by Philippines. Local fishermen were trained to monitor the coral reef environment using manta tow and visual census methods. This program has at least three advantages. The first is enhancing community involvement in management that will lead to better enforcement. The second is strengthening the communication between management authority and the community. And lastly, gathering data for management purposes. Furthermore, even though the fishermen monitoring data are not as comprehensive as the scientific monitoring, those data still show general trend happening in the field.

e. Provision of innovative alternative livelihoods

The root of threats occurring particularly in KNP and generally in Indonesia is poverty. Generally, “adequate provision of alternative economic opportunities that are non destructive to the environment and nondestructive to the social fabric of the community” should be considered to alleviate poverty and particularly succeed the management activities (Fauzi & Buchary, 2002). For the last five years, KNPA has been developing a range of alternative livelihoods such as granting fish nets, coconut oil processing unit, cashew nuts machines, provision of seeds and trainings for the local people through the various user groups (e.g. fishermen, farmers, housewives group) (KNPA, 2005). However, it has not showed significant results. The arising problems are marketing due to the remoteness of the areas from the mainland and quality control. Continued innovation in providing alternative livelihoods for the local people is important. Livelihoods related to ecotourism activities can be considered as an alternative by KNPA. It fits with the local government plan in developing tourism in KNP. The local community can be involved in the provision of goods and services for the tourists.

4. Conclusion

Similar like other areas in developing countries, KNP faces serious anthropogenic threats to its coral reef ecosystem ranging from muroami practices to pollution. A series of management efforts have been put in place. Unfortunately, significant results are not well produced yet. It is suggested that it is time for the management to take into consideration the socioeconomic and cultural background of the local community living within its area. Developing co-management that will lead to more community involvement, followed by high compliance, well established education and communications; participatory monitoring and innovative livelihoods are recommended in the improvement of park management. In managing coral reef ecosystem is not only focus on the biological aspects but also rely on people management using it in a daily basis.

5. Bibliography

Acala, A. & Russ, G., 2006. No-take Marine Reserves and Reef Fisheries Management in the Phillipines: A New People Power Revolution.. *Ambio,* 35(5), pp. 245-254.

Christie, P. & White, A., 2007. *Best Practices for Improved Governance of Coral reef Marine Protected Areas,* s.l.: Coral Reefs Report.

Cinner, J., Marnane, M., McClanahan, T. & Alamany, G., 2006. Periodic Closures as Adaptive Coral Reef Management in the Indo-Pacific. *Ecology and Society,* 11(1), p. 31.

Cinner, J. et al., 2005. *Tenure and Traditions: Influence of Sociocultural Factors on Resource Use in Melanesia..* s.l., Conservation Biology.

Fauzi, A. & Buchary, E., 2002. A Socioeconomic Perspective of Environmental Degradation at Kepulauan Seribu Marine National Park, Indonesia. *Coastal Management,* Volume 30, pp. 167-181.

Foundation, T., 2006. *The Report of Coral Bleaching in Karimunjawa National Park.* 5 ed. s.l.:Taka Foundation.

Hopley, D., 2000. *'Status of Indonesians Reef'.* Bali, Training of Integrated Coastal Management.

Kleypas, J. & Eakin, M., 2007. Scientist Perceptions of Threats to Coral Reefs: Results of A Survey of Coral Reef Researchers. *Bulletion of Marine Science,* 80(2), pp. 419-436.

KNPA, 2004. *The Management of Karimunjawa National Park: Conservation Efforts on Natural Resources and Ecosystems.* 2 ed. Semarang: Balai Taman Nasional Karimunjawa. Semarang.

KNPA, 2004. *The Management of Karimunjawa National Park: Conservation Efforts on Natural Resources and Ecosystems.* 2 ed. Semarang: Balai Taman Nasional Karimunjawa. Semarang.

KNPA, 2005. *Renstra Balai Taman Nasional Karimunjawa Tahun 2006-2009.* 60 ed. Semarang: Balai Taman Nasional Karimunjawa. Semarang.

KNPA, 2005. *Statistik Balai Taman Nasional Karimunjawa Tahun 2005.* 82 ed. Semarang: Balai Taman Nasional Karimunjawa. Semarang.

KNPA, 2006. *Rencana Kerja Tahun 2006 Balai Taman Nasional Karimunjawa.* 81 ed. Semarang: Balai Taman Nasional Karimunjawa.

KNPA, 2007. *Laporan Tahunan Tahun 2006 Balai Taman Nasional Karimunjawa.* 97 ed. Semarang: Balai Taman Nasional Karimunjawa.

Marnane, M. et al., 2003. *Laporan Studi Perikanan Muroami Kepulauan Karimunjawa Tahun 2003.* 17 ed. semarang: Balai Taman Nasional Karimunjawa dan Wildlife Conservation Society-Marine Program..

Marnane, M. et al., 2003. *Laporan Studi Perikanan Muroami Kepulauan Karimunjawa Tahun 2003.* 27

ed. Semarang: Balai Taman Nasional Karimunjawa dan Wildlife Conservation Society-Marine Program.

McClanahan, T., Marnane, M., Cinner, J. & Kiene, W., 2006. A Comparison of Marine Protected Areas and Alternative Approaches to Coral Reef Management. *Current Biology,* Volume 16, pp. 1408-1413.

Polnac, R., Crawford, B. & Gorosspe, M., 2001. Discovering Factors That Influence the Success of Community Based Marine Protected Areas in the Visayas Philippines. *Ocean and coastal Management,* Volume 44, pp. 683-710.

White, A., Courtney, C. & Salamanca, A., 2002. Experience with Marine Protected Area Planning and Management in the Philippines. *Coastal Management,* Volume 30, pp. 1-26.

Wilkinson, C., Green, A., Almany, J. & Dionne, S., 2004. *Monitoring Coral Reef Marine Protected Area..* 72 ed. Australia: Australian Institute of Marine Science.

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DIJKSTRA'S ALGORITHM APPROACH TO DETERMINE THE SHORTEST PATH

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ABSTRACT

In modern life, everyone wants to achieve time and cost efficiency in their travelling journey. The efficiency of travelling time and costs can be achieve by finding the shortest path between the point of origin and the point of destination. One of the most effective algorithms for determining the shortest path is the Dijkstra algorithm. This study aims to apply the Dijkstra algorithm to determine the shortest path from the origin to the destination. This study drawn a case from previous research that use a dynamic programming approach to determine the shortest path. The result of this study shows that the Dijkstra algorithm approach would give a similar shortest path result as calculated by using the dynamic program approach.

KEYWORDS : node, dijkstra algorithm, shorthest path.

1. INTRODUCTION.

When travelling from one place to another, people generally want to get to the destination quickly to save time and cost-effective. The efficiency of time and cost will be achieved if we can find the shortest path from the city of origin to the destination city. Determination of the shortest path can be done by conventional methods and heuristic methods. Conventional methods usually use ordinary mathematical calculations while heuristic methods are applied with artificial intelligence. Some conventional methods commonly used to determine the shortest path include the Dijkstra algorithm (Dijkstra, 1959), the Floyd-Marshall algorithm (Floyd, 1962), Dreyfus Algorithm (Dreyfus,1969) and the Bellman-Ford Algorithm (1958). Heuristic methods applied to the shortest path problems include bidirectional search algorithms, genetic algorithms, ant colonies, and the shortest path algorithm based on neural network, and so on (Kim and Jeong, 2009).

The shortest path problem concentrates on finding a path with minimum distance,time,or cost from the source node to the destination node. Many programming problems, including transportation, routing, communications, and supply chain management, can be regarded as special cases of the shortest path problem (Gao, 2011). Dijkstra is one of the most effective algorithms in finding the shortest path from one location to another (Xu et al, 2007). Dijkstra's algorithm has the basic principle of searching for the two least trajectories. The iteration in the Dijkstra algorithm is useful for finding the point whose distance from the starting point is the shortest. Now, Dijkstra algorithm also has been widely applied to path optimization for vehicle evacuation in emergencies event (Chen et al, 2014).

In this study, the algorithm Dijkstra will be applied to the case study analised in Jumadi (2014). Jumadi (2014) discusses the determination of the shortest path to campus using dynamic programming method. The density of motor vehicles in the streets of Bandung, especially in certain areas and hours motivates researchers (Jumadi, 2014) to find the shortest path from

Taman Bunga Estate, Sukamukti to UIN Sunan Gunung Djati campus, Cibiru District, Bandung regency. Many alternative ways that can be passed from Sukamukti to UIN Sunan Gunung Djati, Bandung. Some of these roads are located in the area of East Bandung, South Bandung and some are in Central Bandung. The Dijkstra algorithm will determine the shortest path from Sukamukti to UIN Bandung. This study will also compare the results of the shortest path calculation obtained with the algorithm Dijkstra with dynamic programming method.

2. LITERATURE REVIEW

2.1 Network Terminology

A network consists of a number of points and a number of lines connecting a particular pair of points. These points are called node or vertices. While the line is called arc/link or branch. The arc is labeled using the name of the two vertices that ends at the end. For example, AB is an arc between nodes A and B. If the flow through an arc is only one way, then the arc we call directed arc. The direction of the arc is shown by adding an arrow to the end of the line indicating the arc. An arc leading from vertex A to node B must be labeled AB and not BA. The arc can also be labeled A → B. If the flow in the arc is allowed in both directions then the arc is said to be an undirected arc. A network that only has a directional arc is called a directed arc. if all arcs in the network is not directed then the network is called undirected network (Hiillier and Lieberman, 2005).

2.2 DIJKSTRA ALGORITHM

Determination of the shortest path in the graph is one of the optimization problems. The graph used is a graph that is weighted graph that each side is given a value or weight. The weights on the graph side can be distance, time, or cost. Weights are assumed to be positive. The word "shortest" can have a different meaning depending on the problem, but generally the shortest means minimizing the weight on the path in the graph (Munir, 2009).

The graph (G) is defined as the set of sets (V, E), written with $G = (V, E)$ notation, where V is the non-empty set of vertices or nodes and E is a set of edges or arcs, which connects a pair of knots [Munir, 2009]. The vertices on the graph are denoted by lowercase letters $(a, b, c, \ldots)$ or by natural numbers $(1,2,3, \ldots)$ or a combination of both. The pair (u, v) represents the side connecting the u node with the vertex v. The sides can also be denoted by e notation. If e is the side connecting u node with vertex v then it can be written with $e = (u, v)$ (Munir, 2009).

Dijkstra's algorithm is a greedy algorithm used to solve the shortest distance problem for a directed graph with non-negative edge value [9]. The basic idea of Dijkstra's algorithm is a process to find the nearest cost value with the goal objective of a weighted graph function, which in the end can provide the optimal path choices. In Dijkstra's Algorithm, nodes are used in directed graphs to determine the shortest path path. This algorithm aims to find the shortest path based on the smallest weight from one point to another. Suppose an node depicts a building and a line illustrates the path bewtwee noded, the Dijkstra Algorithm calculates all possible smallest weights of any node. Figure 2 presents a graphical example with its weight in determining the path using Dijkstra's Algorithm.

3. METHODOLOGY

In this study, the algorithm Dijkstra will be applied to find the shortest path. Firstly, a point which will be the initial node is determined, then weight the distance on the first node to the closest node, one at a time. Dijkstra's algorithm will search the closest distance from one point to another and then to the next available point in a certain logical way. Dijkstra's algorithm has the following logical sequence:

a. Give weight value (distance) for each point to another point, then set the value 0 at the beginning node and the value is not up to the other node (not yet filled).
b. Set all nodes "not selected" and set initial node as "departure node".
c. From the departure node, consider the neighbour node that has not been selected and calculate the distance from the point of departure. For example, if the departure point A to B has a weight of distance 8 and from B to node C is 2, then the distance to C passes B to 8 + 2 = 10. If this distance is smaller than the previous distance (which has been recorded previously) delete old data, save the data distance with a new distance.
d. When we finish considering each distance against the neighbouring nodes, mark the nodes that have been selected as the selected nodes. The selected node will never be checked again, the stored distance is the last and least weighted distance.
e. Set node not selected with smallest distance (from departure node) as the next departure node and continue with return to step 3.

4. RESULT AND DISCUSSION.

The case study was taken from Jumadi research (2014) on determining the shortest path to campus using dynamic programming algorithm. The study was motivated by the density of motor vehicles in the streets of Bandung, especially in certain areas and hours. Jumadi (2014) determines the shortest path from Sukamukti to UIN Bandung campus. Many alternative roads that can be passed from the Housing Garden Flower, Sukamukti to campus UIN Sunan Gunung Djati, District Cibiru, Bandung regency. Some of these roads are located in the area of East Bandung, South Bandung and some are in Central Bandung. Figure 1 shows an alternate road that can be skipped from Sukamukti to UIN Bandung.

Jumadi (2014) uses a backward approach to determine the shortest path from Sukamukti to UIN Bandung. The dynamic reverse program moves from stage n, continuing to retreat to stages $n-1, n-2$ and so on until stage 1. The decision set variable isx_n, x_{n-1}, …, x_1. Determining the shortest path with this reverse dynamic program begins by dividing the map in figure 1 into 10 stages. Each stage will be processed to get the optimal solution.

The decision variable X_n with *n = 1,2,3,...,10* as the area to be taken at stage n. With dynamic program algorithm, the shortest path from Sukamukti to UIN Bandung is Sukamukti - Sayuran - Cangkuang - Palasari - Telkom Univ - SAMSAT - Gedebage - UIN Bandung. The total distance from the shortest path is 60.

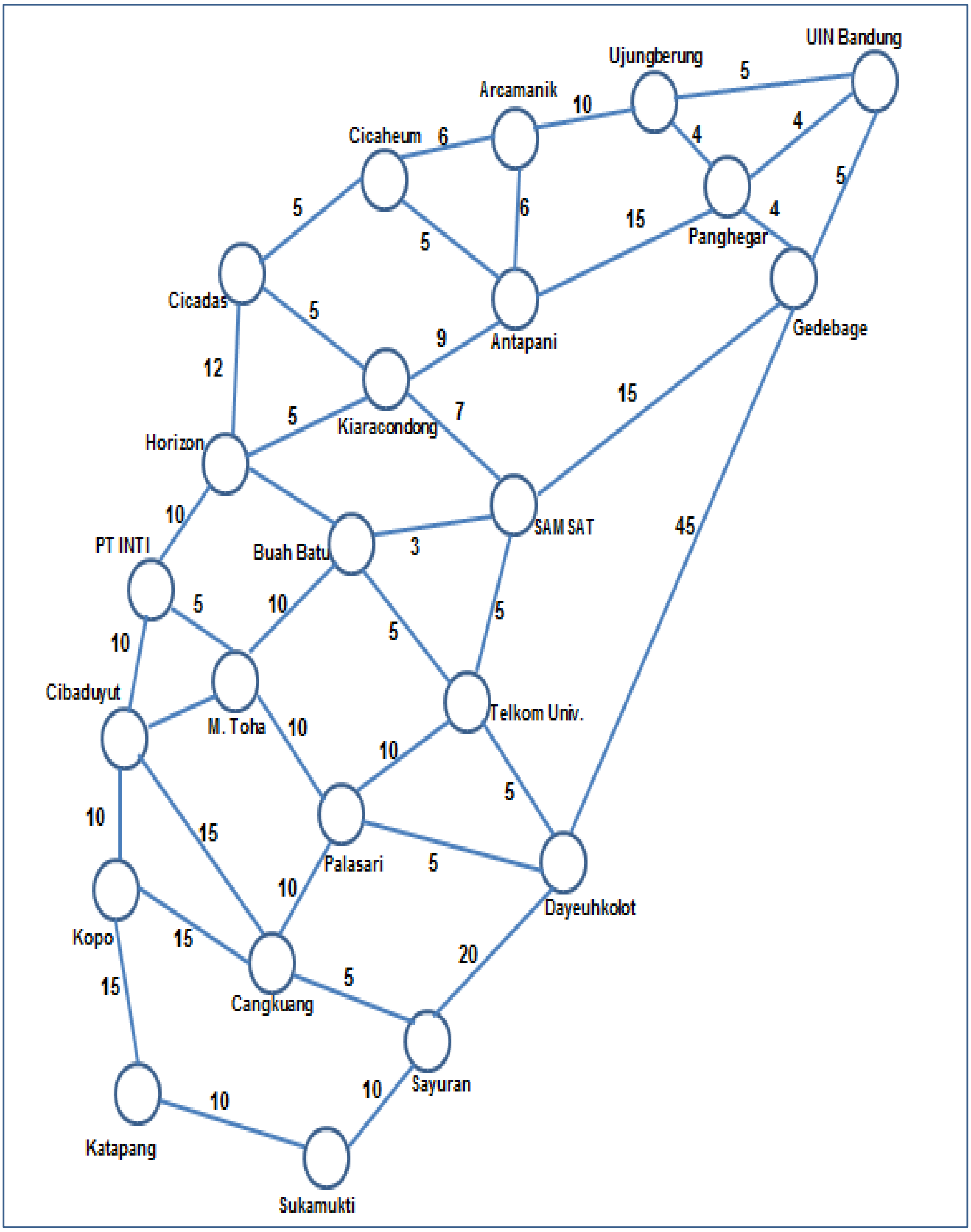

Fig.1 Map Sukamukti to UIN Bandung
(Jumadi, 2014)

This study will determine the shortest path of the problem contained in Jumadi (2014) but with a different approach, using Dijkstra's algorithm. The initial node is Sukamukti while the destination node is UIN Bandung. Below is a detailed explanation of the shortest path from the initial node (Sukamukti) to the destination node (UIN Bandung) with the algorithm Dijkstra. In Figure 1, the initial node 'Sukamukti' and destination node 'UIN Bandung' and each side connecting the node have been assigned a value (weight).

Step 1. Set initial node 'Sukamukti' with value 0 and another node with infinite value.

Step 2. Dijkstra performs calculations on neighbouring nodes that are connected directly to the initial node (departure) 'Sukamukti'. In this case the neighbouring nodes are Vegetables and Ketapang. The weight of the 'Vegetable' node value is 10 (0 + 10 = 10). The weight of the 'Katapang' node value is also 10. Since both nodes have the same value then these two nodes will become the new node of departure (figure 2).

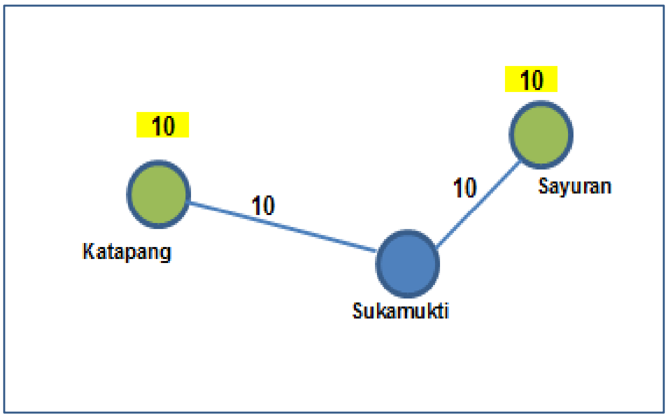

Fig. 2 Step 2

Step 3. The 'Sayuran' node and the Ketapang node are set to the departure node and marked as the selected node. Dijkstra recalculates the neighboring nodes directly connected to the nodes of the 'Vegetable' node and the 'Katapang' node. The neighboring nodes of the 'Vegetables' node are Cangkuang and Dayeuhkolot. The weight value of Cangkuang is 15 (10 + 5) while Dayeuhkolot weight is 30 (10 + 20). The neighbour node of the 'Katapang' node is a Kopo with a weighted value of 25 (10 + 15). Based on the calculation result Dijkstra got that node 'Cangkuang' will be the next departure node because it has the smallest weight value.

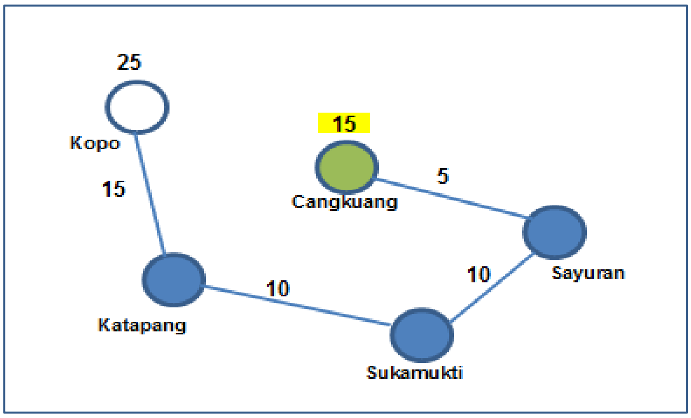

Fig. 3 Step 3

Step 4. The 'Cangkuang' node is set to the departure node and marked as the selected node. Dijkstra recalculates all neighbour nodes that have not been selected (passed) that are connected directly to the selected node. Based on the calculation result Dijkstra found that node 'Palasari' and node 'Kopo' will become the next departure node because it has the smallest weight value that is 25.

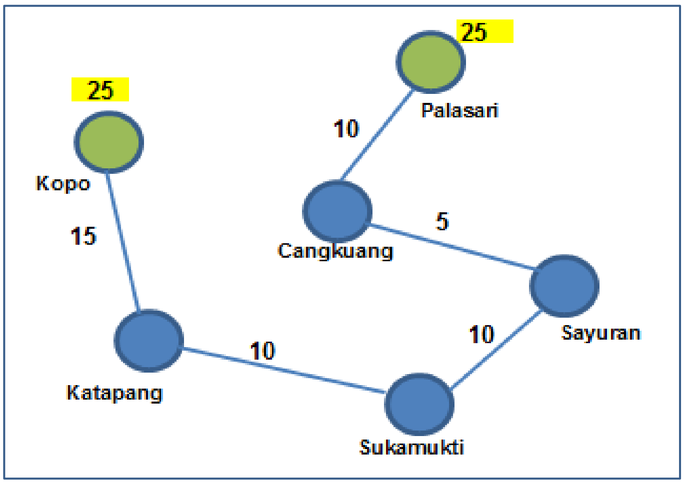

Fig. 4 Step 4

Step 5. The 'Kopo' node and the 'Palasari' node are set to the node of departure and marked as the selected node. Dijkstra recalculates all neighbour nodes that have not been selected (passed) that are connected directly to the selected node. Based on the calculation result Dijkstra found that node 'Dayeuhkolot' will become the next departure node because it has the smallest weight value is 30.

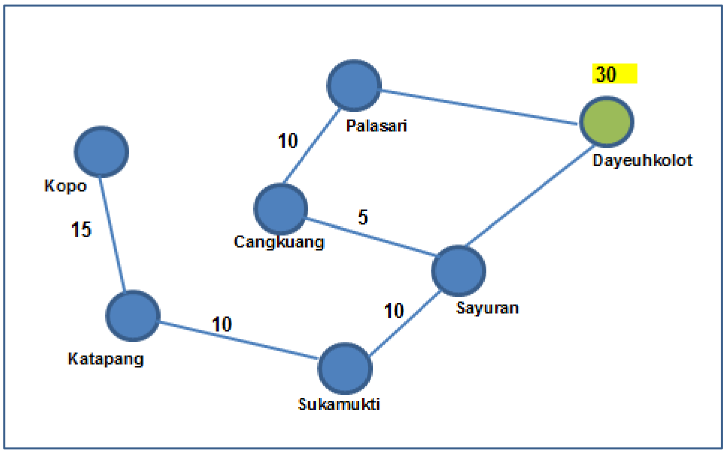

Fig. 5 Step 5

Step 6. The 'Dayeuhkolot' node is marked as the selected node and set to the departure node. Dijkstra recalculates all neighbour nodes that have not been selected (passed) that are connected directly to the selected node. In step 6 there are 3 departure nodes: Dayeuhkolot node, Palasari node and Kopo node. Based on the calculation Dijkstra on all neighbour nodes that have not been selected, obtained the smallest weight value of 35 on node 'Telkom Univ.', Node 'M. Toha 'and node' Cibaduyut '. These three nodes will then become the new departure node.

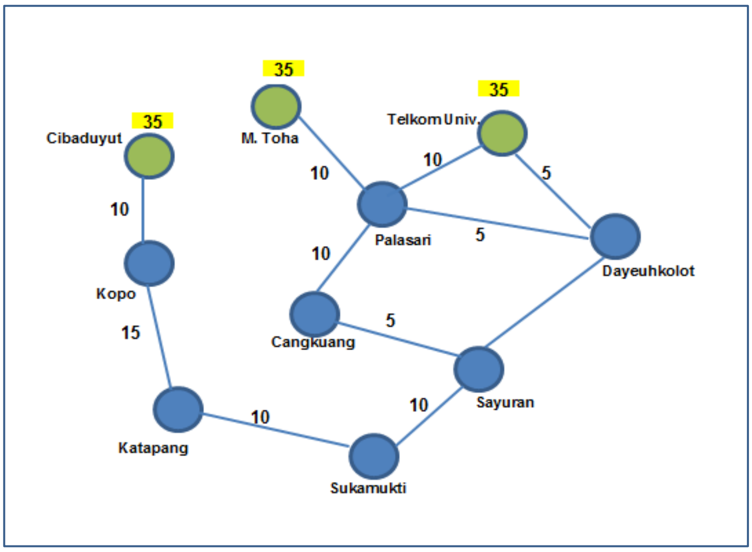

Fig. 6 Step 6

Step 7. The Dijkstra algorithm will continue to perform calculations to all neighbour nodes that have not been selected. This step will continue to be repeated until the destination node has been reached. Calculation algorithm Dijkstra until reach node goal 'UIN Bandung' more can be seen in table 1. The result of calculation in table 1 show that at iteration 11, Dijkstra algorithm have reached destination node UIN Bandung with smallest weight value equal to 60. So it can be concluded that the shortest path from Sukamukti to UIN Bandung is Sukamukti - Sayuran - Cangkuang - Palasari - Telkom Univ - SAMSAT - Gedebage - UIN Bandung. The shortest path from Sukamukti to UIN Bandung is given in figure 7.

Table 1. The Calculation of the Dijkstra Algorithm

N	Solved Node	Unsolved Node	Total distance	The closest node to N	Minimum distance	The connection
1	Sukamukti	Sayuran	10	Sayuran	10	Sukamukti – Sayuran
		Ketapang	10	Ketapang		Sukamukti – Katapang
2	Sayuran	Cangkuang	10+5 = 15	Cangkuang	15	Sayuran – Cangkuang
	Katapang	Kopo	10+15 = 25			
3	Sayuran	Dayeuhkolot	10+20 = 30			
	Cangkuang	Palasari	15+10 =25	Palasari	25	Cangkuang – Palasari
	Katapang	Kopo	10+15 = 25	Kopo		Katapang – Kopo
4	Sayuran	Dayeuhkolot	10+20 = 30			Sayuran – Dayeuhkolot
	Palasari	Dayeuhkolot	25+5 = 30	Dayeuhkolot	30	Palasari – Dayeuhkolot
	Kopo	Cibaduyut	25+10= 35			
5	Dayeuhkolot	Telkom Univ.	30+5= 35	Telkom Univ.		Dayeuhkolot – Telkom Univ.
	Palasari	Telkom Univ.	25+10= 35	Telkom Univ.	35	Palasari –Telkom Univ.
	Palasari	M. Toha	25+10= 35	M. Toha		Palasari –M. Toha
	Kopo	Cibaduyut	25+10= 35	Cibaduyut		Kopo –Cibaduyut
6	Dayeuhkolot	Gedebage	30+45= 75			
	Telkom Univ.	Samsat	35+5= 40	Samsat	40	Telkom Univ.–Samsat
	Telkom Univ.	Buahbatu	35+5= 40	Buahbatu		Telkom Univ.–Buahbatu
	M. Toha	PT INTI	35+5= 40	PT INTI		M. Toha –PT INTI
	Cibaduyut	PT INTI	35+10= 45			
7	Samsat	Kiaracondong	40 + 7 = 47	Kiaracondong	47	Samsat – Kiaracondong
	Buahbatu	Horizon	40 + 7 = 47	Horizon		Buahbatu – Horizon
	PT INTI	Horizon	40 + 10 = 50			
	Dayeuhkolot	Gedebage	30 +45 = 75			
8	Samsat	Gedebage	40 + 15 = 55			
	Kiaracondong	Cicadas	47 + 5 = 52	Cicadas	52	Kiaracondong – Cicadas
	Horizon	Cicadas	47 + 12 = 59			
	Dayeuhkolot	Gedebage	30 + 45 = 75			
9	Cicadas	Cicaheum	52+ 5 = 57			
	Kiaracondong	Antapani	47 + 9 = 56			
	Samsat	Gedebage	40 +1 5 = 55	Gedebage	55	Samsat – Gedebage
	Dayeuhkolot	Gedebage	30 + 45 = 75			
10	Gedebage	Panghegar	55 + 4 = 59			
	Antapani	Cicaheum	56 + 5 = 61			
	Cicadas	Cicaheum	52 + 5 = 57	Cicaheum	57	Cicadas – Cicaheum
11	Cicaheum	Arcamanik	57 + 6 = 63			
	Antapani	Arcamanik	56 +6 = 62			
	Gedebage	UIN Bandung	55 + 5 = 60	UIN Bandung	60	Gedebage – UIN Bandung
	Panghegar	UNI Bandung	59 + 4 = 63			

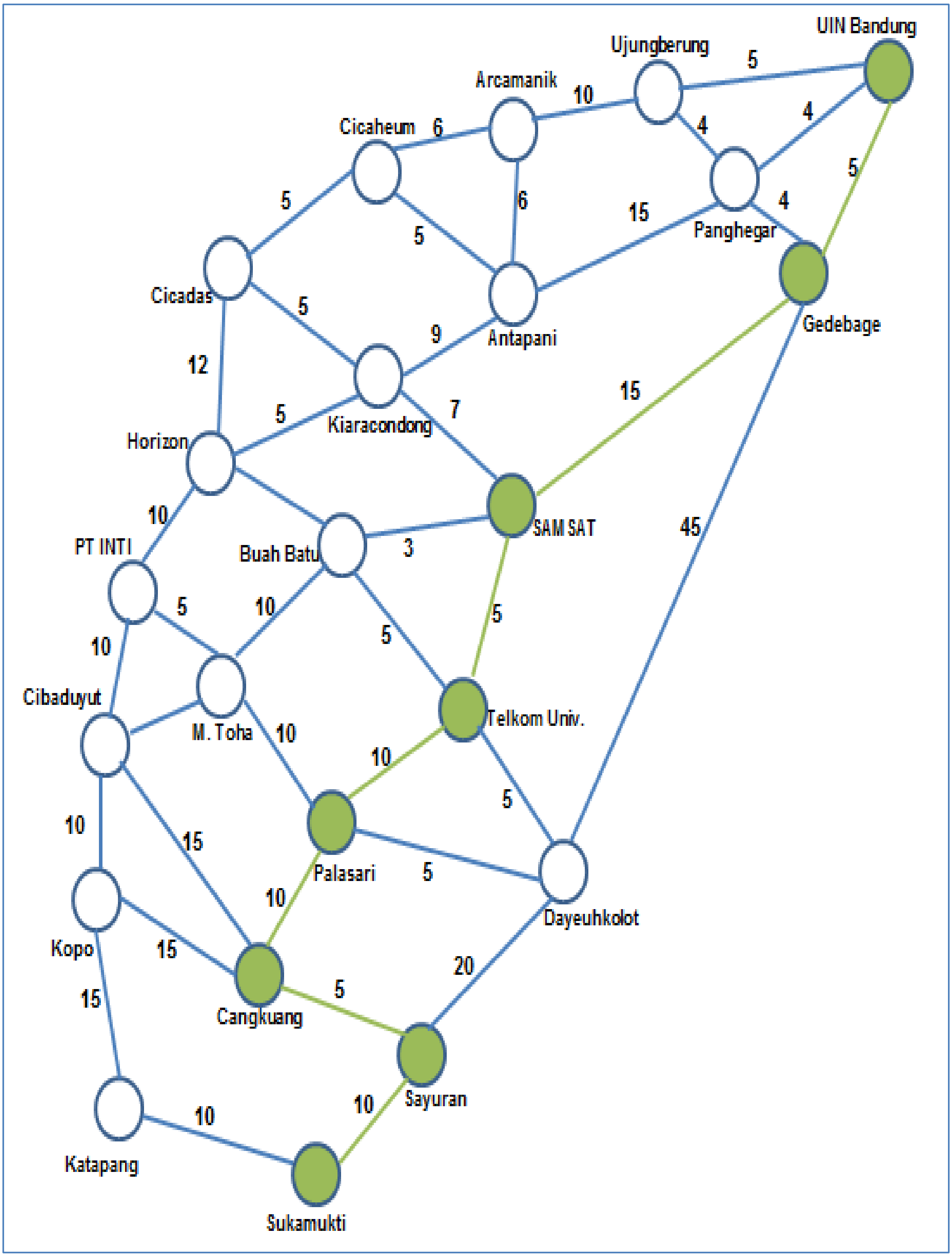

Fig. 7 The shortest path from Sukamukti to UIN Bandung

5. CONCLUSION.

The dijkstra's algorithm can be used to determine the shortest route. The shortest path from Sukamukti to UIN Bandung campus by using dijkstra's algorithm is Sukamukti - Sayuran - Cangkuang - Palasari - Telkom Univ - SAMSAT - Gedebage - UIN Bandung. The minimum distance from the shortest route is 60 km. The result of this study shows that the Dijkstra algorithm approach would give a similar shortest path result as calculated by using the dynamic program approach on the same case study.

6. REFERENCES

Bellman, E., (1958), "On a Routing Problem", *Quarterly of Applied Mathematics*, vol.16, no. 1, pp. 87-90.

Chen, Y., Shen, S., Chen, T., and Yang, R., (2014)," Path Optimization Study for Vehicles Evacuation Based on Dijkstra Algorithm", Procedia Engineering , vol. 71, pp. 159 – 165.

Dijkstra, E.W., (1959)," A Note on Two Problems in Connection With Graphs", *Numerical Mathematics*, vol.1, no.1, pp. 269–271.

Dreyfus, S., (1969)," An Appraisal of Some Shortest Path Algorithms", *Operations Research*, vol. 17, no.3, pp.395–412.

Floyd, R.W., (1962)," Algorithm-97-Shortestpath", *Communications of the ACM*, vol. 5, no. 6, pp. 345.

Gao, Y., (2011), "Shortest Path Problem with Uncertain Arc Lengths", *Computers and Mathematics with Applications*, vol. 62, pp. 2591-2600.

Hillier, F.S., and Lieberman, G.J., (2005), " Introduction to Operation Research", Eight Edition, Penerbit ANDI, Yogyakarta.

Jumadi, (2014) 'Penentuan Rute Terpendek Menuju Kampus Menggunakan Algoritma Dynamic Programming', Jurnal ISTEK, vol. 3, no. 1, pp. 214 – 225.

Kim, B.I., and Jeong, K.,(2009)," A Comparison of Algorithms for Origin - Destination Matrix Generation on Real Road Networks and an Approximation Aproach", *Computers & Industrial Engineering*, vol. 56, pp. 70-76.

Munir, R., (2009)' Matematika Diskrit Edisi Ketiga', Informatika, Bandung.

Xu, M., Liu, Y., Huang, Q., Zhang, Y., Luan, G., (2007)," An Improved Dijkstra Shortest Path Algorithm for Sparse Network", *Applied Mathematics and Computation*, vol. 185, pp. 247-254.

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THE DETERMINATION OF LOCATION CRITERIA OF SUBMARINE TRAINING WITH FUZZY MULTI CRITERIA DECISION MAKING APPROACH (FMCDM)

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ABSTRACT

Indonesian Navy as a marine security defense force has an Integrated Armored Weapon System (SSAT), one of them is the power of Submarine and the amount of it will continue to evolve. The current condition demands to perform a development and review of strategic and optimal submarine training areas to support the exercise and preparedness of the submarine's strength to prepare the readiness of combatcondition. The purpose of this study was to determine the best criteria for the location of the submarine training by analyzing and reviewing some of the existing locations of Navy Submarine Exercise practice and doing a further development. In the selection of submarine training criteria, the method used was Fuzzy Multiple Decision Making Criteria (FMCDM). The result of the criteria weight assessment had been re-verified by the experts with 90% agree, 5% strongly agree and 5% disagree.

KEYWORDS : Determination Criteria,Training Location Criteria, Sumbarime, Fuzzy MCDM.

1. INTRODUCTION

In an effort to improve marine professionalism, Indonesian Navy need routinely and continuity to execute the training of assignment operation. Among several operational exercises conducted, one of them is Submarine Operation Training. Due to the difficulty and more complex factor in any submarine operation area, along with the growing criteria of submarine training areas,it requires better learning and analysis of various submarine training alternatives. By utilizing technology and the development of existing science, hence difficulty can be faced and solved with more effective and efficient.

In the implementation of the determination of submarine training operation area, there is decision-making process and operating goals setting. The right information input and accurate decision-making capabilities were needed to be able to perform this process, whether it is qualitative information or quantitative information. The location of the submarine training site as a part of the submarines training should be meticulously and precisely supporting submarine's operational training.The deployment must be absolutely appropriate so that the impact of the submarine's training area can be felt close to the actual operating area.

The fuzzy theory concept was initiated by Lotfi A. Zadeh in 1965 with his seminar paper "Fuzzy Sets" (Zadeh.L.A, 1975). The ability of fuzzy sets to express the change degree from membership and vice versa has a very wide use. It does not only represent the measurement of uncertainty, but also represents the concept of fuzziness. According to Marimin (Marimin, 2006), the fuzzy system is a structured and dynamic numerical predictor. This system has the ability to develop intelligence systems in uncertain and inapproachable environments. Fuzzy logic is part of Boolean logic that is used to handle the concept of truth degree between right and wrong. Fuzzy logic, with the original idea is how to present the blurring, where the presentation should be sufficient to illustrate the blurring. However, on the other hand it should be simple enough so that computing becomes easier.

The fuzzy method can be developed as a tool in assessing alternative.The other applications as a tool in selecting alternative project partners by taking into account several criteria as requirements (Twiyani, 2001).

In this paper, the authors applied a method that couldexamine alternative evaluation based on qualitative and quantitative criteria by using a Multi Criteria Decision Making Model.In this case, the method used was Fuzzy MCDM (Fuzzy Multiple Criteria Decision Making). Fuzzy Multiple Criteria Decision Making (Fuzzy Multiple Criteria Decision Making) model is very suitable for processing quantitative and qualitative data criteria simultaneously, resulting in DSS (Decision Support System) data for decision makers, which in this thesis research was to determine the ideal and optimal submarine training area for Indonesian Navy.

This study was based on various literature studies, such as the application of fuzzy sets in the decision-making process (zadeh, 1965). Decision making for leaders (Saaty, 1993). Concepts and Applications of Decision Support Systems (Kusrini, 2007). Fuzzy logic and application on GIS (Kainz.W, 2003), Evaluation Development strategy using Fuzzy MCDM approach (Chiou, 2005). The LCD-TV marketing strategy based on customer behavior (Chiu, 2006). Development of Fuzzy MCDC (Chungcu, 2008). The search of Attribute weight on Multi attribute decision making (MADM) with subjective approach using genetic algorithm (Kusumadewi, 2005) Fuzzy Set and Its Application (Zimmermann, 1991,), Fuzzy Approach of MCDM for planning and selection of public facility building design auction (Hsieh, 2004). The concept of linguistic variables and their applications (zadeh, 1965).Tutorials on fuzzy logic (Jantzen, 1998).

This research examined the criteria selection of submarines training area for the Indonesian Navy. It began with data retrieval based on documents and interviews with Experts about submarines and their support with the Koarmatim Submarine Task Force as the base. These data included the factors that influence the selection of the training location and the characteristics of the training location. The data collection was based on the collection method of primary and secondary data. Primary data was obtained from the data collection through questionnaires and interviews with correspondents as the decision makers and experts in the field of submarine training operations. The questionnaire data wass the perception of correspondent against criteria and alternatives. Secondary data was obtained from the results of literature studies or reference books related to the criteria and alternatives.The data obtained was the result of analysis and staff review in the Koarmatim Submarine Unit and had relevance to the research.

This research consisted of several sections, section 2 was the theory of fuzzy theory, section 3 was the research result, section 4 was explanation of weighting assessment on each quantitative criterion, weighting of quantitative criteria, determining mean value, determining mean value of fuzzy number, determining upper limit value and the lower limit of the fuzzy number, calculation of the aggregate weight of each criterion, calculates the defuzzification results of the qualitative and qualitative criteria calculations, calculates the final weight value, and finally section 5 was conclusion and recommendation.

2. RESEARCH METHODOLOGY

2.1. Submarine

Submarines are ships that move below the surface of the water, generally used for military purposes and interests. Most of the Navy own and operate submarines even though the number and population of each country is different. In addition to being used for military purposes, submarines are also used for marine and freshwater science and for duty at depths that are not suitable for human divers. Military submarines are used for the benefit of war or marine investigations of a country. Based on the type, every military submarine is always equipped with weapons such as cannons, torpedoes, anti-aircraft missiles and anti-surface vessels, as well as intercontinental ballistic missiles.

2.2. Submarine Training Location

In conducting combat operations and submarine training, the configuration of archipelagic geography and hydro oseography must be taken into account. The example of it were described as follows:

a. Geography

Geographical physical form of Indonesia consists of a group of islands which have a lot of maritime access straits and choke points that connect ZEE with Archipelagic Water. The large number of maritime access can cause vulnerability for Indonesian marine defense which puts archipelagic waters as resistance field and considered as vital area for Indonesian marine defense

b. Hydro-Oceanography

The geographical form of Indonesia with the number of straits and seas has an effect on the physical properties that also directly affect the parameters of sea water characteristics. It was described bellow:

1) Surface currents, tidal currents and coastal currents.

2) Surface temperature, salinity, and density of sea water.

3) Transparency and color of sea water.

4) The depth of the sea (Bathymetry).

2.3. Fuzzy Theory Concept

The concept of fuzzy theory was initiated by Zadeh in 1965 on his paper called 'Fuzzy Set' (zadeh, 1965). Fuzzy theory shows that all theories can be used as the basic concept of fuzzy set or continues membership function. Broadly speaking, fuzzy theory can be classified into five main areas, namely:

a. Fuzzy Mathematics, where the concept of expanded classical mathematics by changing the classic set with a fuzzy set;

b. Fuzzy Logic & Artificial Intelligence, where estimates for classical logic are introduced and expert systems are developed based on fuzzy information and thought estimates;

c. Fuzzy System, which includes fuzzy control and fuzzy approach with process and communication signals;

d. Uncertainty and Information, where differences of uncertainty are analyzed;

e. Fuzzy Decision Making, where there is consideration for optimization problems.

2.4. Membership Function.

The membership function is a curve which present the mapping of data input points into their membership values (also called membership degrees) that have intervals between 0 and 1. One way that can be used to obtain membership value is through approach function. There are several functions that can be used:

a. Linear Representation

In a linear representation, the mapping of the input to its membership degree is described as a straight line. This form is the simplest and the best choice for approaching a less obvious concept. There are two linear fuzzy set states, the first is that the set increment starts at a domain value that has zeromembership degree [0] moving right to the domain value that has a higher degree of membership.

Membership Function:

$$[x] = \begin{cases} 0; & x \leq a \\ (x-a)/(b-a); & a \leq x \leq b \\ 1; & x \geq b \end{cases} \quad (1)$$

Second, is the opposite of the first. The straight line starts from the domain value with the highest degree of membership on the left side, then moves down to the value of the domain that has a lower membership

Membership Function:

$$\mu[x] = \begin{cases} (b-x)/(b-a); & a \leq x \leq b \\ 0; & x \geq b \end{cases} \quad (2)$$

b. Triangular Curve Representation

The triangle curve is basically a combination of two lines (linear).

Membership Function:

$$\mu[x] = \begin{cases} 0; & x \leq a \text{ or } x \geq c \\ (x-a)/(b-a); & a \leq x \leq b \\ (c-x)/(C-b); & b \leq x \leq c \end{cases} . \quad (3)$$

c. Representasi Kurva Trapesium

The trapezoid curve is basically a triangular shape, except that there is a point that has a membership value of 1.

Membership Function :

$$\mu[x] = \begin{cases} 0; & x \leq a \text{atau} x \geq c \\ (x-a)/(b-a); & a \leq x \leq b \\ (c-x)/(C-b); & b \leq x \leq c \end{cases} .(4)$$

d. Triangular Fuzzy Number (TFN)

In TFN, every single value (crisp) has a membership function consisting of three values and each of it was representing the lower, middle and upper values. Graphically, the membership function with TFN can be describedin the following figure:

$$\mu[x] = \begin{cases} 0; & \text{for } x < a1 \\ \frac{x-a_1}{a_2-a_1}; & \text{for } a1 < x < a2 \\ \frac{a_3-x}{a_3-a_2}; & \text{for } a2 < x < a3 \end{cases} \quad (5)$$

d. Value of Defuzzification

Defuzzification is a process of conversion and quantity of fuzzy into a definite quantity, where the output and fuzzy process can be a combination of logic from two or more fuzzy membership functions defined in accordance with the universe of speech. Defuzzy input and process is a fuzzy set obtained from the composition of fuzzy rules, while the resulting output is a number in the fuzzy set domain. Therefore,when a set fuzzy within a certain range is given, then a certain crisp value as outputshould be taken. There are several defuzzification methods that can be used. They are described bellow:

1) Centroid Method(Composite Moment). In this method, the crisp solution is obtained by taking the center point (z) of fuzzy area.
2) Bisector method. In this method, the crisp solution is obtained by fetching a value on the fuzzy domain that has a membership value of half of the total membership value in the fuzzy area.
3) Mean of Maximum Method (MOM). This method of crisp solution is obtained by taking the average value of domains that have a maximum membership value.
4) Largest of Maximum Method (LUM). This method of crisp solution is obtained by taking a magnified value

from a domain that has a maximum membership value.

5) The Smallest of Maximum Method (SOM). In this method, the crisp solution is obtained by taking the smallest value of the domain that has the maximum membership value.

2.5 Linguistic Variable

Variable linguistic is a variable that has a description of fuzzy numbers and more generally a word represented by fuzzy set.Forexample, the descriptions of linguistic variables for the criteria of threat area of the country in the form of LOW, MEDIUM and HIGH where the description is expressed as fuzzy value (fuzzy value) (Lefteri H. Tsoukalas, 1997). Like algebraic variables that use numbers as values, linguistic variables use words or sentences as values. It forms a set called the "term" set and each value of "term" is a fuzzy variable defined by base variable. While the base variable defines the universe of speech for all fuzzy variables in the "term" set (Jantzen, 1998).

2.6. Multi Criteria Decision Making

Multi Criteria Decision Making (MCDM) is an approach for decision-making process that has a decision problem situation with criteria, objective or multiple attributes (Pohekar.S.D&Ramachadran, 2004).

3. RESEARCH METHOD

3.1. Data Processing

After the data obtained from the questionnaire, the next step was to recapitulate the results of questionnaires and to process the data. The data processing used fuzzy MCDM algorithm. In data processing used the MCDM fuzzy algorithm, the sequence of process would be described as follows(Liang, 1994):

a. Tabulate the criteria weighting result of the qualitative criteria to get the aggregate weight value.

b. Tabulate the results of ratings or preferences for each alternative based on existing qualitative criteria.

c. Determine the middle value of the fuzzy number, by summing the values that appear at each level of the linguistic scale and then dividing the sum with the number of criteria whose value falls into the level of the linguistic assessment. The mathematical notation was described as follows:

$$a_t = \frac{\sum_{i=1}^{k}\sum_j T_{ij}}{\sum_{i=1}^{k} n_{ij}} \quad (6)$$

a_t = Mean of the levelfuzzy

T = Level of assessment, namely very low, low, medium, high and very high.

n = The number of scale factors of the linguistic scale T for the 1st alternative of the i-th factor.

T_{ij} = The numerical value of the linguistic scale T for the 1st alternative of the j-th factor

d. Determining the lower bound value and upper limit value of the fuzzy number, where the lower bound value (ct = b (i - 1)) was equal to the lower mean value, while for the upper bound value (bt = b (i - 1)) was equal to the mean value of the level above it.

e. Determining the aggregate weighting of each qualitative criterion.This study used linguistic appraisal form that already has the definition of fuzzy triangular number. Thus, the aggregate weighting was needed to be determinated.The aggregation process was performed by finding the aggregate value of each lower limit value (c), the mean value (a) and the upper limit value (b), which can be modeled as follows:

$$c_t = \frac{\sum_{j=1}^{n} c_{tj}}{n}\, a_t = \frac{\sum_{j=1}^{n} a_{tj}}{n}\, b_t = \frac{\sum_{j=1}^{n} b_{tj}}{n} \qquad (7)$$

c_{tj} = the value of the lower limit of the qualitative criterion t 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} = the upper limit value to the t-th qualitative criteria by j-th decision makers

n = the number of assessors (decision makers) The Aggregate value was

N = (c_j,a_j,b_j) Where:

Nt = the aggregate weighting value for the t-th qualitative criterion

f. The next step was to find the value of criteriadefuzzification. The defuzzification method used wass the method of centroid. The formula of the defuzzification criteria was described as follows:

$$defuzzification\ N_t = \frac{\left[\left[\int_{c_t}^{a_t} \frac{(x-c_t)}{(a_t-c_t)} x dx + \int_{a_t}^{b_t} \frac{(x-b_t)}{(a_t-b_t)} x dx\right]\right]}{\left[\left[\int_{c_t}^{a_t} \frac{(x-c_t)}{(a_t-c_t)} dx + \int_{a_t}^{b_t} \frac{(x-b_t)}{(a_t-b_t)} dx\right]\right]} \qquad (8)$$

Where: t = criteria of 1,2,3......n

g. The Defuzzification value processing into the Final Weight Value of each Criteria, by dividing the Weight Value of each defuzzification criterion by the total number of weight values across the defuzzification criteria.

NB t = Nt /ΣNt(1-n) (9)

Where :

NB t = The final weighting value of each criterion

Nt = The value of the defuzzification criteria weight

ΣNt(1-n) =The total weighted value of the entire defuzzification criteria

4. ANALYSIS AND DISSCUSSION

The analysis and discussion of choosing submarine location criteria consists of several steps which were:

Step 1. Collection and data processing for data analysis and interpretation and the preparation of Fuzzy MCDM Model. Based on collecting and processing the data, the desired result Data and questionnaires was known to be used to determine the weight of qualitative and quantitative criteria based on each criterion by using fuzzy MCDM algorithm. So, the value rank of importance wight on each could be obtained. Data input was performed using manual calculations from questionnaires. Questionnaires were distributed to Submarine Unit Commander, Submarine Academy Commander, Commander of Chakra, and Commander Nanggala. The data obtained were used to determine the weight of each criterion.The Fuzzy method was used for the data processing and to quantify the data.

Table 1 Describes the recapitulation of the weight in each criterion by the questionnaire generated by Fuzzy MCDM. It calculated by two scoring scales of linguistic scale and numerical scale. The linguistic scale was divided into 5 levels of assessment, namely "very low", "low", "medium", "high" and "very high", while the assessment for a numerical scale was between 1-10.

Table. 1 Recapitulation of questionnaire data for criteria assessment.

NO	Criteria	DM 1	DM2	DM3	DM4

			L	N	L	N	L	N	L	N
1	Qualitative	Conditions of water barrier	ST	9	ST	9	ST	9	ST	10
2		Ship Maneuve	T	8	T	7	T	7	T	8
3		Personnel Logistic Availability	T	7	T	8	T	7	ST	6
4		Materials Availability	S	6	S	6	S	5	T	7
5	Quantitative	Waters Area	T	8	T	7	T	8	T	8
6		Depth	S	6	T	7	T	7	T	8
7		Speed of Current	T	8	T	8	ST	9	ST	9
8		Water Density	T	7	S	6	S	5	T	7
9		Water Sanility	T	7	T	8	T	7	T	8
10		Water Tidal	T	7	T	6	S	5	T	7

Based on the results data presented above, a graph of membership function for each respondent based on the level of importance of qualitative and quantitative criteria could be arranged on the scale of lower, middle, and upper value limits. The results were described as follows:

Table. 2 TFN Respondent of qualitative and quantitative assessment

NO	LINGUISTIC LEVEL	DM 1			DM 2			DM 3			DM 4		
		ct	at	bt	ct	at	bt	ct	at	bt	ct	at	bt
1	Very Low	-	-	-	-	-	-	-	-	-	-	-	-
2	Low	-	-	-	-	-	-	-	-	-	-	-	-
3	Moderate	1	6	7,43	1	6	7,5	1	5	7,2	1	6	7,6
4	High	6	7,43	9	6	7,5	9	5	7,2	9	6	7,6	9,5
5	Very High	7,43	9	10	7,5	9	10	7,2	9	10	7,6	9,5	10

The chart below shows the TFN membership function for each respondent in the criteria importance level. Each criterion of respondents was shown in the value of lower, middle and upper limit with themembership degree of 0-1.

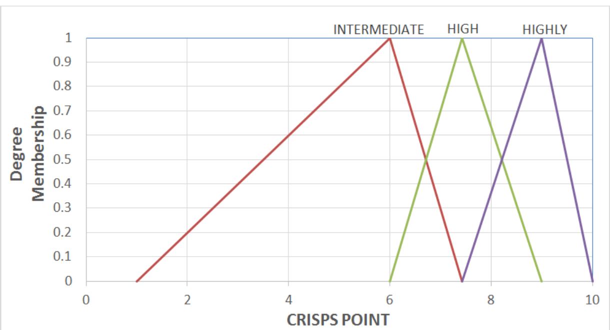

Fig. 1 Membership Function of Triangular Fuzzy Number from DM 1

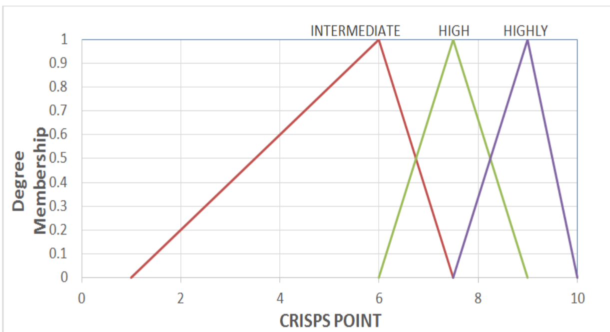

Fig. 2 Membership Function of Triangular Fuzzy Number from DM 2

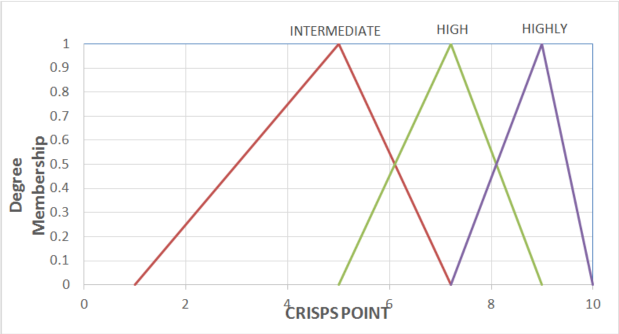

Fig. 3 Membership Function of Triangular Fuzzy Number from DM 3

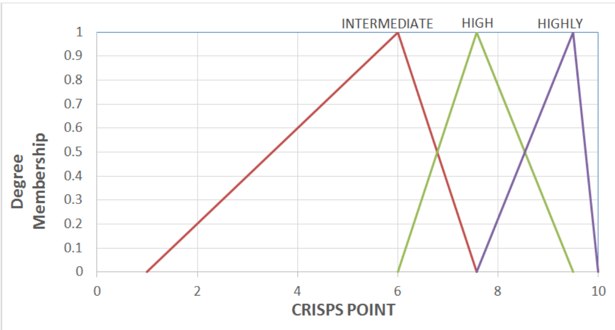

Fig. 4 Membership Function of Triangular Fuzzy Number from DM 4

Respondents evaluated each selection of criteria by using linguistic scales to obtain weight levels for the the criteria importance. The weights on the linguistic scale were shown in the table 1.

Step 2. Calculate the aggregate weight for each criteria that will be used in defuzzification. The results of the average Aggregate Weight for the criteria importancewere presented in Table 3.

Table. 3 Aggregate Weight of Qualitative and Quantitative Criteria

NO	Criteria		Weight Average		
			ct	at	bt
1	Qualitative	Conditions of water barrier	7,43	9,13	10
2		Ship Maneuve	5,75	7,43	9,13
3		Personnel Logistic Availability	4,5	7,03	8,64
4		Materials Availability	2,25	6,14	7,91
5	Quantitative	Waters Area	5,75	7,43	9,13
6		Depth	4,5	7,07	8,73
7		Speed of Current	6,69	8,36	9,5
8		Water Density	3,5	6,5	8,3
9		Water Sanility	5,75	7,43	9,13
10		Water Tidal	3,5	6,5	8,3

Step 3. Calculate the deffuzification using the centroid method by taking the *Crisp* value (singular value) coming from the middle of the existing fuzzy area so that it would match the design of the membership function and the fuzzy rule base used. Defuzzification results were presented in table 4.

Table. 4 Criteria of Defuzzification Weight

NO	CRITERIA		Defuzzification Weight
1	Qualitative	Conditions of water barrier	8,850
2		Ship Maneuve	7,433
3		Personnel Logistic Availability	6,725
4		Materials Availability	5,433
5	Quantitative	Waters Area	7,433
6		Depth	6,767
7		Speed of Current	8,183
8		Water Density	6,100
9		Water Sanility	7,433
10		Water Tidal	6,100

Step 4. Calculate the final weight value of each qualitative and quantitative criteria. The results were presented as follows :

Table. 5 Rank in Each Criteria

NO	CRITERIA		Final Weight	Rangking
1	Qualitative	Conditions of water barrier	0,126	1
2		Ship Maneuve	0,105	3
3		Personnel Logistic Availability	0,095	7
4		Materials Availability	0,077	10
5	Quantitative	Waters Area	0,105	4
6		Depth	0,096	6
7		Speed of Current	0,116	2
8		Water Density	0,087	8
9		Water Sanility	0,105	5
10		Water Tidal	0,087	9

Based on the ranking result on the qualitative and quantitative criteria described above, it could be seen that the first criterionwas the condition of water obstacle/barrier was the first rank with the weight of 0.126 followed by the criteria of Current Speed with the weight of 0.116, and the third rank was the criteria of Ship Maneuvers and the last weight was the availability of material with a weight of 0.077.

Step 5 was verification. Verification was performed to check and collect Expert/DM/Respondents' opinions aboutthe final weighting criteria of submarine training location location. Verification was performed by sending the Questionnaire back to the Decision maker about the final weighted criteria of the submarine training location with the results described in Table 5.

Table. 6 The Results of Verification Total in DM 1 to 4

NO	LOCATION CRITERIA	Final Qight	Rangking	Strongly Disagree	Disagree	Agree	Strongly Agree
1	Barrier Condition	0,126	1	0	0	2	2
2	Speed of Current	0,116	2	0	0	2	2
3	Ship Maneuver	0,105	3	0	0	2	2
4	Waters Area	0,105	3	0	0	3	1
5	Water Sanility	0,105	3	0	0	4	0
6	Depth	0,096	4	0	1	3	0
7	Personnel Availability	0,095	4	0	0	3	1
8	Water Density	0,087	5	0	0	4	0
9	Water Tida	0,087	5	0	1	2	1
10	Material Availability	0,077	6	0	0	3	1
Jumlah				0 %	5 %	70 %	25 %

The other results of weight in DM 1, DM2, DM3 and DM 4 all stated **Agree** and **Strongly Agree** on the weighting of 10 Criteria of Submarine training location. So that the final weighting/value of each Determination Criteria on Location of Submarine Training with Fuzzy MCDM method could be described.

5. CONCLUSION.

After performing research methods and data processing on the selection of naval submarine training location by using MCDM fuzzy method,it can be concluded that:

a. Based on the result of literature study and brainstromimg with the experts in conducting the election of Navy submarine training location, 10 compatible criteria were needed to be considered in selecting the location of Navy submarine training which includes: obstacle/barrier condition, speed of current, ship maneuver, water area, salinity, depth of water, availability of logistics, density, tidal and availability of materials.

b. The decision-making process within the Navy's submarine training location was not done by a single decision maker, but it involves many decision makers, so that each decision maker would provide a different assessment of subjectivity to those criteria.

c. Fuzzy algorithm could be applied in the selection of this submarine location, because it can eliminate the fuzziness of data and criteria that were qualitative with high subjectivity value. FMCDM method was able to accommodate and analyze all the criteria and process so that it could become more easily translated in supporting decision making system.

6. REFERENCES.

Chiou, H. T. G. a. C. D., 2005. Evaluating Sustainable Fishing Development strategies Using Fuzzy MCDM approach. *International Journal of Research in Commerce and Management,* pp. 123-305.

Chiu, Y. J., 2006. Marketing strategy based on customer behaviour for the LCD-TV. *International Journal and Decision Making,* p. 143–165.

Chungcu, T., 2008. An extension to fuzzy MCDM.. *Science Direct.*

Hsieh, T.-Y. L. S.-T. T. G.-H., 2004. Fuzzy MCDM approach for Planning and design tenders selection in public office buildings. *International Journal of Paper Management,* pp. 22, 573-584 .

Jantzen, J., 1998. *Tutorial on Fuzzy logic,* Denmark: Technical University of Denmark, Dept. of Automation, Technical Report.

Kainz.W, D. o. G. a. R. R., 2003. *Intruducing to Fuzzy Logic And application in GIS.* Austria: s.n.

Kusrini, 2007. *Concepts and Applications of Decision Support Systems.* Yogyakarta: Andi Offset.

Kusumadewi, S., 2005. Sought after attribute weight on multi attribute decision. *Gematika Jurnal Manajemen Informatika,* pp. 7, 1, 48-56..

Lefteri H. Tsoukalas, R. E. U., 1997. *Fuzzy and neural approaches in engineering.* Universitas Michigan: Wiley.

Liang, W. a., 1994. A hierarchy Fuzzy MCDM Method for studying electronic marketing strategies in the informations seevice industry. *International Journal Information Magage,* pp. vol 8,1-22.

Marimin, 2006. *Teach and aplicati is creteria,s decision making composite.* Jakarta: Grasindo.

Pohekar.S.D&Ramachadran, 2004. Application of multi creteria decision making to sustanable energy planing-A Review renewable&sustainable energy review. *DOI: 10.1016/j.rser.2003.12.007.*

Saaty, T., 1993. *Decision making for leaders.* Jakarta: s.n.

Twiyani, c., 2001. *Metodhe Fuzzy for project client elect,* Surabaya: ITS Jurusan Teknik Industri.

Zadeh.L.A, 1975. The concept of a linguistic variable and application to approximate reasoning. *Information science,* pp. 8;43-80.

zadeh, L., 1965. Fuzzy Set,Information and Control.

Zimmermann, H., 1991,. Fuzzy set theory and its applications. *2nd ed., Boston,London: Kluwer Academic Publishers.*

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UTILIZATION OF RENEWABLE ENERGI BY METHODE OF CBA (COST BENEFIT ANALYSIS) AND ELECTRE (ELIMINATION ET LA CHOIX TRADUISANT RÉALITÉ) TO ANALYZE THE ELECTRICITY NEED IN THE STATE BORDER AREA

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ABSTRACT

Along with the growth of the national economy, the greater the demand for electricity supply nationwide. Benefits of electricity that can be used directly in everyday life that is for light, as an energy source, as an entertainment infrastructure, producing heat and as a producer of motion. However, not all electricity needs can be met by the State electricity company (PLN) in view of the new Indonesian electrification ratio reached 88.30% and many inhabited islands were untouched by electricity, one of which is P.Romang in Southwest Maluku district. The results of this study indicate that Romang Island holds the potential of renewable energy, with details for the solar power potential of 5.1 kWh / m2 and wind of 5.1 m / s. This potential is feasible to be used for solar power generation and wind power generation fired plant. Therefore, needs electrical energy needs by renewable energy Using the method of cost benefit analysis (CBA) and ELECTRE IIII result SPP and fired plant to be developed, but more SPP provides benefits in accordance with the results of the calculation method of the CBA. The results of the calculation of NPV and IRR calculations show numbers for SPP is Rp 135,189,336,609.72 (interest rate of 6%), Rp 119,259,549,108.26 (9% interest), Rp 111,332,148,055.47 and fired plant is USD 174 985 410 781, 98 (6% interest), Rp 156,111,067,510.21 (9% interest), Rp 146,025,482,870.77 (11%). IRR for the SPP is 24% (6% interest), 28% (9% interest), 31% (11%) and thermal power station is 23% (6% interest), 28% (9% interest), 31% (interest 11%). This result deserves to be developed against both types of these plants.

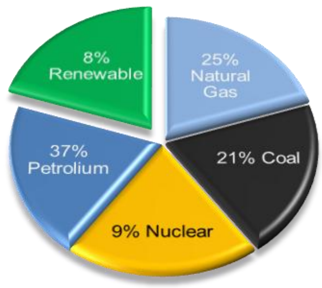
Keywords : Renewable energy, solar power, thermal power station, CBA, ELECTRE IIII

1. INTRODUCTION.

Energy is a fundamental requirement in the modern era, are directly related to the welfare and prosperity of life and the world today requires a large energy supply (Mandal et al., 2017), As well needs national electricity consumption will continue to increase with the growth rate of the national economy. The increase of energy demand in the world in 1970 and the increasing almost doubled in 1997, and the growth of about 57% in 2004 - 2030, it is an alarm for the search for renewable energy sources. That is to overcome the energy crisis when the fuel oil energy source is decreased (Diana, 2012). The electricity consumption is still in the industrial sector, the household sector and the transport sector. Transportation sector that consumes fuel oil energy, now has started to switch and developed vehicles sourced electrical energy. This further indicates an increase in electrical demand Electricity (Gao & Winfield, 2012). Although the electric-powered vehicles development might not utilized by everyone, but to reduce the fuel consumption of vehicles, it has also developed natural gas-fueled vehicles to reduce the rate of world fuel consumption (Gabbar et al., 2016). Consumption in the household sector is directly proportional to the growth in population. Population growth should also be followed by better economic growth. Beginning from the discovery of steam energy sources up to a source discovery of electrical energy, it has provided significant changes to development in each region, creating new activities and new needs for human life (Mazzeo, 2013). It has shown one way to improve the economy is to fulfill the need of electricity as an energy source for increased productivity and infrastructure supporting the economy.

One of the problems Indonesia is geography position as an archipelago state that makes constraints quite difficult to increase the electrification ratio, especially in eastern Indonesia (Aditya & Addin, 2017). Indonesia's electrification ratio in the country - most regional countries are still relatively low. With the electrification ratio amounted to 88.30%, there are still many Indonesian people who have not enjoyed electricity, when most other people can not imagine how to live without electricity. While the ratio electrification of Singapore 100%, Brunei 99.7%, Malaysia 99%, Thailand 99.3% and Vietnam 98%. Adequate energy needs will always improve living standards for people in all facets of life. This can be evidenced in countries - .

developing countries, where the country has been implementing a transition towards greater electrification with consideration of the impact of economic, social, health and the environment. Since energy is a vital factor in production (Best et al., 2017). Countries in Southeast Asia are beginning to recognize the need to diversify their energy sources. This needs to be done to reduce dependence on import energy. Similarly, Indonesia, which began to increase the utilization of natural gas energy sources (Birol et al., 2015). In Table 1.



The Energy Policy of Southeast Asian Countries, indicates that the processing and utilization of energy is a thing that must be well planned in the long run.

Fig. 1. Data source of electricity in the world (Banerjee & Choudhury, 2015)

Source of electricity in the world today is still predominantly use fossil fuels, the details of which oil by 37%, natural gas 25% and coal 21%. Nuclear electricity sources 9% and 8% renewable energy sources. Comparison of the electricity source can be seen in Figure. 1 Data Sources of electricity in the world

Table 1. The Energy Policy of Southeast Asian Countries (Birol et al., 2015)

Country	Sector	Policy and targets
Brunei Darussalam	Efficiency Renewables	Reduce energi intensity by 45% from 2005 levels by 2035 Achieve 10% of electricity generation from renewable by 2035
Cambodia	Efficiency	Reduce energy consumption 20% from BAU level by 2035.
Indonesia	Efficiency "New and renewable energy" Climate change	Reduce energy intensity by 1% per year to 2025. Increase share of "new and renewable energy" in primary energy supply to reach 23% by 2025 and 31% by 2050. Reduce GHG emissions 26% from BAU level by 2020, increase to 41% reduction with enhanced international assistance.
Lao PDR	Efficiency Renewable	Reduce final energy consumption from BAU level by 10%. Achieve 30% share of renewable in primary energy supply by 2025.
Malaysia	Efficiency Renewables Nuclear Climate change	Promote energy efficiency in the industry, buildings and domestic sectors Increase capacity of renewables to 2 080 MW by 2020 and 4 000 MW by 2030 Government is developing plans and undertaking feasibility, site selection and regulatory studies. Reduce carbon intensity of GDP by 40% by 2020 from 2005 levels.
Myanmar	Efficiency Renewables	Reduce energy demand by 10% from BAU level. Achieve 15% to 18% share of renewables in total generation capacity by 2020.
Philippines	Efficiency Renewables	Attain energy savings equivalent to 15% of annual final demand relative to BAU by 2020. Triple the installed capacity of renewables power generation to 15GW by 2030
Singapore	Efficiency Climate change	Reduce energy intensity by 35% by 2030 from 2005 levels Reduce GHG emissions by 7% to 11% below BAU levels by 2020, which will be increased to 16%, if there is a legally binding global agreement on climate change. Reduce GHG emissions intensity by 36% by 2030 from 2005 levels
Thailand	Efficiency Renewables Nuclear	Reduce energy intensity by 30% compared with 2010 by 2036 through the removal of fossil-fuel subsidies and accelerated energy efficiency improvements. Renewables to reach 20% of power generation by; biofuels to reach 20% of transport fuel use by 2036. Two commercial reactors have been planned since 2007, although progress has stalled since the Fukushima Daiichi accident.
Vietnam	Efficiency Renewables Nuclear	Reduce energy consumption by 5% to 8% by 2015 and 8-10% by 2020 relative to BAU Increase the share of renewables in electricity generation to 4.5% by 2020 and 6% by 2030 Develop 10.7 GW of nuclear power capacity by 2030.

A while electricity in Indonesia is still using fossil fuel / coal and in Indonesia eastern includes Sulawesi, Nusa Tenggara, Maluku to Papua using a power source of fuel oil / diesel fuel and the effect of decreasing the production of diesel fuel at the oil refineries in the country, while the demand for diesel fuel requirement increases, it forces the government to import diesel fuel, causing increasing burden of state finances. This condition causes the diesel fuel to be one component of an expensive costs, and the impact on the difficulty of the electricity demand in eastern Indonesia to fulfill. Included also resulted in many areas of unmet electricity demand, especially in PPKT (minor outlying islands). One of them is on Romang Island and surrounding areas, there are included in the subdistrict administrative region Romang Islands, Southwest Maluku district, Maluku Province. Given the Maluku province is the State Border Area with Australia and Timor-Leste, it already should be subject of study to be carried out on all sides, especially the considerations of strategy developments. Actions relating to defense strategy includes planning and organizational development and infrastructure provision, the determination of the best use of resources and sources of procurement, identification of work standards to be achieved, and the establishment of control mechanisms and reporting (Sokolovic et al., 2013). Construction of the power plant is one of the ventures of strategic actions in the form of infrastructure development for the provision of a source of energy / resources. Of course, in the construction in Romang Island Maluku should also refer to the regulations on spatial border area in Maluku Province as stipulated in Presidential Regulation Number 33 of 2015, which explained that the border area in the province of Maluku is a national strategic area, that of national spatial arrangement prioritized for has a very important influence nationally against the country's sovereignty, defense and resilience of the state, economic, social, cultural or environmental.

With yet insufficient source of electrical energy in Romang Island, it is necessary to find an alternative way out in the form of renewable energy sources as a solution to energy cryssis, so that people can enjoy the support of electrical energy sufficient and sustainable. Research this energy source will open up investment projects that can provide benefits and impact on the economic development of the local or regional economy, optimization of transportation flows but it also have negative effects such as population displacement (Andrei et al., 2009). Of course, in meeting the need for energy independence should still be the best solution by using renewable energy sources. Renewable energy is an energy source that comes from nature and are directly usable on - time, such as a source of wind energy, solar energy, wave energy, tidal energy, geothermal energy, biofuels energy, and others. In this study will be restricted on the comparison between wind energy and solar energy as a source of electrical energy in Romang Island, Southwest Maluku, Indonesia.

2. MATERIAL AND METHODOLOGY

In the presidential regulation on spatial explained that the border area is an area or region in the form of a national strategic area and is located on the inner side along the state border. Border area in question in this research is an area that is located in Maluku province, bordering the states of Australia and Timor Leste. While the national strategic areas can be defined as spatial arrangement areas prioritized because it has a very important influence nationally against the sovereignty of the State, defense and resilience of the State, economic, social, cultural, and / or the environment, including areas that have been designated as world heritage, Spatial planning border area in Maluku province has a role as an operational tool and a means of coordination in implementing development in the border area between the Republic of Indonesia, Australia and East Timor. It also serves as a guideline for determining the location and function of investments, as well as management of border area. Development in country border areas should be based on the idea of sustainable development with due regard to social, economic and environmental aspects (seferaj, 2014)

The energy source that has been used is the energy derived from fossil fuels and conventional / it can not be updated. The greater utilization and energy needs of the world it will be faster as well the loss of this energy source. This prompted many of the modern countries to developt and build nuclear reactors as an alternative step for future sources of electrical energi (Shykinov et al., 2016) However, in addition to nuclear energy can also be used as a replacement source of fossil energy is wind energy and solar energy as an alternative source of renewable energy that will never run out utilized, so that it can be interpreted that the definition of renewable energy is energy derived from nature and can be used continuously without any risk of running energy resources.

PV (Photovoltaic) is a process to convert the radiant energy of the sun into direct current electrical energy, made of silicon material and given additional layer of special materials. If the sunshine on the cell the electrons out of the atoms and the flow causing an electrical voltage and pass an electric generation effort that can be arranged either in parallel or in series. Given the energy source is the sun then the condition of the electricity generated will be strongly influenced by the weather and the movement of the sun so that the intensity of the sunlight received by the cell will always change, and the generated electric power becomes unstable. PV has been developed and it has been refined of a technology called PVGIS (Photovoltaic Geographical Information System). This type of PV is able to adjust to the sunlight conditions both when the weather is bright and cloudy and also able to adjust the angle of the sun's position elevation so that the process of changes solar radiation into electric current can be more efficient. This PV can produce electricity of 763 kWh per year (Taus et al., 2015) The sun's movement in question is the movement of the sun throughout the year which are always shifting between 23,5º N up to 23,5º S. For the geographical position of Indonesia in the region around the equator, the effects of this condition does not causes too big difference, but for a country that geographical located at high latitudes away from the equator, the effect of these differences become apparent. See bellow to the Figure 2. The orbit of earth arround the sun.

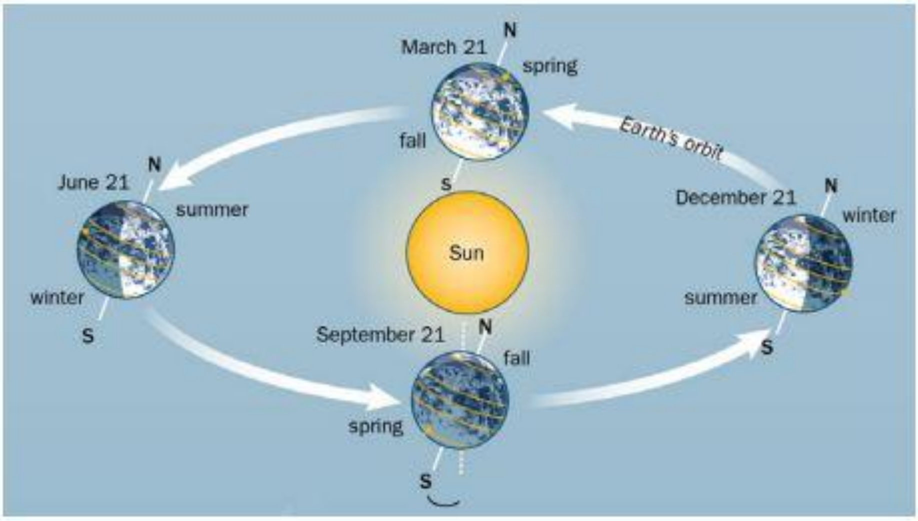


Fig. 2. The orbit of the earth arround the sun (Mendez, 2016)

However, the source of solar energy produced from Solar PV is a very good technology and should be utilized to increase the supply of electricity whenever possible (Rutkowski, 2016). Therefore some of hybrid system are combined with an electric power source other to strengthen the power of a solar power plant (SPP), for example SPP - Genset, SPP - Mikrohydro, SPP - wind power (Treado, 2015), even can also be combined in a 3 sources of electrical such as solar power - wind power – mikrohydro. Solar cells are made of 2 different layers of silicon and are capable of conducting electricity. The lower layer has few electrons which are then called the Positive P type, the lower layer has more electrons and is called the Negative N type. Both of these types are limited by an isolator so that they can not be by passed by electron flow. In conditions where the electrons can not go beyond the insulator there will be no litric flow, and when solar radiation occurs to this layer, there will be energy generating an electron jump capable of passing the insulator. The more intensity of sunlight it receives the more electron jumps will occur. From this process the occurrence of electricity.

Symptoms of radiation absorption are then converted into electrical energy like this is called PV photovoltaic (jurecka et al., 2006), Light can provide enough energy to enlarge the number of holes in the P and the number of electrons in the N section. Based on these PV phenomena can be created electronic components PV cell.

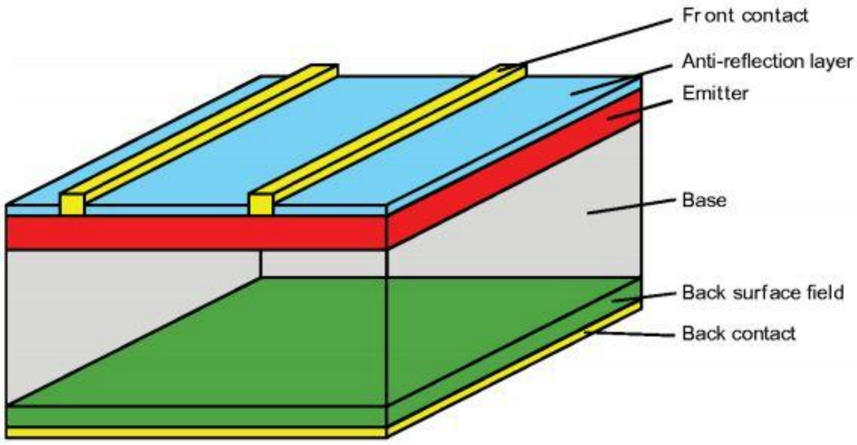


Fig. 3. Section of Solar Cell (Vozel, 2011)

In simple way the workings of this solar cell can be seen to the diagram in Figure 4. System work of solar cell below.

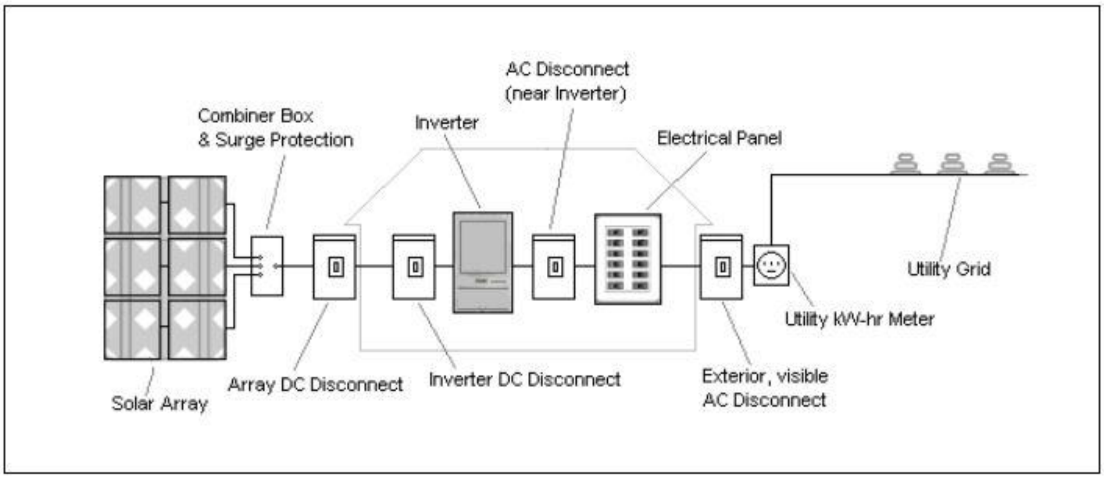


Fig. 4. Work system of solar cell (Roos & Nelson, 2009)

Solar cell consists of 2 Positive P-type layers (located below) and type N Negative (above). When type N is exposed to sunlight, the electrons in the Type N layer will jump over the insulator and move to the P type layer :

a. When the sunlight illuminates the N-type layer, the photons will fill the layer.
b. Photon will carry its energy entering the N type layer.
c. Photon will transfer its energy to the electron particle in the P type layer.
d. The electrons will jump over the insulator and move to the N-type layer and escape to the circuit.
e. Electron motion in this circuit which then generates electrical energy.

In addition to solar energi which include renewable energy in this research is wind energy. Wind energy is an energy generated from the movement of air that move because of the influence of meteorologic law. The pressure difference between the different places causes the wind shifts from high pressure toward the low pressure region. The movement of air or wind is then used to convert into electrical energy. In the energy capture of wind, often use the windmills are usually in the coastal areas and mountains, due to the rotating blades required wind speed of 2 meters / second, whereas to obtain a stable electricity needed wind with a speed of 6-10 m / s , so the placement of these windmills should be taken into account where the region has a high wind intensity. Utilization of wind energy has been supplying 5% of the world's energy needs based on data in 2016 (Mwaniki et al., 2017).

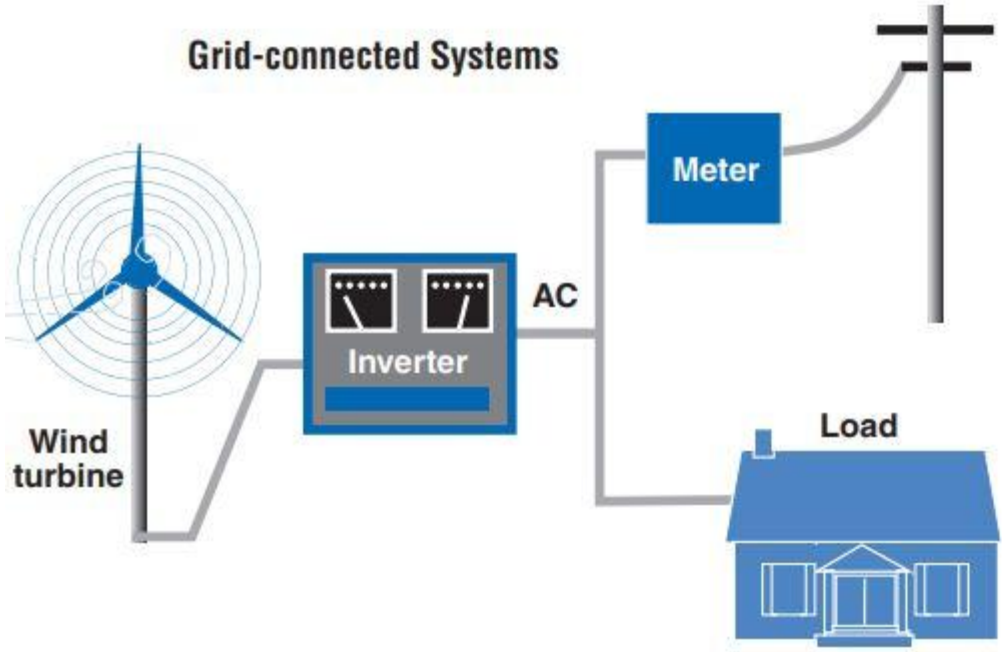


Fig. 5. Wind energy schema (Laboratory, 2007)

In some countries that have developed wind potential as a source of power, one way to increase the capacity of wind power consumption is to utilize an energy storage facility for storing electricity during a wind power surplus period (Rong et al., 2015). The stored electrical energy can be utilized at other times when wind energy can not produce abundant electrical energy production. In addition to providing an economic value to the cost of wind powered electricity production it must also calculate the layout and area of the windmill built (Knapp & Ledenburg, 2015).

This study uses a Cost Benefit Analysis CBA, where this method is often used in the project development investment (transport infrastructure, waste management, research centers, land improvement, production or distribution of electricity) are expected to provide advantages and effects on other sectors such as local economic development or regional, optimization of transport flows but may also have negative effects such as population displacement, noise and environmental modifications (Andrei et al., 2009). This method aims to provide a comparison between the costs and the benefits of a project activity, with the following characteristics:

a. Gives a comparison between the costs and benefits in a common project, the impact will be felt by the people, including things - other things that can not be measured by the value of the currency.

b. Analyzing the benefits which the benefit must have a value greater than zero which means that benefits should be greater than the total cost required. And the value of these benefits should be the largest among the alternative value of the other benefits that can be implemented in a common project.

Step - a step in the use of CBA method consists of 8 steps (Andrei et al., 2009) that is :

a. Identification of projects to create a scenario and an alternative choice.

b. Identify the parties will receive the benefits and bear the costs

c. Evaluating the impact it will have and determine indicators of measurement

d. Taking into account the quantitative effect as long as the project is still worthwhile.

e. Determining the effects of monetary value

f. Upgrading the benefits and costs

g. Calculating the net economic value of a project

h. Risk and sensitivity analysis

Turning to the ELECTRE method which is also used as a method in this study, is one of the MADM methods are determined by perangkingan to value - value pairs criteria (Yan & Min, 2016), The method was developed in Europe in the 1960s, its use when the need for decision-making in many cases with little consideration criteria. Step - a step in the method ELECTRE-II as follows:

a. determine the normal value for all criteria. The formula in this step

$$r_j = \frac{\mathrm{x_{ij}}}{\sqrt{\sum_{i=1}^{m} x_{ij^2}}} \qquad (1)$$

$$i = 1, 2, 3 \ldots\ldots m, dan\ j = 1, 2, 3 \ldots\ldots n$$

This formula can not be used if the criteria contained one number from any fees, unless the criteria are changed prior to the scale of the level of interest that ultimately all of the criteria are the criteria of profitability, with a formula that is used as follows:

$$rij = \frac{\mathrm{X_{ij}}}{\mathrm{Max_i}\ X_{ij}} \qquad (2)$$

if j is the advantage / benefit, and

$$rij = \frac{\mathrm{Min_i}\ X_{ij}}{\mathrm{X_{ij}}} \qquad (3)$$

if j is an attribute of the cost / cost

b. Calculating the decision matrix paired with the formula: with wj is the weight of the interests of criteria to

$$\mathrm{j}V_{ij} = W_j\ x\ r_{ij} \qquad (4)$$

c. Develop a matrix of concordance and disconcordance. The formula to determine the concordance index is as follows:

C (j, k)= J, k = 1,2, ..., n.

J ≠ k$\sum_{gj(Aj) \geq gi(Aj)} W_i$ (5)

The formula for the index Disconcordance:

d (j, k) = 0

if g_i () ≥ ()$A_j g_i A_k$

$$\frac{Max_{gi(Ak) \geq gi(Aj)} \, (gi\ (Ak) - gi(Aj))}{Max_{i=1,\ldots,m} \, (gi\ (Ak) - gi(Aj))} \quad (6)$$

j, k = 1,2, ..., k ≠ nj

By (Aj) is the value of alternative j on criteria i.g_i

d. By setting three-level reduction of the threshold value concordance P *, Po, P (0 = P = Po = P * = 1) and 0 <qo <q * <1 indicates no decrease in the level 2 on the threshold value disconcordance, decision makers can determine the relationship between strong outranking with the weak.

Strong outranking relationship is defined as follows:

c (j, k) ≥p * d (j, k) ≤q * and W + ≥W-

for weak outranking relationship is defined by

c (j, k) ≥p- d (j, k) and W + ≥W- ≤q0

e. Developing a graph representing the relationship of dominance among alternative

f. Determining alternative priority

The purpose of this research can be explained into several parts that are research sourcing of renewable energy as an alternative solution for the problem in the absence of electrical energy in Romang Island and to tap into investment for the owners of capital.

3. RESULTS AND DISCUSSION

Furthermore, it can be considered the result of calculations on the economic aspects of each sources of electricity:

a. SPP

Table 1. Power Cost Calculation SPP

Calculation	Interest rate		
	5%	9%	11%
Power costs	124,645,666.67	124,645,666.67	124,645,666.67
Operation Age (Years)	20	20	20
Capacity (Kw)	600	600	600
Capital Cost (US $ / Kwh)	2084.27	2482.00	2767.97
O and M costs (US $ / Kwh)	447.97	447.97	447.97
Total Cost (US $ / Kwh)	2532.24	2929.97	3215.07
Profit 10%	2785.46	3222.97	3536.58
Investment (USD)	**74,787,400,000.00**	**74,787,400,000.00**	**74,787,400,000.00**

b. PLTB

Table 2. Power Cost Calculation PLTB

Calculation	Interest rate		
	5%	9%	11%
Power costs	168,852,333.33	168,852,333.33	168,852,333.33
Operation Age (Years)	20	20	20
Capacity (Kw)	600	600	600
Capital Cost (US $ / Kwh)	2819.02	3373.19	3758.70
O and M costs (US $ / Kwh)	447.97	447.97	447.97
Total Cost (US $ / Kwh)	3266.99	3821.16	4206.67
Profit 10%	3593.69	4203.28	4627.34
Investment (USD)	**101,311,400,000.00**	**101,311,400,000.00**	**101,311,400,000.00**

c. NPV calculation of financial feasibility test SPP

Table 3. Calculation of NPV and IRR for the thermal power station SPP

NPV and IRR	NPV			IRR		
	6%	9%	11%	6%	9%	11%
Solar power	Rp 135,189,336,609.72	Rp 119,259,549,108.26	Rp 111,332,148,055.47	24 %	28 %	31 %
Wind power	Rp 174,985,410,781.98	Rp 156,111,067,510.21	Rp 146,025,482,870.77	23 %	28 %	31 %

Decent / No	NPV			IRR		
	6%	9%	11%	6%	9%	11%

Solar power	feasible	feasible	feasible	feasible	feasible	feasible
Wind power	feasible	feasible	feasible	feasible	feasible	feasible

In the table above calculation shows that the NPV and IRR for both types of generation are feasible development.

d. Ranking with ELECTRE III Method

Results of ranking according to the method ELECTRE can be seen in Table 4 below

Table 4. Aggregate Dominant matrix

	alternative 1	**alternative 2**
alternative 1	0	1
alternative 2	0	0

4. CONCLUSIONS AND RECOMMENDATIONS

a. Conclusion

The results of this study indicate that Romang Island holds the potential of renewable energy, with details for the solar power potential of 5.1 kWh / m2 and wind of 5.1 m / s. This potential is feasible to be used for solar power generation and wind power generation fired plant.

While the results of the calculation of NPV and IRR calculations show numbers for SPP is Rp 135,189,336,609.72 (interest rate of 6%), Rp 119,259,549,108.26 (9% interest), Rp 111,332,148,055.47 and fired plant is USD 174 985 410 781, 98 (6% interest), Rp 156,111,067,510.21 (9% interest), Rp 146,025,482,870.77 (11%).

IRR for the SPP is 24% (6% interest), 28% (9% interest), 31% (11%) and thermal power station is 23% (6% interest), 28% (9% interest), 31% (interest 11%). This result deserves to be developed against both types of these plants.

From the calculation of the value of investments to both types of power plants are using CBA showed that the development of SPP provides greater benefits than the wind power station.

From the results out put ELECTRE III showed a ranking of alternative electoral powerhouse of renewable energy is solar power plants (SPP).

b. Suggestion

Required active role between central and local government to attract investors in order to ensure the availability of sufficient electricity, good quality at a reasonable price, in order to realize the welfare and prosperity of the people in a fair and equitable and to realize a sustainable national development, in accordance with the Laws of the Republic Indonesia Number 30 / 2009 on Electricity.

To be carried out research and identification of sources of renewable energy on the islands that has a low electrification ratio to meet the needs of a sustainable electrical energy.

REFERENCES

Aditya & Addin, 2017. Mataloko Geothermal Power Plant Development Strategyin oerder to Maintain the Sustainability of Supply and Demand Electric Energy in Kupang, East Nusa Tenggara (A SystemDynamics Framework). *JGEET: Journal of Geoscience, Engineering, Environment and Technology*, II(3), pp.224-29.

Andrei, P., Valentin, M., Marius, P. & Delia, G., 2009. Methodological Approaches in Realizing and Applying Cost-Benefit Analysis For The Investment Projects. *Annals of the University of Oradea: Economic Science.*, II(1), pp.156-62.

Banerjee, R. & Choudhury, B.K., 2015. Optimization of the Building Energy Performance through Dynamic Modeling, Systems Simulation, Field Monitoring and Evaluation of Renewable Energy Applications. *International Journal of Engineering Research and Application*, V(2), pp.30-37.

Best, Rohan, Burke & J., P., 2017. The Importance of GovernmentEffectiveness for Transitions toward Greater Electrification in Developing Countries. *Energies*, X(9), p.Doi 10.3390/em 10091247.

Birol, f., Bromhead, A., Blasi, A. & Ikeyama, S., 2015. *Southeast Asia Energy Outlook*. World Energy Outlook Spesial Report. Paris France: International Energy agency International Energy Agency.

Diana, P., 2012. Environmental Implications Of The Increasing Demand For Energy. *Annals of the University of Oradea: Economic Science*, I(1), pp.358-64.

Gabbar, H.A., Bedard, R. & Ayoub, N., 2016. Integrated modeling for optimized regional transportation with compressed natural gas fuel. *Alexandria Engineering Journal*, LV(1), pp.533-45.

Gao, L. & Winfield, Z.C., 2012. Life Cycle Assessment of Environmental and Economic impacts of Advanced Vehicles. *Energies*, V(3), pp.605-20.

jurecka, S., pincik, E. & Brunner, R., 2006. Thin Film Solar Cells and their Optical Properties. *Advances in Electrical and Electronic Engineering*, V(1), pp.347-49.

Knapp, L. & Ledenburg, J., 2015. How Spatial Relationships Influence Economic Preferences for Wind Power—A Review. *Energies*, VIII(6), pp.6177-201.

Laboratory, D.N., 2007. *Small Wind Electric Systems*. U.S.Department of Energy.

Mandal, S., Sarker, M.R.I., Rahman, M.S. & Beg, M.R.A., 2017. An Analysis of Braking Energy Regeneration in Electrc Vehicles. *International Journal of Renewable Energy Research*, VII(3), pp.999-1006.

Mazzeo, G., 2013. City and Energy Infrastructures between Economic Processes and Urban Planning. *TeMA: Journal of Land Use, Mobility and Environment*, VI(3), pp.311-24.

Mendez, B., 2016. The Calendar in the Sky. *Astronomy Beat*, 29 January. pp.1-7.

Mwaniki, J., Lin, H. & Dai, Z., 2017. A Condensed Introduction to the Doubly Fed Induction Generator Wind Energy Conversion

Systems. *Journal of Engineering*, 2017, pp.1-18.

Rong, S. et al., 2015. Optimal Allocation of Thermal-Electric Decoupling Systems Based on the National Economy by an Improved Conjugate Gradient Method. *Energies*, IX(1), pp.1-21.

Roos, C. & Nelson, M., 2009. *Solar Electric System Design, Operation and Installation*. Washington: Washington State University.

Rutkowski, G., 2016. Study of Green Shipping Technologies - Harnessing wind, waves and solar power in new generation marine propulsion system. *International Journal on Marine Navigation and safety of sea transportation*, X(4), pp.627-32.

seferaj, K., 2014. Sustainable Development Aspects in Cross-Border Cooperation Programmes: The Case of Macedonia and Albania. *Romanian Journal of European Affairs*, XIV(4), pp.44-55.

Shykinov, N., Rulko, R. & Mroz, D., 2016. Importance Of Advanced Planning of Manufacturing for Nuclear Industry. *Management and Production Engineering Review*, VII(2), pp.42-49.

Sokolovic, V.S., Andrejic, M.D. & Ljubojevic, S.D., 2013. An integrated approach to calculate life cycle costs of arms and military equipment. *Vojnotehnički Glasnik*, LXI(4), pp.138-60.

Taus, P. et al., 2015. Optimization of Energy Consumption and Cost Effectiveness of Modular Buildings by Using Renewable Energy Sources. *Acta Montanistica Slovaca*, XX(3), pp.200-08.

Treado, S., 2015. The Effect of Electric Load Profiles on the Performance of Off-Grid Residential Hybrid Renewable Energy Systems. *Energies*, VIII(10), pp.11120-38.

Vozel, K., 2011. *Solar Cells*. Seminar. Ljubljana: University of Ljubljana.

Yan, S.S. & Min, Z.H., 2016. Research on Inferring ELECTRE-III's Parameters with Fuzzy information and A Case on Naval Gun Weapon System Integration. *MATEC Web of Conferences*.

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STRATEGIC DECISION MEASUREMENT OF NAVAL BASE STATION DEVELOPMENT IN A BORDER AREA: A CASE STUDY

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ABSTRACT

The world economy path that uses Indonesian sea lanes can make Indonesia as the world's maritime axis. The construction of Naval Base in the border area has been prioritized to increase the strength of maritime defense as an important pillar of Indonesia's development. Due to the current conditions of necessity in some border areas, it is necessary to formulate a strategy of Navy Base development. The use of Borda-SWOT combination methods can measure the priority of a strategic value decision. The result of analysis showed that the development in the boundary area using S-T strategy was the weight of 10.66% where the Navy base had Strength's influence with the weight of 17.89%. The priority formulation of the strategy of Navy Base facility development was to build facilities Command Headquarters - Housing Facilities and Mess - Service Facilities - Port Facilities and Communication Facilities.

KEYWORDS : Naval Base, Priority Strategic Decision, Border Area

1. INTRODUCTION

Indonesia's archipelago territory located on the crossroads of continents and oceans make Indonesia as a regional economic crossing paths of various countries. More than 40% of the world's economic pathways use Indonesian maritime or maritime lanes including using path that pass through the territory of the Indonesian Archipelagic Sea Pass (ALKI) (Ismah Rustam, 2016). Vessel of foreign countries whether commercial vessels or warships that are through the ALKI can pass without having to ask permission first to the Indonesian government. The existence of ALKI gives security consequences in Indonesian waters mainly because many of the economic crossing lines are also the border of Indonesia with other countries.

Joko Widodo as Indonesian President has launched the national strategic policy of Indonesia as the World Maritime Axis. This strategic policy brings Indonesia's ideals towards the excellence in the maritime field. The excellence of the maritime state as expressed by the President is performed through development based on the 5 main pillars of building maritime culture, maintaining and managing marine resources, building maritime infrastructure and connectivity, strengthening maritime diplomacy and building maritime defense forces (Murniningtyas, 2016).

Building maritime defense forces becomes one of the important instruments to maintain the situation and stability of the region on the border of the country. One of the role of the military force presence in the border of the country is to support the smoothness and sustainability of the wheels of the country's economy. In addition, the presence of Indonesian maritime defense forces serves as a unit of state interest to observe the dynamics of the surrounding region (Adhira, 2017). This is because the conditions in some border areas of Indonesia which is also the path of the world economic path still requires a lot of attention. Some of the strategic aspects that need to get important attention are sovereignty aspect, defense aspect and economic aspect.

Therefore, the Navy as one of the defense components will deploy the power of the Integrated Fleet Weapon System (SSAT) throughout Indonesia including the cross-sea route on the state border (Santoso et al., 2013). Thus, the development of Navy Base in Indonesian maritime territory bordering with other countries is an important priority (Saputra & Nadlir, 2016). However, the declining budget outlook (Figure 1) and the ever-changing geostrategic environment have urged the Navy's institution to change its decision-making strategy to build a Naval Base (Russell et al., 2015) (Trisutrisno, 2016) (Wicaksono & Asmara, 2017)

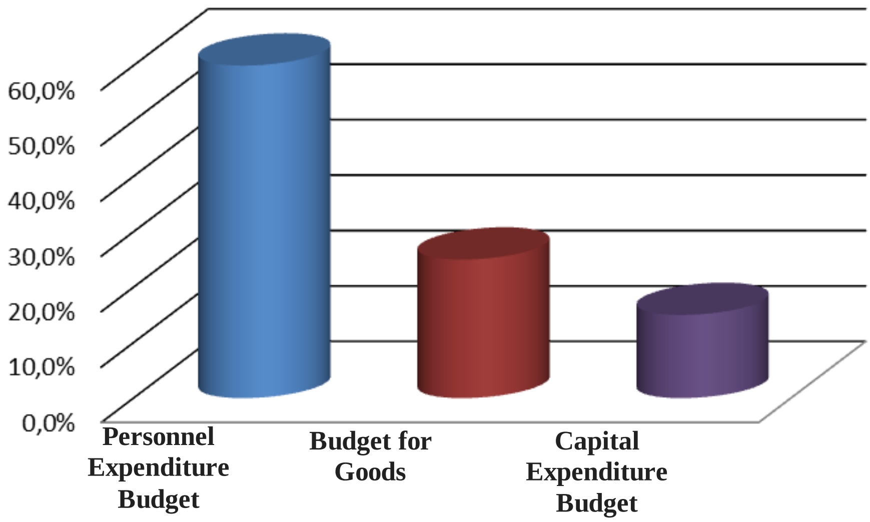

Fig 1. The Expenditure of Indonesian Defense Budget (Trisutrisno, 2016)

Therefore, every planning and implementation of the Navy's development is always based on policies that sharpen and strengthen the Navy's development program toward Minimum Essential Force (MEF). The preparation of programs and activities along with budget allocations is implemented realistically and prioritizing the priority principle. The development of the Navy Base on the border prioritizes the construction of facilities and basic infrastructure facilities on strategic islands (Kemhan, 2017). It is expected that the acceleration of Naval Base development in the border area can help the development goals in the border areas. The targets of border area development are prosperity, security and environment (Sholihah, 2016).

Thus, in order to measure the strategic decision of Naval Base development in Indonesian border area, the Borda method and SWOT method is used. The Borda method can show which alternatives are better in pairwise comparisons. The decision-making is based on an alternative choice of various Naval expert respondents by making the criteria into a numerical calculation (Garcia-Lapresta et al., 2008). While the SWOT method analysis is useful to create strategic formula by conducting an overall evaluation of the strengths, weaknesses, opportunities, and threats. The end result of the SWOT approach is to obtain a decision which shows the variable along with the added value or less value (Wang, 2007).

By combining Borda-SWOT method in measuring the strategic of decision-making process, a precise ranking of strategic variables in the development plan of Naval Base in the border area will be generated. Furthermore, this strategic planning can be used as a tool of the organization to start and manage its main tasks. Strategic planning is part of a research operation based on a multi-criteria decision-making (MCDM) process. MCDM-based research operations are a series of alternatives evaluations in a set of criteria to achieve optimal strategic formulation (Triantaphyllou et al., 1998).

The benefit of this study is the development plan of Naval Base that has the benefit and great contribution in the border region. The order of development priorities is part of the strategy formulation in order to enhance the benefit of Naval Base development to be perceived immediately by the border community development target. In addition, it also provides a case study for the development of the Naval Base and its facilities in the future.

In this paper, the Methodology used would be described in Section 2, Research Results in Section 3, Discussion in Section 4, and Conclusions in Section 5.

2. METHODOLOGY

2.1. Naval Base Development

The functions of the Naval Base Station are classified into 5Rs including Base as Replenishment/Refueling, a Repairing Place, a Resting Place, a Refreshing Place, and a Resistance (Base for Defense) (Suharyo et al., 2017). In order to carry out the function, the main facility that must be built in an Naval Base, including Port facilities, Maintenance and Repair facilities, Supplies facilities, Personnel maintenance facilities and Base building facilities. While the supporting facilities of the main facilities consist of Housing and Messing facilities, Command Headquarters facilities, Public facilities, Communication facilities, Defense facilities, Service facilities, and Operating and Training facilities (Indonesian Navy Headquarters, 2013). The following Figure 2 is the amount of budget for the construction of Naval Base facilities

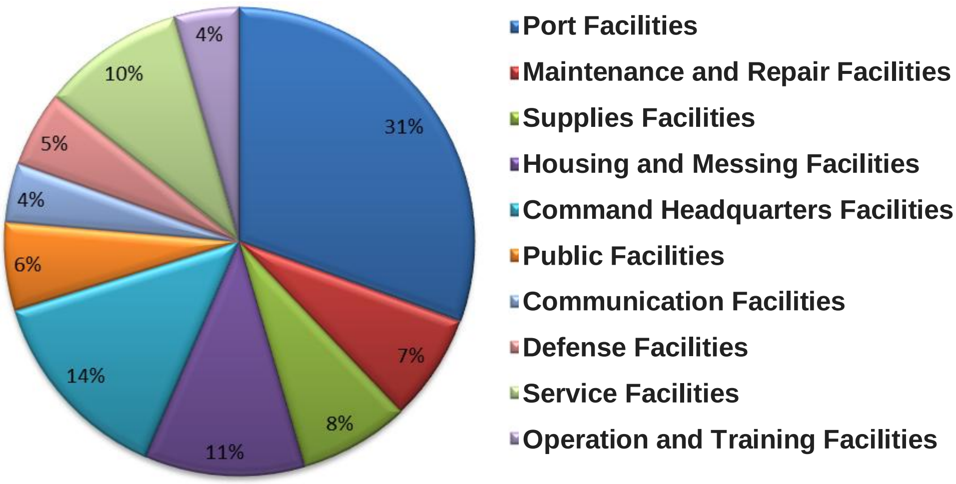

Fig. 2 The Amount of Navy Base Facilities Budget Development (Indonesian Navy Headquarters, 2013).

2.2. Indonesian Maritime Power Development

Indonesia as an archipelagic country has a geo-strategic aspect that demands the development of naval power as the main theme in the development of Indonesia's defense force (Perwita & Komeini, 2012). In Indonesia maritime development, the policy is strongly influenced by political policy, economy, defense, and state interest (Vertzberger, 1984). The Navy's development program towards MEF is performed not only with the modernization of defense to ensure Indonesia's territorial sovereignty and marine resources to be maintained, but also to keep the navigation path and maritime trade safe. In the development of naval power, the Naval Base development is based on six characteristics that influence the condition of national naval power such as geography, natural resources, climate, land area, community character and character of local government (Gindarsah & Priamarizki, 2014).

2.3. Borda Method

De Borda's voting method is used to rank out problems with multicriteria (Costa, 2017). The measurement steps with Borda method are as follows:

a) Evaluator determination, decision makers, judges or members of the jury sourced from experts

b) The elements determination or alternatives to be classified

c) Assessments collection from each evaluator in the form of perceptual assessments to form alternative sequences

d) A ranking score association for each alternative, as well as evaluate the main purpose of the problem

e) For each alternative, add up the rank rank rankings

f) Getting the final ranking of the alternatives.

In Borda's rule, it is known that the points given or ratings to each alternative is based on voter preferences or experts. In this method if there are (n) alternatives, then the first choice score has a weight of (n-1), the second choice score has a weight of(n-2) and so on until the last option, which is 0 points. Based on the measurement of the voter number on the criteria, the Total Frequency (Rt) can be calculated with the following formula

(1)

$$R1 = \sum_{j=1}^{n} R_{1j} \quad (2)$$

; where *j* = (n-1), (n-2), ..., (n-n)

As for knowing Weight (W*i*) on each choice variables, it is formulated into:

$$W_i = \frac{R_i}{\sum_{i=1}^{m} R_1} \quad (3)$$

; where *i* = variable option

So, the priority rank of variable option is

$$W_{i1} > W_{i2} > W_{i3} \ldots > W_{in} \quad (4)$$

; where *n* is the amount of variable option.

The theoretical characteristic of Borda's measurement is to determine the value of the majority of variables whose median value is consistent. While the ranking of variables is defined as the majority as well as the highest weight among the chosen various options (Mohajan, 2011).

2.4. SWOT Method

SWOT approach Analysis is a simple way to communicate an idea or policy. This technique is very effective because it is structured, objective, and focused on strategy with strong goals (Heyer, 2004). The information obtained has been systematically represented in the matrix, in which the combination of the four matrix factors is a tool in determining strategy. SWOT can build optimal strategies by relying on strengths and reducing their weaknesses, while also taking advantage of opportunities and determining plans to eliminate threats to be faced (Živković et al., 2015). By maximizing Strengths and Opportunities, and simultaneously minimizing *Weaknesses* and *Threats*, it will result in strategic decisions of several factors or variables (Jyrki Kangas, 2016). Some strategies that can be used in the SWOT matrix (Table 1) is the S-O (Maxi-Maxi) Strategy, W-O (Mini-Maxi) Strategy, S-T (Maxi-Mini) Strategy, and W-T (Mini-Mini) Strategy (Gretzky, 2010).

Table 1. SWOT Matrix

(Gretzky, 2010)

SWOT Matrix	**Strength (S)** Existing internal conditions and can be strengthened in planning.	**Weakness (W)** Internal conditions that can be improved in planning.
Opportunity (O) External conditions that can be taken advantage of.	**S-O Strategy** Utilizing Internal strength to take advantage of opportunities	**W-O Strategy** Fixed internal flaws by taking advantage of opportunities
Threat (T) External conditions that can not be controlled and have a negative impact.	**S-T Strategy** Use the power to avoid or reduce the impact of threats	**W-T Strategy** Defensive strategy to reduce internal weakness and avoid threats

2.5. Conceptual Framework

A research flow diagram integrating Borda and SWOT methods (Figure 3) will help to measure strategic decision making processes. The Borda-SWOT method is a simple alternative to present another explanation that priority decisions have a widespread impact in society (Ishida & Oguro, 2017). In addition, the construction of Naval Base in the border area is a strategic decision that has a wide impact on the maritime environment to make Indonesia as a maritime axis of the world.

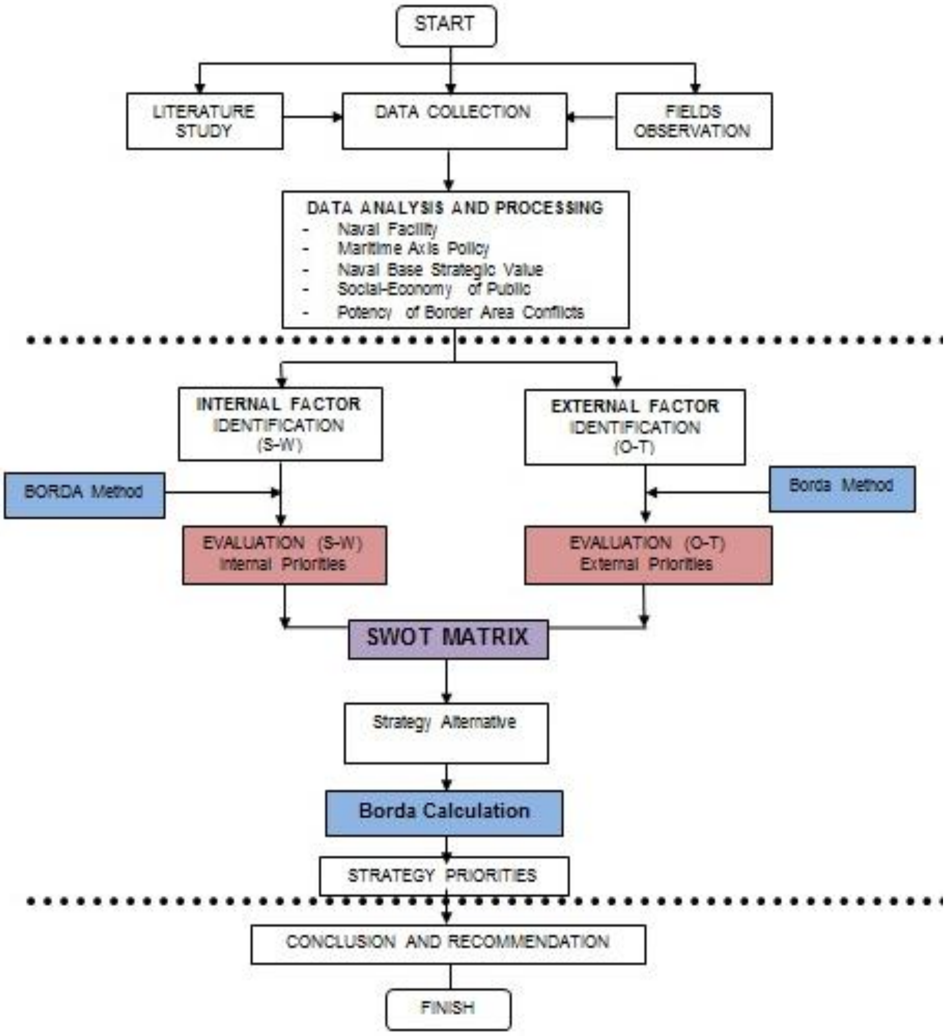

Fig. 3. Research Diagram of Borda-SWOT Integration (Ishida & Oguro, 2017)

3. RESULT OF RESEARCH ANALYSIS

3.1 Numerical Calculations Design

Borda-SWOT primary data processing was conducted by interviews and questionnaires to officers of officials within the Naval Base Area, Naval Base Facilities Office, and Navy officers who have both technical and strategic expertise. Placement of SWOT criteria was shown on SWOT Analysis Software sourced from expert data. Interview data and questionnaires were subsequently processed using Excel to get weighted calculations according to numerical design calculations with the the priority ranking strategy as the final results.

3.1.1. Internal Criteria

Tabel 2. Primary Data of Strength and Weakness

Source: Expert Data Processing and Questionnaire

Internal Criteria	***Strengths***		
	S.1	World Maritime Axis Policy	85
	S.2	Strategic Location	68
	S.3	Naval Base	51
	S.4	Operation Area	46
	S.5	Defense System Readiness	35
	Weaknesses		
	W.1	Development Center	74
	W.2	Supporting Facilities	64

	W.3	Availability of Shipyard	55
	W.4	Availability of Area Logistics	54
	W.5	Availability of Public Facilities	38

3.1.2. External Criteria

Table 3. Primary Data of Opportunities and Threats
Source: Expert Data Processing and Questionnaire

External Criteria	***Opportunities***		
	O.1	National Patriotism	69
	O.2	Availability of Fields	65
	O.3	Geostrategic and Geo-economy	56
	O.4	Resident Population	56
	O.5	Area Supports	39
	Threats		
	T.1	Illegal Act	71
	T.2	Shipping Safety	66
	T.3	Separatism	55
	T.4	Sailing Lane Volume	54
	T.5	Social Cultural Insecurity	39

3.1.3. SWOT Diagram of Border Maritime Area Development

Using the Borda method in accordance with Tables 2 and 3 above, it was found that existence of Naval Base had a Strength effect to maritime development of border area with weight of 17,89% and rating score of 0.0447 from the whole variable. While the internal factor weight (S-W) was greater than the external factor (O-T) which indicated that maritime development in the border area could be done well if there wass strong commitment from the government despite many challenges faced (Figure 4).

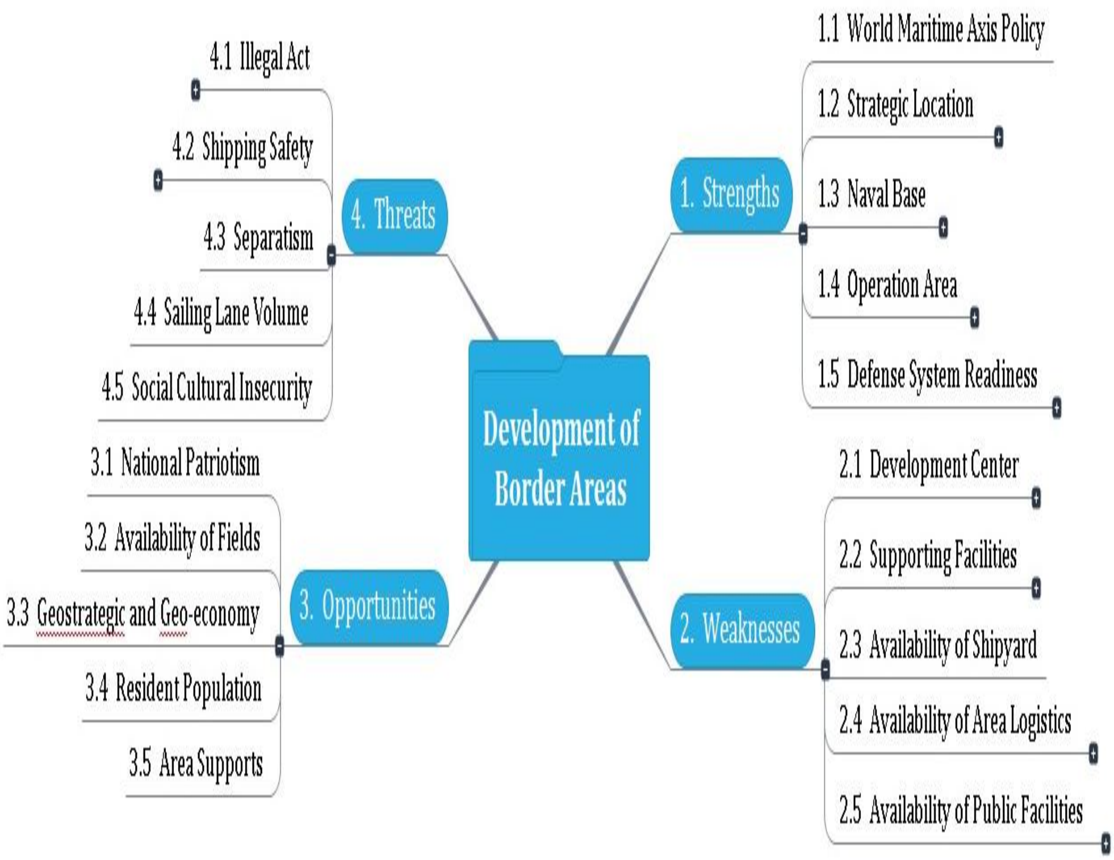

Fig. 4. Research SWOT Diagram
Source: *SWOT Analysis Software*

3.1.4. SWOT Matrix of Border Maritime Area Development

Table 4. Research SWOT Matrix

Internal Factor / External Factor	*Strengths* S1. World Maritime Axis Policy S2. Strategic Location S3. Naval Base S4. Operation Area S5. Defense System Readiness	*Weaknesses* W1. Development Center W2. Supporting Facilities W3. Availability of Shipyard W4. Availability of Area Logistics W5. Availability of Public Facilities
Opportunities O1. National Patriotism O2. Availability of Fields O3. Geostrategic and Geo-economy O4. Resident Population O5. Area Supports	**S-O Strategy** Maritime becomes national policy which provides the power to improve maritime security capabilities to protect resources in certain region. **(S1) (S3) (O3) (O5)**	**W-O Strategy** Strong human resources potentially make the economic power in the border region supported by the construction of facilities and infrastructure **(W1) (W4) (O2) (O4)**
Threats T1. Illegal Act T2. Shipping Safety T3. Separatism T4. Sailing Lane Volume T5. Social Cultural Insecurity	**S-T Strategy** The Naval base conducts maritime security operations to prevent illegal activities and keep the shipping lines safe **(S3) (S4) (T1) (T4)**	**W-T Strategy** The facility development can reduce the various conflicts of society, especially separatism and other socio-cultural vulnerabilities **(W2) (W5) (T3) (T5)**

Based on the SWOT matrix(Table 4), the maritime development in the border area was using S-T strategy. With a weight of 10.66%, this strategy was implemented with the establishment of Naval Base that serves to provide support for maritime security operations of the Navy to prevent illegal activities and keep the shipping lines safe.

4. DISCUSSION

4.1. Strategy Priority Weighing of Naval Facility Development

In order to implement the S-T strategy of the SWOT matrix and to build the Naval base, the development of necessary facilities was performed. The objective of the analysis in 10 Naval base facility using the Borda method was to obtain priority facilities (Figure 5).

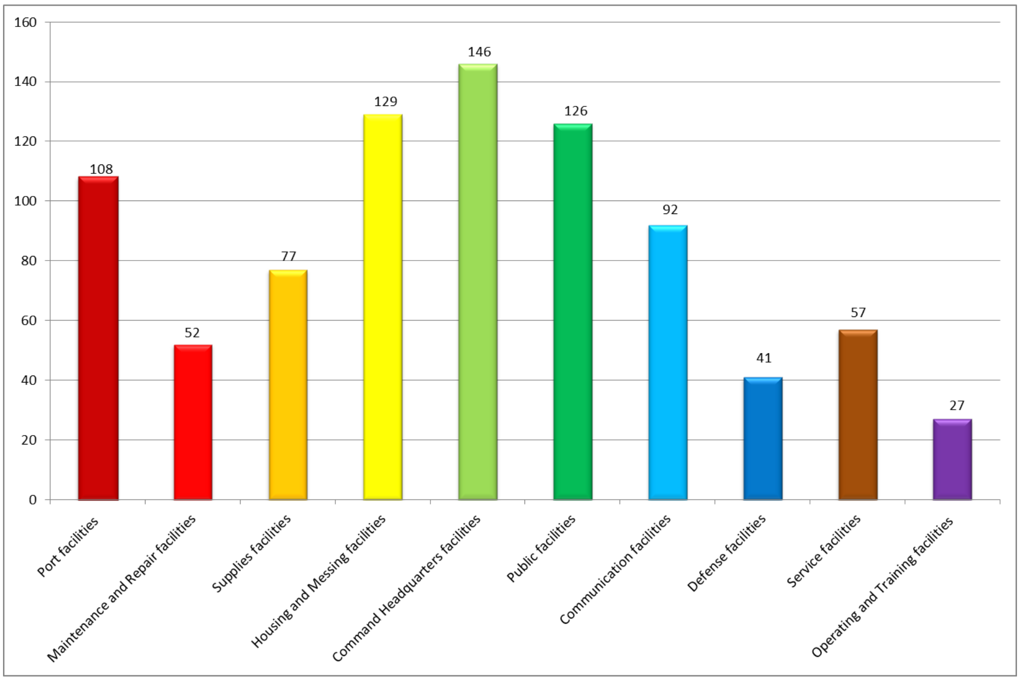

Fig. 5. Diagram of Priority Weinging in Research Strategy

4.2. Strategic Priorities Formulation

The strategic decision formulation of Naval Base Development in border area was obtained from weight calculation from each facility that would be built. The ranking of weighted rankings was a priority order of facility construction required in border areas(Figure 6).

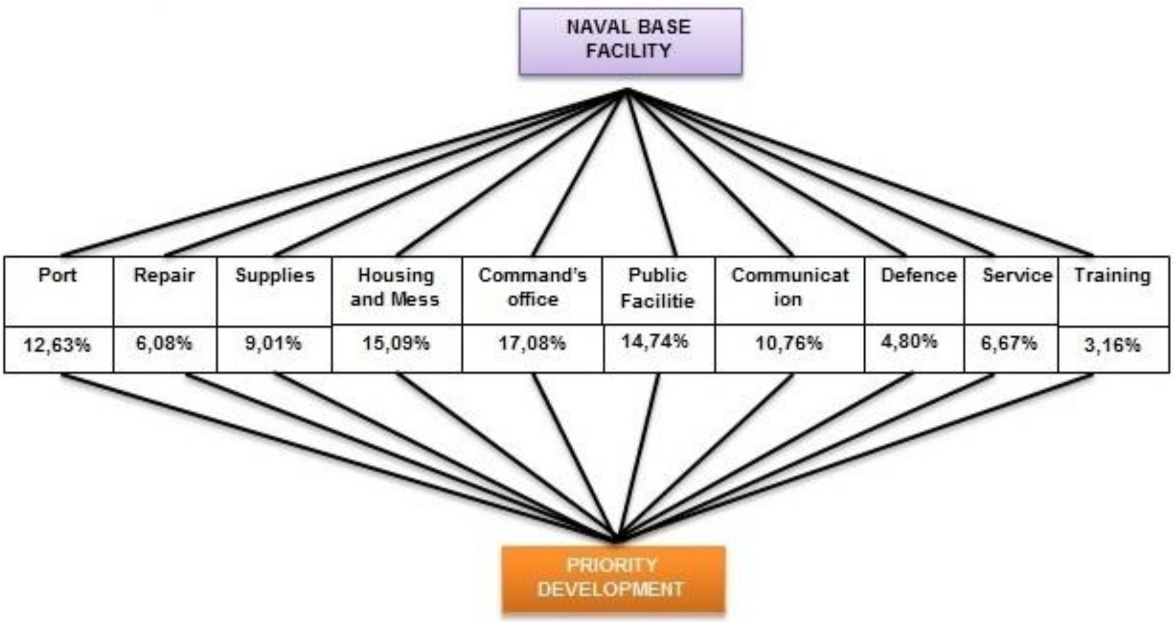

Fig. 6. Diagram of Research Strategy Priority Formulation

5. CONCLUSION

Strategic decisions measurement of the Naval Base Development in the border area using the Borda-SWOT method is one of the quicker ways of conveying the idea of multi-criteria decision-making. The S-T strategy approach is the best strategy to develop a challenging border region. While the development of the Naval Base is an important part of Indonesia's maritime development which has an impact on the security of international shipping lines. Based on the strategy priority formula, it can be known that Naval Base Facilities which have a major impact on the border region is Command Headquarters Development - Housing Facilities and Mess - Service Facilities - Port Facilities and Communication Facilities. It is expected that this research can be continued in the future to know the ability of logistics and administrative support for sea security operations in the border region.

References

Adhira, P., 2017. *Development Policy of China Military Base in Djibouti, Africa 2016.* Yogyakarta: Universitas Muhammadiyah.

Costa, H.G., 2017. AHP-DE BORDA: A Hybrid Multicriteria Ranking Method. *Brazilian Journal of Operations & Production Management* , 14, pp.281-87.

Garcia-Lapresta, J.L., Martinez-Panero, M. & Meneses, L.C., 2008. Defining The Borda Count In A Linguistic Decision Making Context. *Elsevier Science* , pp.1-16.

Gretzky, W., 2010. Strategic Planning And SWOT Analysis. In Harrison, J.P. *Essentials of Strategic Planning in Healthcare*. Chicago: Health Administration Press. pp.91-97.

Heyer, R., 2004. *Understanding Soft Operations Research: The methods,Their Application and Its Future in the Defence Setting*. Australia: DSTO Information Sciences Laboratory.

Indonesian Navy Headquarters, 2013. *Indonesian Naval Base Standard Administration Handbook*. Jakarta: Indonesian Navy Headquarters.

Ishida, R. & Oguro, K., 2017. *Borda Count Method for Fiscal Policy: A Political Economic Analysis*. Tokyo: Policy Research Institute Research Department Policy Research Institute.

Ismah Rustam, 2016. ALKI Challenge in Achieving Indonesia's Ideal as a World Maritime Axis. *Indonesian Perspective*, 1, pp.1-21.

Jyrki Kangas, M.K.P.L.a.M.K., 2016. Incorporating MCDS And Voting Into SWOT – Basic Idea. *Serbian Journal of Management*, pp.1-13.

Kemhan, I.J., 2017. *The Chief of Indonesia Navy Opened a Naval Financial Coordination Meeting 2017*. [Online] Available at: www.kemhan.go.id [Accessed 28 April 2017].

Mohajan, H.K., 2011. Majority Judgment in an Election with Borda Majority Count. *Internationa lJournal of Management and Transformation*, 6(1), pp.19–31.

Murniningtyas, E., 2016. *Optimizing the Utilization of Marine Potential Toward the Realization of Indonesia as a Maritime Axis*. Jakarta: Badan Perencanaan Pembangunan Nasional (BAPPENAS).

Perwita, A.B. & Komeini, Y., 2012. *Readiness of Indonesia Sea Power in Facing Indonesia's Maritime Security in Southeast Asia*. Jakarta: Universitas Presiden Universitas Presiden.

Russell, D.J.A. et al., 2015. *Navy Strategy Development: Strategy in the 21st Century*. California: Naval Research Program.

Santoso, P. et al., 2013. The Implementation of Multi-Attribute Approach in Decision Making for Defense Sea Region Models. *Journal of Theoretical and Applied Information Technology*, pp.134-41.

Saputra, R. & Nadlir, M., 2016. *Natuna Military Base Project Must Be Completed In 3 Years*. [Online] Available at: http://www.viva.co.id/berita/nasional/791903 [Accessed 29 June 2016].

Sholihah, I., 2016. Legal Policy for Development of Border Area through Technology Based Infrastructure. *Jurnal RechtsVinding*, 5, pp.305–21.

Suharyo, O.S., Manfaat, D. & Armono, H.D., 2017. Establishing the Location of Naval Base Using Fuzzy MCDM and Covering Technique Methods: A Case Study. *International Journal of Operations and Quantitative Management IJOQM*, 23(1), pp.61-87.

Triantaphyllou, E., Shu, B., Sanchez, S.N. & Ray, T., 1998. Multi-Criteria Decision Making: An Operations Research Approach. *Encyclopedia of Electrical and Electronics Engineering*, pp.175-86.

Trisutrisno, B., 2016. *TNI Strength: The Dilemma of the Guardian of the State*. Jakarta: Artikel Pertahanan Lembaga Kajian Pertahanan Untuk Kedaulatan NKRI.

Vertzberger, Y.Y.I., 1984. *Coastal States, Regional Powers,Superpowers and the Malacca Singapore Straits*. California: Institute Of East Asian Studies University of California.

Wang, K.-c., 2007. *A Process View Of SWOT Analysis*. Taipei, Taiwan: Business Management Department National Taipei University, Taipei, Taiwan, R.O.C.

Wicaksono, K. & Asmara, C.G., 2017. *Minister of Finance Will Lower the Allocation of Defense Budget*. [Online] Available at: http://www.viva.co.id/berita/bisnis/947412 [Accessed 17 August 2017].

Živković, Ž. et al., 2015. Analytical Network Process in the Framework of SWOT Analysis for Strategic Decision Making (Case Study: Technical Faculty in Bor, University of Belgrade, Serbia). *Acta Polytechnica Hungarica* , 12, pp.199-216.

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DECISION MAKING MODEL ELECTION OF LOCATION OF MENTAWAI NAVAL BASE BY THE APPROACH OF BORDA AND PROMETHEE METHODS (CASE STUDY ELECTION OF LOCATION OF DOCK AND NAVAL BASE OFFICE)

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ABSTRACT

Padang Naval Base plans to establish an naval base at the type of "C". Following this matter, the Regional Government of Mentawai Islands District provides 3 (three) alternative places namely in Semabuk Bay, Siuban Bay and Semebai Bay for the location of dock and office. In the selection of Mentawai base this method using Borda and Promethee, this is used because the method can consider alternative evaluation based on factors that are qualitative and quantitative (Pavic, 1991). Based on research of Borda method calculation on 16 base selection criteria, it is found that criteria (K1) of Sailing Flow has the highest weight value that is equal to 10.9% and for the lowest criteria weighted value is occupied by criterion (K14) that is Political Condition of 2%. For the results of ranking against the alternative using Promethee method obtained Semebai Bay is the best location to serve as the location of the base of the Mentawai Naval Base. From the research results can be concluded that the model of decision making by combining Borda and Promethee method is a way to develop the logical relationships that underlie the problem of decision making into a mathematical model that reflects the relationships that occur between the criteria involved.

Keywords: Naval Base, Decision Making, Borda, Promethee.

1. INTRODUCTION

Indonesian navy as the main component of state defense in the sea seeks to always maintain sea security (Indonesian Navy Headquarter, 1996). The Naval Base is the spearhead of the power in carrying out support for the task of combat operations, especially as a supporter for war ship operations (Indonesian National Army, 2010). The Mentawai Islands Regency is the outermost archipelago of the West Sumatra Province which lies along the westernmost part of Sumatra island which is surrounded by the Indian Ocean (Indonesian Navy Headquarter, 2007). This area has abundant marine potentials such as fish wealth, marine tourism potential and front row of islands that face to face with neighboring country.

Given the geographical condition and the potential of natural resources, it often triggers illegal fishing practices and cross-border violations committed by foreign ships passing around the Mentawai islands, in addition to this area is an area prone to earthquakes (National Development Planning Bereu, 2016).

In order to suppress the rampant illegal fishing practices, supervision of foreign ships and support the disaster relief operations that may occur in the Mentawai Islands, the Padang naval base plans to form a naval base. Thus, the Navy in cooperation with the local government of Mentawai

Islands District has provided 3 (three) alternative places or location options to be selected as Base (in this case as dock and office location), as shown in Figure 1.

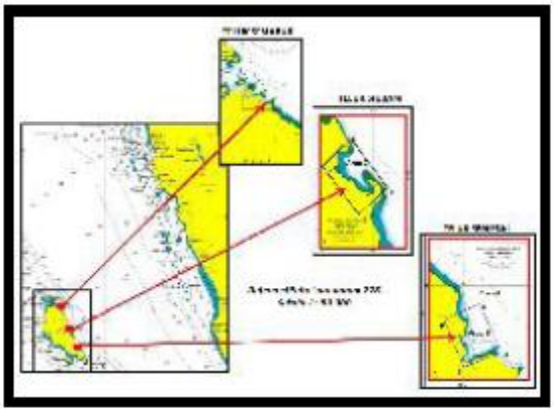


Fig. 1 The Naval Base Plan

In order to select the location of the base, it is necessary to analyze the three alternatives in order to be selected as the best base location. This is very important because the best base is a base that can ensure the implementation of combat support, logistical support and administrative support to each navy operation unit in the framework of marine control and can ensure continuous operation of Fleet Weapons System Integrated/SSAT component operation (Indonesian Navy Headquarter, 2005).

So far, the method used in determining the location of the naval base is based on the results of the team's decision which is the result of qualitative brainstorming and sometimes in the elements of subjectivity of the people in the team. In addition, problems that often occur sometimes tops as decision makers know the criteria that affect the decision, but can not let where the criteria are very influential and which are lacking.

Decision-making will be complex if each alternative has advantages over different criteria (Saaty, 2001). Suppose the alternative of Semabuk Bay is superior in terms of criteria of social condition of society and supporting facilities of staple food, Siuban Bay alternative is superior to the criteria of the shipping channel and health and education facilities, while the third alternative of Semebai Bay is superior in criteria of amphibious landing location and coastal morphology condition. Taking into account the advantages of each alternative will make it difficult for a decision maker to determine which alternatives will be selected.

In this research, it is proposed the use of a method that can consider alternative evaluation based on qualitative and quantitative criteria, and also attempt to facilitate decision making by conducting analysis on criteria that significantly influence the base determination by using Borda method, so we will get the criterion weight which has significant influence in determining the base selection policy (Paun, 2014). According to (Brans Roy, 1986) Promethee (Preference Ranking Organization Method for Enrichment Evaluation) method is able to fix Borda method to rank the alternatives based on the assessment of survey data with the weighting obtained from the Borda method (Mareschal B, 2008), so it is hoped to be able to get the best Mentawai naval base selection model.

Formulation is based on the description above then the problem that can be formulated is "How to model decision making in location selection of Naval Base of Mentawai by using combination of Borda and Promethee method (Preference Ranking Organization Method for Enrichment Evaluation) so get best location fulfilling criterion based on standardization Base" .

The purpose of this research is to first model the decision-making problem to select the location of the Mentawai naval base based on the standardization of the naval base and analyze the criteria that affect significantly. The second applies a decision-making model using a combination of Borda and Promethee methods to get the best of naval base location from three alternate locations: Semabuk bay, Siuban and Semebai bay.

While the benefits of this research is first to make a significant criteria analysis and influential towards the system in the selection of the location of the Mentawai naval base and the second as a reference navy chief in considering the policy in choice of location of Mentawai naval base.

2. METHODOLOGY

2.1. Flowchart Diagram

This research flowchart uses BORDA and PROMETHEE integration. Research begins with field observation / location and collects data from the literature.

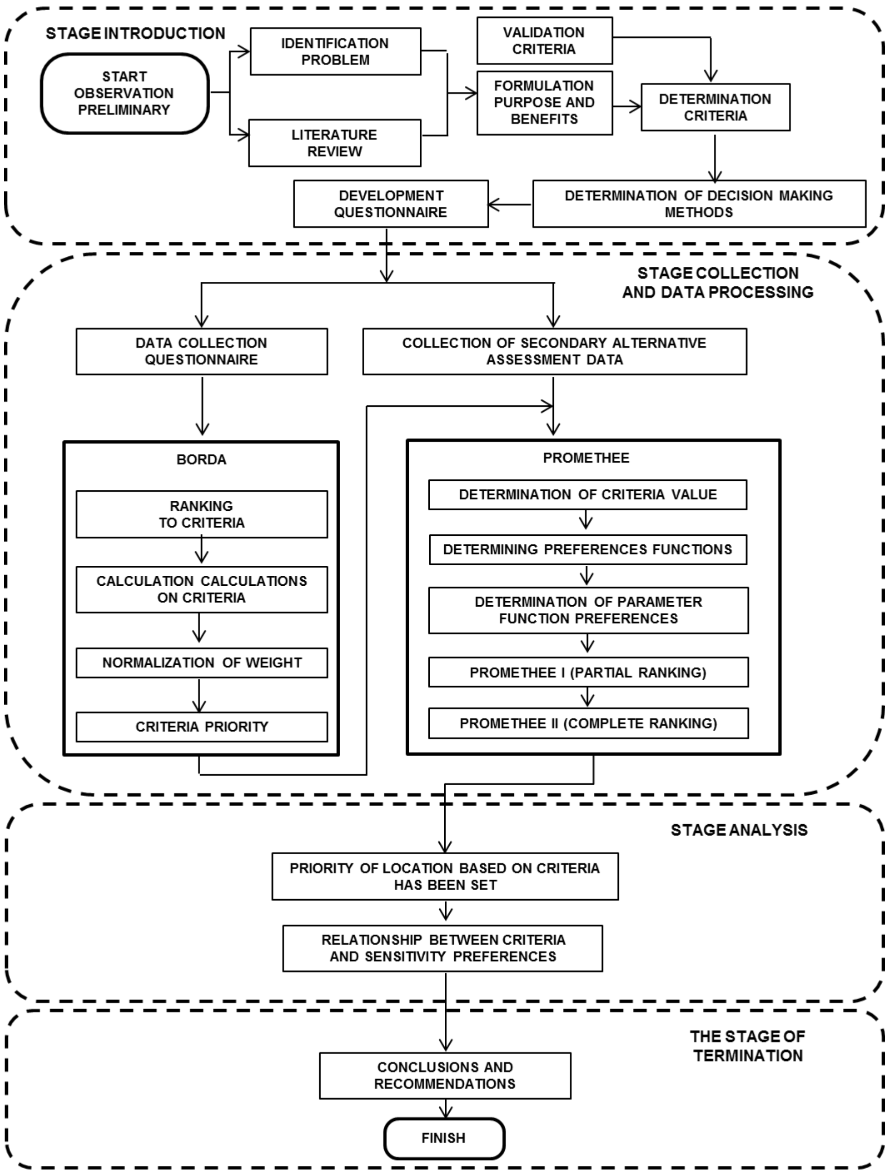


Fig. 2 Flowchart Diagram

2.2. Criteria Determination

Indonesian Naval Base requirements include Port Facility, Maintenance and Repair Facility, Supplies or Logistics Facility, Personnel Care Facility, and Training Base Facility (Indonesian Navy Headquarter, 2013). Then it can be formulated about the criteria that will serve as the determinant criterion in the selection of the location of the Naval base of Mentawai as shown in figure 3

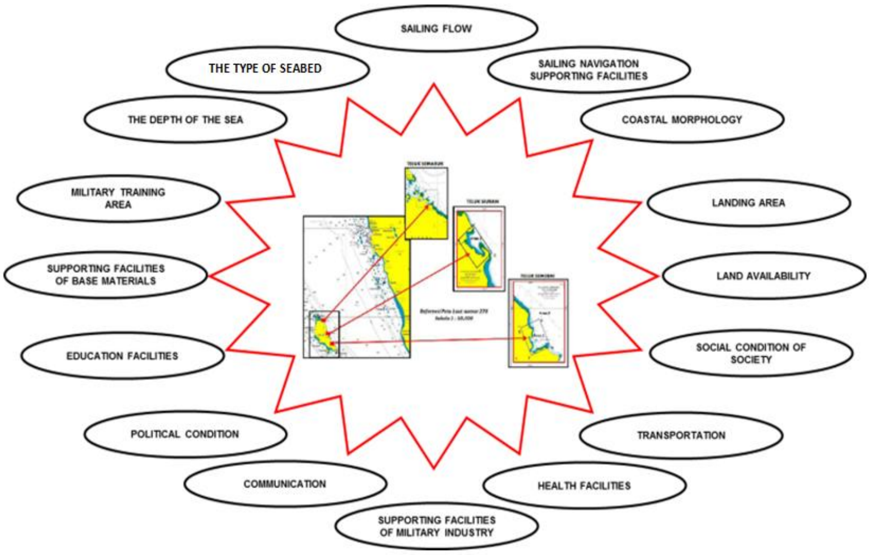


Fig. 3 Model Selection Criteria Location of Naval Base Selection

2.3. Borda Method

The Borda method invented by its discoverer Jean Charles de Borda in the 18th century. The privilege of this method can overcome the difficulties of other methods where people / things that are not in the first rank will be automatically eliminated (W. D. Keyser, 1996). The basic idea in the Borda method is to give weight to each of the first ranking criteria, second rank, and so on. In the explanation of the criteria importance assessment (Paun, 2014), described as equation 1 as follows:

$$R_1 \sum_{j=1}^{n} R_{ij} \qquad (1)$$

Where:

R1: The sum of rankings is weighted for all criteria 1

Rij: The rank evaluated by j for criterion 1

As for the weight obtained as:

$$W_1 = \frac{R_1}{\sum_{i=1}^{m} R_1} \qquad (2)$$

Where:

W1: weighting criterion 1 for evaluator n.

2.4. PROMETHEE (Preference Ranking Organization Method For Enrichment Evaluation)

According to (Brans Roy, 1986), (Macharis, 2004) Promethee is a method of determining the order (priority) in multicriteria analysis (Salvatore Corrente, 2012). The key issues are simplicity, clarity and stability. The alleged predominance of the criteria used in Promethee is the use of value in outranking relationships (Gothner, 2009). All the parameters that are stated have a real influence according to the economic view.

The principle used is an alternative priority assignment which has been set based on consideration $(\forall \dashv | / fi(.) \rightarrow \Re[\text{Realword}])$, with the basic rules:

Max{f1(x), f2(x), f3(x),….. fj(x),…. Fk(x) / x□□} (3)

Where K is a set of alternatives, and fi (I = 1,2,3, ..., K) is the relative value / size of the criteria for each alternative. In its application a number of criteria have been set to explain K which is an assessment of $\Re$ (real word). Promethee belongs to the family of outranking methods developed by (Brans Roy, 1986) which includes two phases:

a. Building an outranking relationship from K.

b. Exploitation of this relationship provides an optimization answer of the criteria in the paradigm of multicriteria problems.

In the first phase, the value of outranking relationships based on the consideration of the dominance of each criterion. The Preference Index is set and the outranking values are graphically presented based on the preferences of the decision maker. Preferences structure built on the basis of criteria (as seen in equation 4):

$$\left.\begin{array}{l}\forall\, \partial, b \varepsilon A \\ F(a), f(b)\end{array}\right\} \Rightarrow \begin{array}{l} f(a) > f(b) \Longleftrightarrow aPb \\ f(a) = f(b) \Longleftrightarrow a|b \end{array} \quad (4)$$

The basic data for evaluation with the Promethee method are presented as follows:

Table. 1 Basic Data Analysis Promethee
(Brans Roy, 1986)

	$f_1(.)$	$f_2(.)$	. .	$f_j(.)$	. .	$f_k(.)$
a_1	$f_1(a_1)$	$f_2(a_1)$	. . .	$f_j(a_1)$	. . .	$f_k(a_1)$
a_2	$f_1(a_2)$	$f_2(a_2)$	. . .	$f_j(a_2)$	. . .	$f_k(a_2)$
. .	. . .	. . .	. . .	. . .	. . .	. . .
a_i	$f_1(a_i)$	$f_2(a_i)$	. . .	$f_2(a_i)$	. . .	$f_2(a_i)$
. .	. . .	. . .	. . .	. . .	. . .	. . .
a_n	$f_1(a_n)$	$f_2(a_n)$	. . .	$f_2(a_n)$	. . .	$f_2(a_n)$

The value of outranking relationships in Promethee can be explained in the form of (Rudolf Vetschera, 2012) :

a. Criteria Domination

The f value is the real value of a criterion f : K →ℜ and the purpose of an optimization procedure For each alternative a $\mathcal{E}$ k, f(a) is an evaluation of these alternatives for a criterion. When two alternatives are compared, a, b, $\mathcal{E}$ k must be determined by comparison of their preferences.

Intensity delivery (P) of alternative preferences a to alternative b such that:

1) P (a, b) = 0 means there is no indefferent between a and b, or no preferences of a more both from b.
2) P (a, b) ~ 0 means the weak preference of a is better than b.
3) P (a, b) ~ 1 means the strong preference of a is better than b.
4) P (a, b) = 1 means the absolute preference of a is better than b.

From this method, the preference function often results in different function values between the two evaluations, so that:

P (a,b) = P (f(a) - f(b)) (5)

For all criteria an alternative will be considered to have a better criterion value determined by the value of f and from the accumulation of this value determines the preference value of each alternative to be selected.

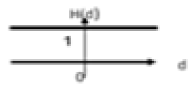
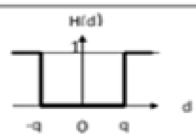
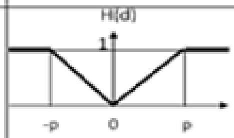
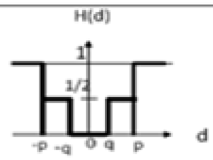
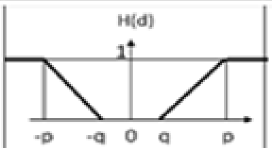
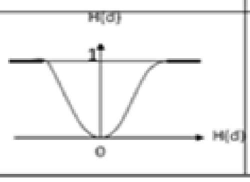
b. Recommended Function Preferences for Application

In Promethee presented six forms of criteria preference function. This is of course not absolute, but this form is good enough for some cases. To provide a better picture of unequal areas, a function of the difference between the alternate values of H (d) is used, where this has a direct relationship to the preferences function P:

$$H(d) = \begin{cases} P(a,b), & d \geq 0. \\ P(b,a), & d \leq 0. \end{cases} \quad (6)$$

In Table 2 summarizes the 6 (six) general types of preferences in which the decision maker can choose, and the parameters to be made permanently. The decision maker can adjust the form of the problem with parameters that make a significant influence on the economic aspects. Table 2 Summary of the Six Common Criteria.

Table. 2 Summary of the Six Common Criteria
(Brans Roy, 1986)

The Type of criteria		Parameter
1. *Usual Criterion*		-
2. *Quasi Criterion*		*q*
3. *Criterion wih Linier preference*		*p*
4. *Level Criterion*		*q,p*
5.*Criterion with linier prefrence and indifference area*		*q,p*
6. *Gaussian criterion*		*σ*

As mentioned above, the process of determining the preference is an important step so that when the calculation of preference index can be representative of the problem. In helping to determine the level of preference can be seen in Table 3.

Table. 3 Determination of Preference Level
(Brans Roy, 1986)

Consideration	Function Level Preferences					
	I	II	III	IV	V	VI
Accuracy	Rude	Rude	Accurate	Rude	Accurate	Accurate
The trend is no different |d| <q	No	Yes	No	Yes	Yes	No
Absolute solid tendency |d| <q	No	No	No	Yes	Yes	No
Normal distribution	Maybe	Maybe	Maybe	Maybe	Maybe	Yes

c. Index of Multicriteria Preferences (M. Ehrgott, 2010)

The purpose of the decision maker is to set the preferences function P, and πi for all criteria f_i (i = 1, ..., k) of the compound criterion optimization problem. The weight πi is a relative measure of the importance of the criterion f_i; if all criteria have equal importance in decision making then all weight values are equal. The multi-criterion preferences index (determined by the weighted average of the P_i. preference function.

$\wp\,(a, b) = \sum_{i=1}^{n} \pi\, Pi\,(a,b) : \forall\, a, b \varepsilon A$ (7)

$\wp$ (a, b) is the intensity of the decision maker's preference which states that alternative a is better than alternative b with simultaneous consideration of all criteria. It can be presented with a value of 0 to 1, subject to the following conditions:

1) $\wp$ (a, b) = 0, showing weak preference for alternative a over alternate b based on all criteria.

2) $\wp$ (a, b) = 1, shows a strong preference for alternative a over alternate b based on all criteria.

The preference index is determined based on the value of outranking relationships on a number of criteria from each alternative. This relationship can be presented as a graph of the value of outranking, the nodes are an alternative based on the assessment of certain criteria. Among the two nodes (alternatives), a and b, are curved lines having values $\wp$ (a, b) (no relation between $\wp$ (a, b) and $\wp$ (b, a) the relation can be seen in Figure 4

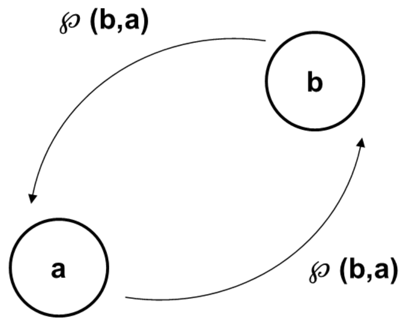


Fig. 4 Relationships between nodes (Brans Roy, 1986)

3. RESULT AND DISCUSSION

3.1. Data Processing

The steps of data processing are done as follows:

a. Conducting weighted processing on criteria based on expert questionnaire results. Processing and result of weighting Borda method as shown in Table 4 and 5.

Table. 4 Processing Borda method

		K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15	K16
NPS	**1**	15	11	13	12	14	1	2	5	6	7	3	4	9	10	0	8
	2	15	11	12	13	14	6	7	1	10	0	9	8	4	3	5	2
NOS	**1**	11	8	3	2	15	1	4	6	13	5	7	10	9	0	14	12
	2	13	12	5	10	11	9	8	7	6	4	3	2	1	0	15	14
NBF	**1**	9	8	7	6	5	4	3	2	10	11	12	13	1	0	15	14
	2	15	12	11	10	9	4	2	14	1	13	7	6	5	0	8	3
HIDROS	**1**	14	12	13	10	15	9	8	6	7	5	3	1	3	0	11	5
	2	13	7	12	15	14	1	2	3	11	0	4	5	10	6	9	8
TOTAL		**105**	**81**	**76**	**78**	**97**	**35**	**36**	**44**	**64**	**45**	**48**	**49**	**42**	**19**	**77**	**66**
WEIGHTING CRITERIA		0.109	0.084	0.079	0.081	0.101	0.036	0.037	0.046	0.067	0.047	0.050	0.051	0.044	0.020	0.080	0.069
THE ORDER OF CRITERIA		**0.109**	**0.084**	**0.079**	**0.081**	**0.101**	**0.036**	**0.037**	**0.046**	**0.067**	**0.047**	**0.050**	**0.051**	**0.044**	**0.020**	**0.080**	**0.069**
		1	**3**	**6**	**4**	**2**	**15**	**14**	**12**	**8**	**11**	**10**	**9**	**13**	**16**	**5**	**7**

Table. 5 Weighted Borda method

No Weight	Criteria	Code	Weight
1	Sailing Flow	K1	0.109
2	The Deep of the Sea	K5	0.101
3	Sailing Navigation Supporting Facilities (SNSF)	K2	0.084
4	Coastal Morphology	K4	0.081
5	Transportation Facilities	K15	0.080
6	Seabed Type	K3	0.079
7	Means of Communication	K16	0.069
8	Supporting Facilities of Base Materials	K9	0.067
9	Health Facility	K12	0.051
10	Education Facilities	K11	0.050
11	Supporting Facilities of Maritime Industry	K10	0.047
12	Land Availability	K8	0.046
13	Social Condotion of Society	K13	0.044
14	Military Training Area	K7	0.037
15	Landing Area	K6	0.036
16	Political Condition	K14	0.020

b. After obtaining the weight of each criterion, the next step is to process the results of alternative assessment using Promethee method using Microsoft Excels software and to facilitate the analysis of Promethee using Visual Promethee Version 1.1.0.0 which is a tool in solving Promethee method. The working order is as follows:

1) Determination of Criteria Preference Type. The determination of this type of preference is determined through brainstorming with decision makers and based on data accuracy. Guidelines for data selection based on data accuracy are presented in Table 6.

Table. 6 Type selection

Data Accuracy Rate	Seleted Type	Parameter
Accurate or Precise	Type III	p
	Type V	q,p
	Type VI	Ō
Not Accurate or Coarse Estimates	Type I	-
	Type II	p
	Type IV	q,p

2) Then the research on the tendency is not different if the appreciation of the value is below the parameter value p, if it has no tendency below the parameter value of p then the possible types are type II, type III, type IV and type V. Next is the assessment for different tendencies absolute after exceeding the parameter value q. If it has an absolute distinct tendency after it exceeds the parameter q, then the type chosen is type IV and type V. If the values | d | form a normal distribution, then the type of preferred function selected is

type IV. A complete selection of preference types is presented in Table 7.

Table. 7 Type of Preference criteria

No	Criteria	Criteria Type
1	Sailing Flow	Type III
2	Sailing Navigation Supporting Facilities (SNSF)	Type III
3	Seabed Type	Type V
4	Coastal Morphology	Type V
5	The Depht of the Sea	Type III
6	Landing Area	Type I
7	Military Training Area	Type I
8	Land Availability	Tiye III
9	Supporting Facilities of Base Materials	Tiye II
10	Supporting Facilities of Maritime Industry	Tiye IV
11	Education Facilities	Tiye III
12	Health Facility	Tiye III
13	Social Condition of Society	Tiye II
14	Political Condition	Type I
15	Trasportation Facilities	Type II
16	Means of Communication	Type II

3) Threshold Threshold Determination. The threshold value of each criterion is required as a basis to provide an assessment of outranking relationships between alternatives on a given criterion whether an alternative is preferred, not different, or preferably to a certain degree. Thus the threshold value must be given to each criterion, where the person who is considered the most important role here is the decision maker or expert. The procedure for determining the Threshold value as follows:

a) Calculate the value of the absolute difference between alternative criteria.

b) Calculating the range threshold for each criterion, calculating the absolute difference for each criterion by calculating the difference between the maximum and minimum absolute values.

c) Divide the range obtained from step (b) into three classes of the same class width to obtain indifference threshold values or q, preference threshold (p), and veto threshold (v) with rule q<p<v. The result of calculating threshold value as Table 8

Table. 8 The threshold value of the criteria

No	Criteria	Rule	Parameter		
			q	p	s
1	Sailing Flow	Max	116.667	233.333	177.858
2	Sailing Navigation Supporting Facilities (SNSF)	Max	1.333	2.667	2.000
3	Seabed Type	Max	0.333	0.667	0.577
4	Coastal Morphology	Max	0.667	1.333	1.000
5	The Depht of the Sea	Max	3.333	6.667	5.774
6	Landing Area	Max	0.333	0.667	0.577
7	Military Training Area	Max	0.000	0.000	0.000
8	Land Availability	Max	5.000	10.000	7.638
9	Supporting Facilities of Base Materials	Max	0.000	0.000	0.000
10	Supporting Facilities of Maritime Industry	Max	0.667	1.333	1.000

No	Criteria	Rule	Parameter		
			q	p	s
11	Education Facilities	Max	0.333	0.667	0.577
12	Health Facility	Max	0.333	0.667	0.577
13	Social Condition of Society	Max	0.000	0.000	0.000
14	Political Condition	Max	0.000	0.000	0.000
15	Trasportation Facilities	Max	0.000	0.000	0.000
16	Means of Communication	Max	0.000	0.000	0.000

4) The next step is the calculation of the preference value, because there are 3 alternatives then done 3 combinations of combinations of preferences.

5) And the final result of the calculation is the calculation of Preference Index from the combination of the three alternatives. The preference index of ℘ (a, b) is calculated on each pair on the criterion by formula (6), then the value of preference index between alternatives as shown in Table 9 follows.

Table. 9 Value of Preference Index

ΠP(a,b)	A1	A2	A3
A1	0.0000	0.0486	0.0000
A2	0.3708	0.0000	0.2407
A3	0.4720	0.1979	0.0000

6) Calculation of Preference Direction. By looking at the results akir processing then we can know the direction of preference. For the direction of preference is divided into two directions: Leaving Flow (LF) and Entering Flow (EF). LF is the size of the character outranking a, while EF is the size of a character in outrank. The positive outranking flow (F + (a)) declares to dominate the other (the power of a). The negative outranking flow (Φ ^ + (a)) states how each alternative is dominated by the other (the weakness of a). The ranking of Promethee I is based on each of the values of LF and EF. The bigger the LF value and the smaller the EF the better the alternative. The paretal ranking of Promethee I is presented in Figure 5 below

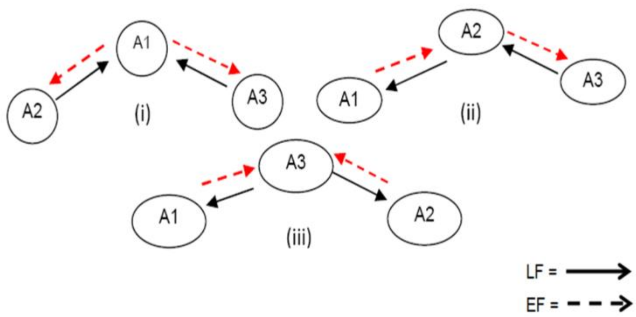


Fig. 5 Node relationship between alternative Promethee I

So the best alternative sequence in accordance with the ranking is as follows:

a) Ranking 1 Semebai.
b) Ranking 2 Siuban.
c) Ranking 3 Semabuk.

While Promethee II is based on its Net Flow (NF), the bigger the NF the higher the ranking. The ranking is shown in Figure 6.

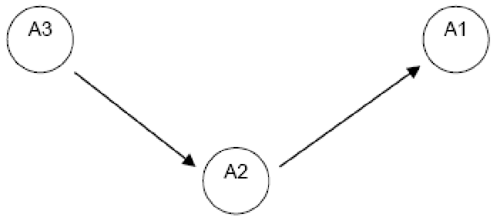


Fig. 6 Node relationship between alternative Promethee II

Based on Net Flow the best alternative sequence in accordance with the following rankings:

a) Ranking 1 Semebai.
b) Ranking 2 Siuban.
c) Ranking 3 Semabuk.

3.2. Analysis of Borda Results

Based on the result of the research, it is found that the criteria of the Sailing Channel (K1) with the weight of 10.9% is a criterion that significantly affects the determination of base site selection, and the second criterion that is the depth of the sea (K5) with weight of 10.1%. For the other criteria weighs less than 9%, while the criterion that has the lowest weight is the criterion of Political Condition (K14) of 2%.

3.3. Analysis of Promethee Results

Promethee is a method that complements or enriches the decision-making process of the preferences function (Belton, 2002). In the process of Promethee work is very dependent on the choice of type of preference conducted on each criterion, because in determining the type of preference is crucial to the end result of ranking. The result of the combination of these two methods resulted in Semebai Bay being ranked first in the selection of base sites.

3.4. Sensitivity Analysis

Sensitivity analysis is carried out to determine the extent of the decision changes that occur when the changes are made to the weight of the existing criteria. Based on data processing by Promethee II method, the result of weight sensitivity interval of each criterion is at certain value interval. For the breakdown of sensitivity values are presented in Table 10.

Table. 10 Interval sensitivity value

No	Criteria	Weight	% Interval
1	Sailing Flow	0.109	(0.00%, 16.69%)
2	Sailing Navigation Supporting Facilities (SNSF)	0.084	(0.00%, 14.31%)
3	Seabed Type	0.079	(0.00%, 100%)
4	Coastal Morphology	0.081	(3.64%, 100%)
5	The Depht of the Sea	0.101	(0.00%, 100%)
6	Landing Area	0.036	(0.00%, 100%)
7	Military Training Area	0.037	(0.00%, 100%)
8	Land Availability	0.046	(1.18%, 39.08%)
9	Supporting Facilities of Base Materials	0.067	(0.00%, 100%)
10	Supporting Facilities of Maritime Industry	0.047	(0.09%, 100%)
11	Education Facilities	0.050	(0.00%, 13.01%)
12	Health Facility	0.051	(0.00%, 13.10%)
13	Social Condition of Society	0.044	(0.00%, 100%)
14	Political Condition	0.020	(0.00%, 100%)

No	Criteria	Weight	% Interval
15	Trasportation Facilities	0.80	(0.00%, 100%)
16	Means of Communication	0.69	(0.00%, 100%)

Based on the sensitivity analysis conducted by Promethee method, the results obtained are sensitive to changes in weight at certain intervals such as changes in the weight of the criteria of Sailing Channel (K1), SNSF (K2), Coastal Morphology (K4), Land Availability (K8), Supporting Facilities Maritime Industry (K10), Health Facilities (K11) and Education Facilities (K12). On these 7 criteria it can be explained that at this stable level the alternative rankings will not change, but when outside the stable level interval there will be a change of rank on the alternative. As for the other criteria with an increase in weight value up to close to 100%, the predominance of this criterion will certainly not affect the final outcome of the sequence of alternatives. Visually seen in Figure 7 of the seven criteria that have a stable interval at a certain level.

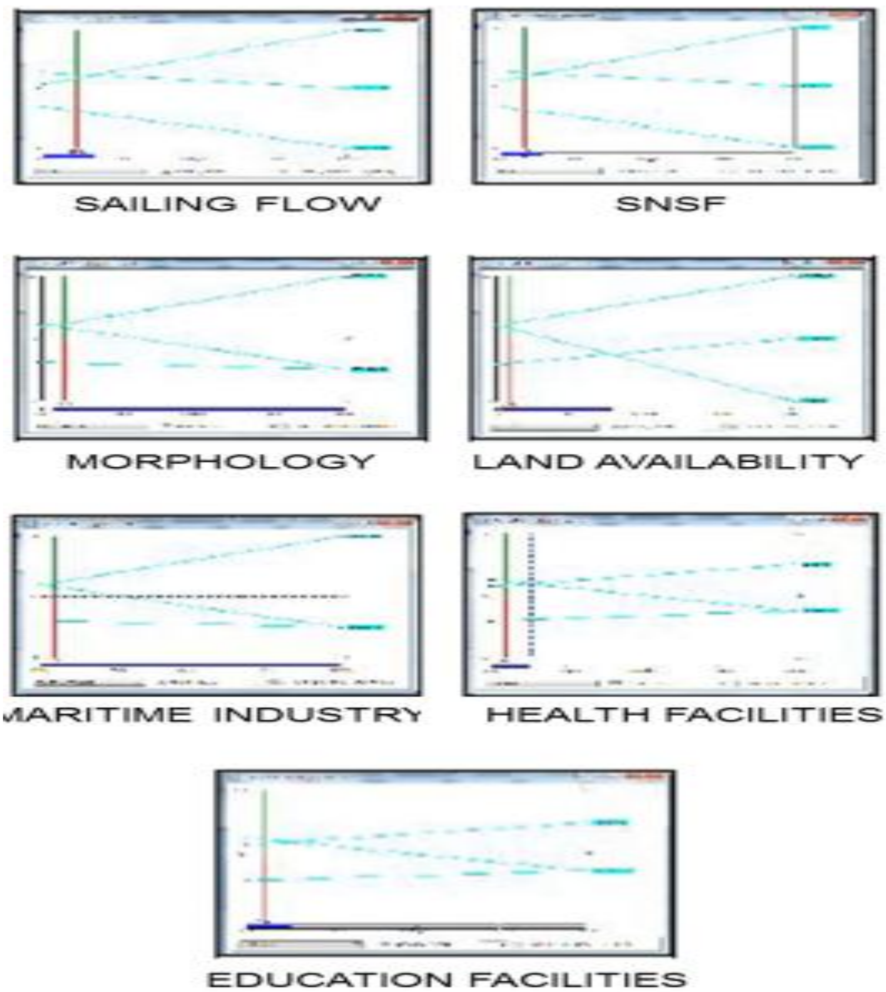


Fig. 7 Visualization of stable interval criteria

Sensitivity analysis is also done to alternative judgment value, this is done to know how big of change of rank which happened if in the future will experience change of appraise to alternative. The assessment of the criteria on each alternative is done on the criteria of SNSF, Land Availability, Support Facilities of Maritime Industry. And judgment assessment is given to alternatives that have the lowest or lowest value, to be able to know the ranking change of the existing alternatives. The result of the sensitivity analysis of the alternative does not change the ranking, it is seen in Figure 8.

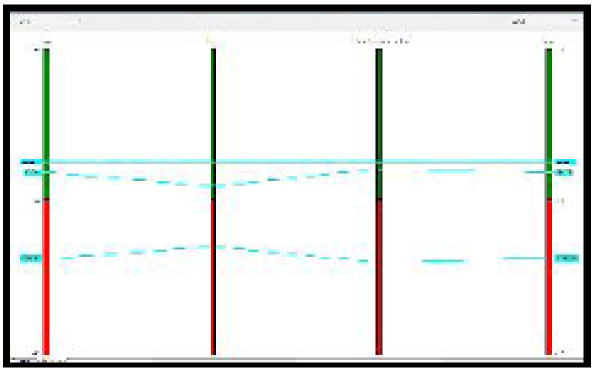


Fig. 8 Results of alternative change sensitivity analysis

4. CONCLUSION

Decision-making within an organization is the result of a continuous process of communication and participation of all members of the organization. The model of decision making by combining Borda and Promethee methods is a way of developing logical relationships that underlie the problem of decision making into a mathematical model reflecting the relationships that occur between the criteria involved. Based on the result of the research, it is found that the criteria of the Sailing Channel (K1) with the weight of 10.9% is a criterion that significantly affects the determination of base site selection, and the second criterion is the Depth of Sea (K5) with weight of 10.1%. For the other criteria weighs less than 9%, while the criterion that has the lowest weight is the criterion of Political Condition (K14) of 2%. Based on the result of research with Borda and Promethee combination method, the best base location of the Mentawai naval base, in order of priority as follows:

Sequence 1: Semebai Bay

Sequence 2: Siuban Bay

Sequence 3: Semabuk Bay

Thus we conclude that Semebai Bay is the best location to serve as the location of Mentawai naval base. In general, the results of sensitivity analysis on the criteria and alternative weightings do not change with the selected alternative ranking result, so it can be said that the model is really robust.

5. Bibliography

Belton, V. S. (2002). *Multiple Criteria Decision Analysis : An Integrated Approach.* New Jersey: Kluwer Academic Publisher.

Brans Roy, P. V. (1986). How to Select and How to Rank Projects : The PROMETHEE Method. *European Journal of Operational Research* , 228-238.

Gothner, M. S. (2009). A Novel Approach to incubator evaluations : The Promethee outranking procedures. *IWH-Discussion Papers* , 1.

Indonesian National Army. (2010). *Minimum Essentitial Force (MEF).* Jakarta: Indonesian National Army.

Indonesian Navy Headquarter. (1996). *Battle Marine Base Defense Guidelines.* Jakarta: Indonesian Navy Headquarter.

Indonesian Navy Headquarter. (2007). *Hydro Oceanographic Data of Indonesia Oceans.* Jakarta: Indonesian Navy, Pushidrosal.

Indonesian Navy Headquarter. (2013). *Indonesian Naval Base Standard Administration Handbook.* Jakarta: Indonesian Navy Headquarter.

Indonesian Navy Headquarter. (2005). *The Design of The Indonesian Naval Posture.* Jakarta: Indonesian Navy Headquarter.

M. Ehrgott, J. F. (2010). *Trends in Multiple Criteria Decision Analysis.* Berlin: Springer Science & Business Media.

Macharis, C. S. (2004). Promethee and AHP the design of operational synergies in multicriteria analysis : Strengthening Promethee with ideas of AHP. *European Journal of Operational Research* , 307-317.

Mareschal B, d. S. (2008). Rank Reversal in The Promethee II : Some New Results. *IEEE* .

National Development Planning Bereu. (2016). *Report of the Strategic Initiative for the Ministry of Marine Affairs and Natural Resources.* Jakarta: National Development Planning Bereu.

Paun, R. A. (2014). On The Borda Methods for Multicriterial Decision Making. *Journal International Monetary Fund Institute* , 31.

Pavic, Z. B. (1991). The use of the PROMETHEE method in the location choice of a production system. *International Journal of Production Economics* , 165-172.

Rudolf Vetschera, A. T. (2012). A PROMETHEE Based Approach to Portfolio Selection Problems. *Journal of Computer & Operations Research* , 39.

Saaty. (2001). *Decision Making With Dependence and Feedback The Analytyc Network Process.* Pittsburgh, USA: RWS Publication.

Salvatore Corrente, S. G. (2012). Multiple Criteria Hierarchy Process With ELECTRE and PROMETHEE. *Journal of Economics and Business* , 60.

W. D. Keyser, P. P. (1996). A note on the use of Promethee Multicriteria Methods. *European journal of Operational Research* , 457-461.

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SELECTION OF SURFACE TO SURFACE MISSILES (SSM) IN INDONESIAN WARSHIP SAMPARI CLASS USING DECISION MAKING TRIAL AND EVALUATION LABORATORY (DEMATEL) AND ANALYTYC NETWORK PROCESS (ANP)

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ABSTRACT

Indonesian warship is one of the main weapon system belongs to Indonesian Navy. On this year planning programme, The Navy procure a PT PAL's Fast Attack Craft (FAC) which have much more advantages either on platform and sewaco side comparing with other convensional Warship that called Indonesian Warship Sampari Class. In order to fullfill it's warfare capabilities, this Sampari Class will be equipped with surface-to-surface missile. Selecting the type of missile requires proper method on analizing many aspects and criterias. In the procurement decision-making process, those aspects and criterias cannot be exemined in a hierarchically method as it involves interaction and dependency of the higher and lower level elements. Therefore, this study uses a method of Decision Making Trial and Evalution Laboratory (DEMATEL) and Analytical Network Process (ANP) to accommodate the link among them, which is considered as the most proper and simple method available. The results of this study based on analysis and interpretation of data processing results explained that the main subcriteria that received the highest priority weight in the selection of surface-to-surface missiles is the Accuracy subcriteria with a weighting value of priority 0.146213, Surface to Surface Missile (SSM) alternatives to the selected Indonesian warship Sampari class are those that get the greatest value from the calculation using Super Decision Software is C 705 missile with a priority weight value of 0.493386, and then sequentially the second alternative priority in the selection of surface-to-surface missiles then is the C-802 missile with a priority weight value of 0.310814 and as the last priority of the three alternatives is the Exocet MM 40 Block 2 missile with a priority weight value of 0.195800.

KEYWORDS : DEMATEL, ANP, Alternative, Surface to Surface missile, Main Criteria.

1. INTRODUCTION.

Geographically, the Republic of Indonesia is a country that is known as an archipelago (archipelagic state) the largest total area, occupying nearly two-thirds of Southeast Asia where this country has a quirk with islands - islands scattered from Sabang to Merauke, amounting to nearly 17,845 islands (Navy, 2017). Several large islands in Indonesia, among others, the island of Sumatra, Java, Kalimantan, Sulawesi and Irian Jaya island and its islands - other smaller islands (A.Person & Weerd, 2006).

The territorial waters of the vast Indonesian government demands to build a strong sea power to maintaining the territorial integrity of the Republic of Indonesia (Defense Ministry Of The Republic Indonesia, 2015). It is in intended to keep the range of potential threats that will occur in the territorial waters of Indonesia, both potential threats from within and potential threats from outside the

Homeland. Based on (Regulation of The Republic Indonesia No.34, 2004) Defence force in the field of maritime reliable and fast is the core of defense for military preparedness in general and the Navy in particular. Navy in this very direct influence in the field of maritime defense is very required to always be alert in maintaining security throughout the archipelago sea.

In addition, the position of Indonesia, located in a very strategic position at the intersection between the two continents; Asia and the Australian Continent; and 2 oceans; the Indian Ocean and the Pacific Ocean; naturally makes the territorial waters of Indonesia as one of the main lines of world trade (Laksamana, 2011). By having abundant natural resources, on the one hand to benefit the welfare of the nation, but on the other hand contains a vulnerability to the presence of the interests of other countries that may interfere with the sovereignty, integrity, security and safety of the nation. This is a challenge and a potential vulnerability in a very large and complex for Indonesia. Challenges and potential vulnerability of course, must be addressed and anticipated with the planning and development strategies as well as in the form of an act of protection and security of Indonesia to be implicated in the maritime field to strengthen the defense of the country's defense system with a strong deterrent power to melindungai all resources are in the territory of the Republic of Indonesia, both in peacetime and in wartime.

Government efforts to improve the defense must be supported by a sophisticated and modern armaments. A case we know the real condition of the existing defense equipment is very much as expected because of the limitations or shortcomings in terms of both quantity and sophistication of armaments block, impressed the way place and seemed to decline technologies. It can be seen from the average - average age of defense equipment is very old and even obsolete without regeneration defense equipment should follow a continuous and sustainable. The existence of defense equipment is a necessity for any country.

Indonesian warship Sampari Class is designed in such a way as to be able to carry out combat duties and security assistance duties. Mobility, disruption, destructive power and control system command capabilities with elements of water and aircraft vessels make this battleship an unreliable water vessel capable of carrying out marine operations tasks.

The combat capability of this Sampari class warship should be equipped with a missile weapon capable of supporting its main task. Therefore this final project research is expected to help provide advice and input to the Indonesian naval leadership in choosing missile weapons on water objectively. The method used in this reasearch is Decision Making Trial and Evaluation Laboratory (DEMATEL) and Analytic Network Process (ANP). The DEMATEL method can change the relationship between cause and effect of a criteria into an easily understood, structured model system (Fontela & Gabus, 1973). This is done to get consideration of decision making by knowing the relationship of interconnection between criteria (Saaty, 2001).

1.1. Related Works.

(Tsaur, et al., 2002) conducting a study on Quality Evaluation of Aviation Services With the Fuzzy MCDM study describing the evaluation of aircraft service quality as a domestic and international flight in Taiwan. (Ching-HsueCheng, et al., 1999) examined the Evaluating Attack Helicopters by AHP Based On Linguistic Variable Weight a study of new methods for evaluating weapon systems by process (AHP) based on the weight of linguistic variables. Application of MCDM research methods (Aghaee & Fazli, 2012) about an improved MCDM method for maintenance approach selection: A case study of auto industry. A research entitled A Novel Approach To Incorporate Customer Preference and Perception Into Product Configuration: A Case Study On Smart Pads performed by (Wang & Hsueh, 2013). A study of management strategy (Nadali, et al., 2011) ANP-FIS Method for Determining the Knowledge Management Strategy. Research conducted by (Kuan & Chen, 2014) on A hybrid MCDM framework combined with DEMATEL-based ANP to evaluate enterprise technological innovation capabilities assessment. A study conducted by (Vanany, 2003) who raised the title of "Application of Analytical Network Process (ANP) On Performance Measurement System Design (Case Study on PT.X)". A study of surface-to-surface missiles conducted by (Zandavi, 2017) on Surface-To-Air Missile Path Planning Using Genetic and PSO Algorithms. In a study conducted by (Bashetty & Chodisetti, 2015) about Design and Analysis Of Surface To Surface Missile.

2. METHODOLOGY

2.1. Research Method

The MCDM approach in the selection of surface-to-surface missiles by proposing a decision-making based on questionnaires to Eexpert in the Indonesian Navy. The result of technological capability and innovation analysis that will be applied on the Sampari class warship by proposing 5 criteria and 36 subcriteria in this research can be seen in Table 1.

Table. 1 Criteria and Sub criteria of Surface-to-surface Missiles

Criteria	Sub criteria	Assessment Parameters
General Requirements	Operational	The degree of ease in the operation of missiles.
	Age Use	Age of missile wear for at least 10 years and can be relifing again.
	Security	Security guarantees for missile crews during shooting.
	Politis	Related to diplomatic relations both bilaterally and multilaterally
		in determining political policy in decision making.
	Strategic	Prospects for future use of missiles in the development of science and technology.
	Geography	This criterion relates to missile capability associated with geographic conditions.
Tactical Requirements	Power Destroyed	Damage assessment for destroyed targets
	Environmental conditions	Missiles are able to operate in environmental conditions in Indonesia.
	Speed	Missile capability in achieving goals
	Endurance	The missile capability begins to be fired until it reaches the target
	Range	The range of missiles against the target
	Accuracy	The precision of missiles in the target
	electronic warfare	The weapon system must have an anti-jamming system so that it can be used optimally
		even if the enemy uses the jamming system to destroy weapon system functions.
	Survivability	Ability to face opponent missile action
Technical Requirements	Altitude detection	Missile capability in sector gravity center in missile journey towards target.
	Movement Detection	The missile capability maintains speed and altitude at sea level
	Control Chain	Liaison between a computer system with a missile fin in missile exercise
	Homing Head	The missile electronic device in reaching the target
	Warhead	Parts containing explosives and missile detonators
	Propulsion	The part that contains the fuel of the missile plunger
	Guidance	The ability to control missiles before and during the course of the target to threats from
		opposing vessels (related to radar / seeker sensors)
	Voltage	The required power supply of the missile is adjusted to the availability of power
		supply on the ship (requires converter).
	Gyro	The missile capability to adjust the shifting changes and the nod of the ship corresponds to the gyro on board.
	Sensors	The ability of a missile sensor to detect a predetermined target until it reaches it.
Maintenance	Dimensions and Weights	The dimensions here include the length and width of the missile, while for this weight
		the weight of the missile will affect the MPK (Main Pushing Machine).
	Parts	The availability of spare parts and against the possible impact of the embargo
	Technician	Availability of technicians in the technology transfer process
	Maintenance Tools	Availability of equipment maintenance and maintenance support equipment
	Field maintenance	Ensuring easy weapon conditions in easy field maintenance.
Risk	Warranty	Guarantee is a service guarantee from the manufacturer if there is damage.
	Misfire	Misfire is a condition where the missile can not be fired because of the internal influence
		of the missile itself, eg: a missile, and others.
	Explode in the Container	Exploding in a Container is a condition that is the most dangerous risk of exploding in a tube
		or place of a missile (container).
	Embargo Spare Part	Spare part embargo is a condition where there is a ban on the sale of spare parts (spare parts) from
		producer country to consumer country.
	Technology Transfer Failure	Technology Transfer Failure is a situation where there is no technological delivery process from producer
		country to consumer country
	Technology unpreparedness	Technology unpreparedness is a measured or compatible state of technology between the PIT system
		(Combat Information Center) in Indonesian warship with technology systems in missiles
	Uncompounded missile crew	The unpreparedness of missile combatants is a condition where the unpreparedness of Navy soldiers in manning
		in manning missile alternatives to be installed, eg unpreparedness of science and technology of Navy soldiers.

2.2. Using DEMATEL To Know The Relationship Between Criteria or Sub criteria in Decision Making.

Based on DEMATEL literature it is useful to describe causal relationships in complex problems. Calculations from DEMATEL method (Fontela & Gabus, 1976) are generally carried out through five steps:

Step 1: Combine the direct link matrix values that the experts have filled with the average value. In the DEMATEL formulation, respondents indicate the degree of direct influence on a scale of 0, 1, 2, 3 and 4, which represent “Complete no influence (0)”, “Low influence (1)”, “Medium influence (2)”, ”High influence (3)” and “Very high influence (4)” by experts, respectively.

Step 2: Perform normalization on the linked matrix directly by multiplying the value of each column by the total value of the sum of the values of each row is acquired using Eq. (1) and Eq.(2).

$$M = k.A \tag{1}$$

$$k = Min\left(\frac{1}{\underset{1\le i\le n}{max}\sum_{j=1}^{n}|a_{ij}|}, \frac{1}{\underset{1\le j\le n}{max}\sum_{i=1}^{n}|a_{ij}|}\right) \tag{2}$$

$$i, j \in \{1,2,3,\dots,n\}$$

Step 3: Obtain the total linkage matrix by subtracting each column of identity matrix values from the normality matrix, followed by processing them with Minverse and MMULT can be obtained by using Eq.(3).

$$S = M + M^2 + M^2 + \dots = \sum_{i=1}^{\infty} M^i$$
$$S = M\,(I - M)^{-1} \tag{3}$$

Step 4: Count the dispatcher group and receiver group. Group dispatchers and receiver groups are obtained by determining the value of D and R first. The D value is derived from the sum of the row values on the matrix processed by MMULT. While the value of R obtained from the number of columns of matrix values after the process MMULT by using Eq.(4), Eq.(5), Eq.(6).

$$S = \left[S_{ij}\right]_{nxn}, i, j \in \{1,2,3,\dots,n\} \tag{4}$$

$$D = \sum_{j=1}^{n} S_{i,j} \tag{5}$$

$$R = \sum_{i=1}^{n} S_{i,j} \tag{6}$$

Step 5: Set the threshold value and get the impact-diagraph map. In order to obtain an appropriate impact map, the decision-maker must establish a threshold value for the level of influence. The impact-diagraph map can be obtained by mapping the values (D + R, D-R), where the horizontal axis is the value of D + R and the vertical axis is the value of D-R (Tzeng, et al., 2007).

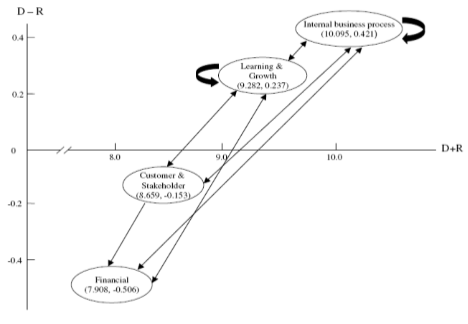

Fig. 1 Impact-Diagraph Map

(Wu & Lee, 2007)

2.3. ANP Method For The Relationship Between Sub-Criteria Innerdependence and Outerdependence.

According to (Saaty, 1996) ANP method is able to fix weaknesses AHP is the ability to accommodate linkages between criteria or alternatives. ANP data processing is done after the ANP questionnaires the experts to fill has been reassembled. Preparation of questionnaires using reference network model that has been formed. The questionnaire is based on the relationship between subcriteria both innerdependence and outerdependence and the preference relationship between the criteria and the goals by pairwise comparison between the cluster and between the cluster nodes.

The first stage performed on the ANP method to determine the priority criterion is to compile pairwise comparisons, comparing in pairs all the criteria for each hierarchical subdivision. The comparison is then transformed in the form of a pairwise comparison matrix for numerical analysis which can be seen in Table 2.

Table. 2 Pairwise Comparison Matrix (Saaty, 2001)

C	A_1	A_2	A_3	.....	A_n
A_1	a_{11}	a_{12}	a_{13}	.....	a_{1n}
A_2	a_{21}	a_{22}	a_{23}	.....	a_{2n}
A_3	a_{31}	a_{32}	a_{33}	.....	a_{3n}
....	....	.....	.....	......	.....
A_n	a_{n1}	a_{n2}	a_{n3}	.....	a_{nm}

The value of a_{11} is the ratio value of the A_1 element (row) to A_1 (column) stating the relationship: (a) How far the importance of A_1 (row) to criterion C is compared to A_1 (column) or (b) How far is the dominance of A_1 (row) to A_1 (column) or (c) How many properties of C criterion are in A_1 (row) compared to A_1 (column). The numerical value applied for the whole comparison is obtained from the comparison scale in Table 2. If the weight of the A_i criterion is W_i and the element weight of A_j is W_j then the base scale 1-9 is composed representing the comparison *(W_i / W_j) / 1*. The absolute numbers on the scale represent a very good approximation to the weight ratio of elements A_1 to element A_j. Shown in Table 3.

Tabel. 3 Comparative Assessment Scale (Saaty, 1996)

Level of Importance	Definition	Information
1	Just as Important	Both elements have the same effect.
3	Slightly more Important	Experience and judgment are one-sided to one's partner
5	More important	One element is well-liked and practically very dominant, compared to its partner elements
7	Very important	One element proved to be highly favored and practically very dominant, compared to its partner elements
9	Absolutely more important	One element proved to be absolutely preferred over the other, at the highest confidence level
2,4,6,8	Middle value	Given if there is any doubt between two adjacent belief levels
$A_{ji} = 1/a_{ij}$	The opposite	Given when the element in column j is preferred over the counterpart

Geometric Mean (geometric mean) is the midpoint between two or more different decision-makers. After the results of the questionnaire test of each expert is tested consistency, then the results of the filling is feasible to be unified through the geometric mean of each question. Calculation of geometric mean on ANP using Eq.7

$$\sqrt[n]{\prod_{i=1}^{n} X_i} \qquad (7)$$

X_i = Decision on comparison of criterion-1

3. RESULT AND DISCUSION

3.1. Data Processing DEMATEL

This research is the object is surface to surface missiles missiles that have been offered to the Indonesian navy, among others: (a) Missile Exocet MM-40 Blok 2 (b) Missile C 802 (c) Missile C 705. The results of expert assessment who served as head of the weapon repair and maintenance workshop of the Indonesian Navy.

In this section aims to evaluate the criteria associated with surface-to-surface surface-to-surface selection of 3 alternatives already offered to the Indonesian navy. The criteria are: general requirements, sub criteria (operational, age, security, politics, strategic, and geography), criteria of both tactical requirements, sub criteria (destructibility, environmental conditions, speed, endurance, range, accuracy, electronics, survivability), the third criterion of technical requirements, sub-criteria (altitude detection, movement detection, control chain, homing head, warhead, propulsion, guidance, voltage, gyro, sensor, and dimension), the fourth criterion is maintenance, sub criteria (spare parts, technicians, maintenance tools, field maintenance, and warranty), the last criterion is risk, sub-criteria (miss fire, burst in container, spare part embargo, technological failure, unpreparedness, unattended personnel). The expert consists of six people, one representing the procurement field, two representing armaments, and three representing the field of Indonesian naval weapons repair.

The DEMATEL method introduced in Section 2.2 serves as a guide in the decision structure. First, the matrix of direct influence for criteria. Then, the normalization matrix of direct influence for the criterion can be calculated by Eq. (1) and Eq. (2). Third, the total direct-influence matrix for criteria/dimensions was derived based on Eq. (3). The fourth counts the dispatcher group and receiver group was derived based on Eq. (4), Eq. (5), and Eq.(6) (see Table 4). Finally sets the threshold and impact digraph map which shown in Fig. 2.

Table. 4 Sub-criteria Dispatcher and Receiver

	J					
I		D	R	D+R	D-R	
GENERAL REQUIREMENTS	OPS	0,048432484	0,071653384	0,120085848	-0,02322088	Receiver
	AU	0,062450029	0,085367026	0,147817056	-0,022916997	Receiver
	SEC	0,043537395	0,082431351	0,125968746	-0,038893955	Receiver
	POL	0,030360138	0,03121756	0,061577699	-0,000857422	Receiver
	STR	0,029994158	0,043491267	0,073485425	-0,013497109	Receiver
	GEO	0,058021164	0,000597025	0,058618189	0,057424139	Dispatcher
TACTICAL REQUIREMENTS	PWR	0,125970962	0,036451792	0,162422754	0,08951917	Dispatcher
	ENVI	0,086400225	0,000303315	0,08670354	0,08609691	Dispatcher
	SPD	0,065546276	0,039293328	0,104839604	0,026252949	Dispatcher
	END	0,058877184	0,04015263	0,099029814	0,018724555	Dispatcher
	RNG	0,060256699	0,039751472	0,100008171	0,020505226	Dispatcher
	ACC	0,131527899	0,039875181	0,17140308	0,091652719	Dispatcher
	EW	0,093062652	0,013254502	0,106317154	0,07980815	Dispatcher
	SUR	0,087394792	0,024805395	0,112200187	0,062589397	Dispatcher
TECHNICAL REQUIREMENTS	ATT	0,062652633	0,019937343	0,082589977	0,04271529	Dispatcher
	MVT	0,063111931	0,019462182	0,082574113	0,043649749	Dispatcher
	CCN	0,064825842	0,006558272	0,071384114	0,058267569	Dispatcher
	HMH	0,07287745	0,012183602	0,085061052	0,060693848	Dispatcher
	WRH	0,067887916	0,002881811	0,070769727	0,065006105	Dispatcher
	PROP	0,048497473	0,021804567	0,07030204	0,026692906	Dispatcher
	GUI	0,096723849	0,008726023	0,105449872	0,087997826	Dispatcher
	VOLT	0,061360928	0,003057544	0,064418473	0,058303384	Dispatcher
	GRO	0,063065404	0,002718565	0,065783969	0,060346838	Dispatcher
	SNR	0,082458531	0,007138745	0,089597276	0,075319786	Dispatcher
	DIM	0,062208062	0,00050096	0,062709022	0,061707102	Dispatcher
MAINTENANCE	PRT	0,065323255	0,010004565	0,07532782	0,05531869	Dispatcher
	TECH	0,065787492	0,010004565	0,075792057	0,055782927	Dispatcher
	MTT	0,064208067	0,016974324	0,081182392	0,047233743	Dispatcher
	FIM	0,06739517	0,016960654	0,084355824	0,050434516	Dispatcher
	WARR	0,044133172	0,028021417	0,072154589	0,016111755	Dispatcher
RISK	MSF	0,051956493	0,063428573	0,115385067	-0,01147208	Receiver
	EXCO	0,030846638	0,088928489	0,119775127	-0,058081851	Receiver
	EBS	0,064965766	0,030702594	0,09566836	0,034263172	Dispatcher
	TTF	0,077607592	0,07568114	0,153288732	0,001926452	Dispatcher
	TUN	0,094869157	0,069980871	0,164850029	0,024888286	Dispatcher
	UNM	0,067879773	0,044658894	0,112538667	0,02322088	Dispatcher

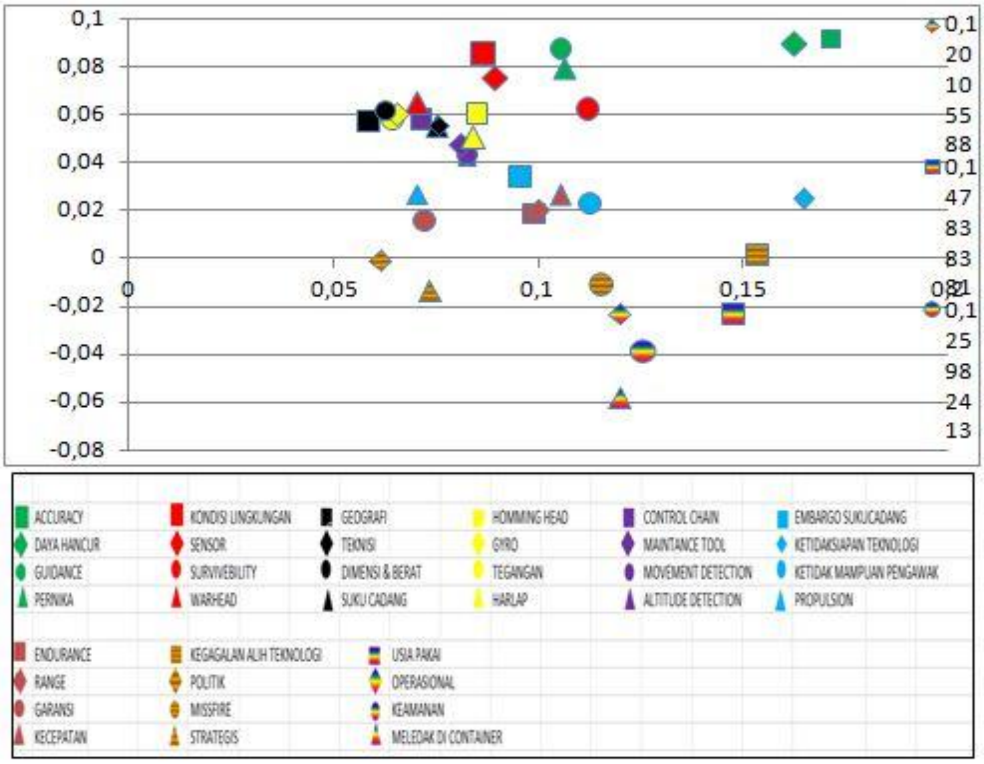

Fig. 2 Impact Diagraph Map

To determine whether there is a relationship between subcriteria one with other subcriteria, it is necessary to determine the value of threshold valuenya first. Threshold value can be found in two ways; that is: Takes the average value of the result table value MMULT and can be determined through expert opinion. The value of treshold value is determined the average value of the result of the mmult table is 0.022840247.

3.2. Data Processing ANP

Geometric Mean (geometric mean) is the midpoint between two or more different decision-makers. After the results of the questionnaire test of each expert is tested consistency, then the results of the filling is feasible to be unified through the geometric mean of each question using Eq. (7). Shown in Tabel 5.

Tabel. 5 Geometric Mean Matrices Comparison Pair on Criteria

Geomean	General	Technical	Tactic	Maintenance	Risk
General	0	0	0	3	5
Technical	4	0	0	3	6
Tactic	5	4	0	3	4
Maintenance	0	0	0	0	3
Risk	0	0	0	0	0

The results of processing using Superdecision software it is known that five subcriteria that have the biggest weight are Accuracy (0.146213), then Power Destroyed (0.103095), Politis (0.064534), Pernika (0.047829) and Survivebility (0.047687).

After knowing the weight of each subcriteria, then the weight of each criterion can also be known. The way to know the weight of the criteria is to add weight of the subcriteria to each criterion. about the criteria weight, the result that the criteria that have the highest weight is the Tactical criterion (0.408843). The next rank is Technical (0.194588), General (0.18956), Treatment (0.093741), and Risk (0.079613).shown in Table 6.

Tabel. 6 Weighting Criteria

NO	Criteria	Weight
1.	General	0,18956
2.	Technical	0,194588
3.	Maintenance	0,093741
4.	Tactic*	0,408843
5.	Risk	0,079613

Using super decision software. The software can facilitate network relationships that occur between criteria, between subcriteria or between alternatives that exist. The final calculation result is the ranking value of each alternative priority of Surface Surface Selection to Surface at Indonesian warship Sampari Class. From the results of questionnaires ANP, obtained data processing Fig. 3 and Fig. 4.

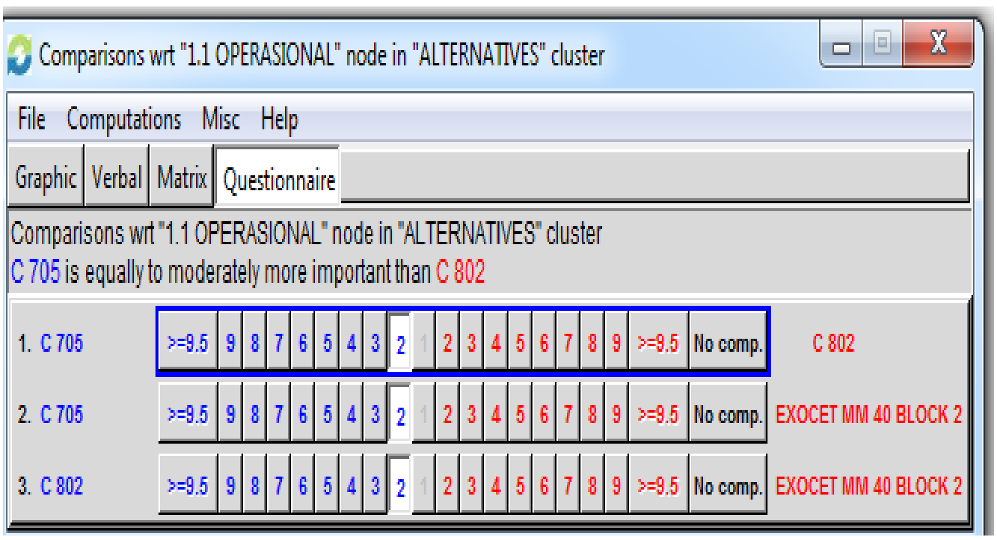

Fig. 3 Comparison of Paired Operational Nodes in Cluster Alternatives on Super Decision

Figure 3 describes the result of processing using Super Decision software that comparison of sub-criteria "operational" to each alternative that is cluster C 705 is equally to moderately more important than C 802.

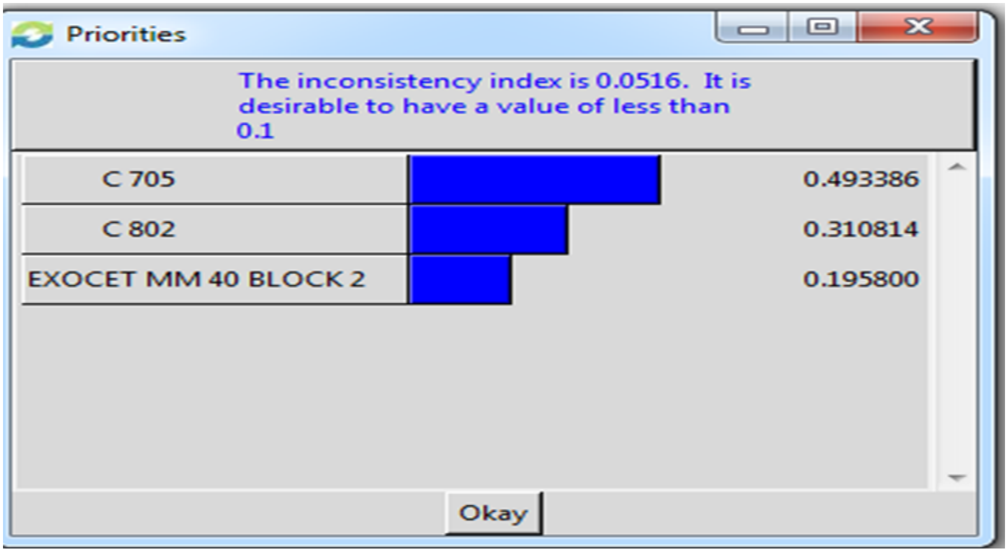

Fig. 4 Index Inconsistency Figure 4.15 is 0.0516

The end result of the synthesis process of all data then obtained the value of alternative weight or alternative priority value of missile selection and ranking of the alternatives shown in Fig. 5.

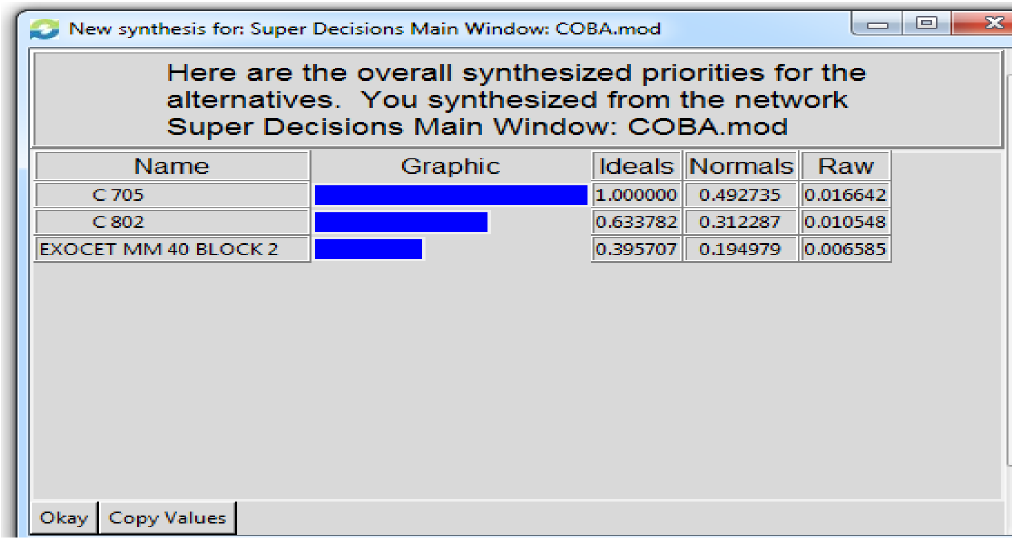

Fig. 5 Alternative Priority Value Of Missile Selection

3.3. Sensitivity Analysis

Sensitivity analysis is conducted to find out the extent of stability of the priority of the alternatives. The vertical line indicates the weight value of each indicator to be tested for sensitivity, while the horizontal line is the indicator hose for the change of weight value in each alternative. In this study Sensitivity analysis is done by changing the value of weight on the alternatives and nodes tested can be seen in Fig. 6 and Fig. 7.

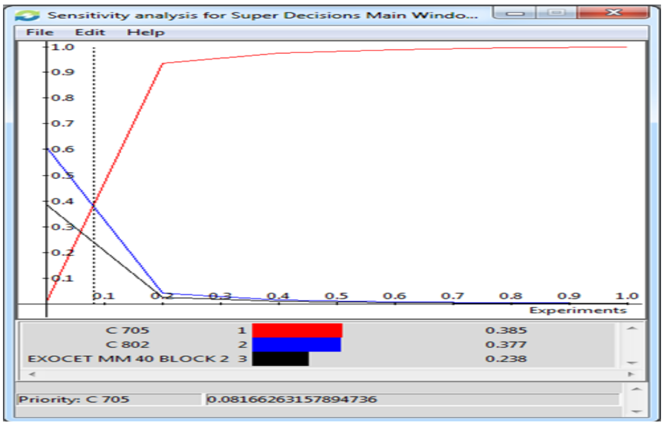

Fig. 6 Alternative Sensitivity Analysis of Missile C 705

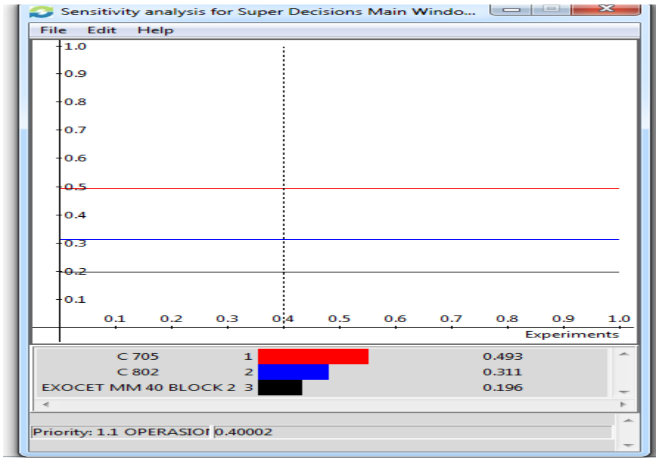

Fig. 7 Sensitivity Analysis of Operational Node Work

4. CONCLUSION

The results of data collection and processing, as well as analysis and interpretation of the results of data processing has been done that sub criteria main / critical that get the highest priority weight in the selection of surface surface to surface alternative is the Accuracy subcriteria with the priority weight value of 0.146213. In the selection of Surface to Surface Missile / SSM (Surface to Surface Missile / SSM) priority on a very complex Indonesian warship Class Sampari, the DEMATEL method is very helpful in describing the relationship between criteria and subcriteria clearly. However, because in DEMATEL method has not produced an alternative priority hence needed a method to find alternative priority that is ANP method, so that more accurate alternative priority is obtained. In addition, in this research it is found that the addition of Expert number does not affect the significant difference either consistency or rank value alternatives to be selected. Surface to Surface Missile (SSM) alternatives to the Selected Selected Indonesian warship are the ones who get the greatest value from the calculation using Super Decision Software ie C 705 missile with priority weight value of 0, 493386 and then sequentially the second alternative priority in the selection of surface-to-surface missiles then is the C-802 missile with a priority weight value of 0.310814 and as the last priority of the three alternatives is the Exocet MM 40 Block 2 missile with a priority weight value of 0, 195800.

BIBLIOGRAPHY

A.Person, G. & Weerd, M. V., 2006. Biodiversity and Natural Resource Management in Insular Southeast Asia. *Island Studies Journal,* 1(1), pp. 81-108.

Aghaee, M. & Fazli, S., 2012. An Improved MCDM Method For Maintenance Approach Selection: A case Study of Auto Industry. *Management Science Letters,* Volume 2, pp. 137-146.

Bashetty, S. & Chodisetti, L., 2015. DESIGN AND ANALYSIS OF SURFACE TO SURFACE MISSILE. *International Journal of Modern Trends in Engineering and Research,* 02(03), pp. 439-449.

Ching-HsueCheng, Yang, K.-L. & Hwang, C.-L., 1999. Evaluating attack helicopters by AHP based on linguistic variable weight. *European Journal of Operational Research,* 116(2), pp. 423-435.

Defense Ministry Of The Republic Indonesia, 2015. *Defence White Paper.* Jakarta: The Directorate General of Defense Strategy.

Fontela, E. & Gabus, A., 1973. *World problems, an invitation to further thought within the framework of DEMATEL.* Geneva: Battelle Geneva Research Centre.

Fontela, E. & Gabus, A., 1976. *The DEMATEL observer, DEMATEL 1976 Report,* Geneva: Battelle Geneva Research Center.

Kuan, M.-J. & Chen, Y. M., 2014. A hybrid MCDM framework combined with DEMATEL-based ANP to evaluate enterprise technological innovation capabilities assessment. *Decision Science Letters,* Volume 3, pp. 491-502.

Laksamana, E. A., 2011. The Enduring Strategic Trinity: Explaining Indonesia's Geopolitical Architecture. *Journal of the Indian Ocean Region,* 7(1), pp. 95-116.

Nadali, A., Nosratabadi, H. E. & Pourdarab, S., 2011. ANP-FIS Method for Determining the Knowledge Management Strategy. *International Journal of Information and Education Technology,* 1(2), pp. 107-113.

Navy, P. I., 2017. *DATA OF THE TERRITORY OF THE UNITARY STATE OF THE REPUBLIC OF INDONESIA,* Jakarta: PUSHIDROSAL.

Regulation of The Republic Indonesia No.34, 2004. *Indonesian Armed Forces.* s.l.:President of The Indonesian Republic.

Saaty, 1996. *Decision Making with Dependence And Feedback The Analytic Network Process.* Pitsburgh: RWS Publication.

Saaty, 2001. *Decision Making With Dependence and Feedback The Analytic Network Process.* 2nd ed. Pittsburgh, USA: RWS Publication.

Tsaur, S.-H., Chang, T.-Y. & Yen, C.-H., 2002. The evaluation of airline service quality by fuzzy MCDM. *Tourism Management,* Volume 23, pp. 107-115.

Tzeng, G. H., Chiang, C. H. & Li, C. W., 2007. Evaluating Intertwined effects in e-learning programs: A novel hybrid MCDM model based on factor analysis and DEMATEL. *Expert Systems with Applications,* 32(4), pp. 1028-1044.

Vanany, I., 2003. Application of Analytical Network Process (ANP) On Performance Measurement System Design (Case Study on PT.X). *Industrial Engineering Journal ,* 5(1), pp. 50-62.

Wang, C.-H. & Hsueh, O.-Z., 2013. A novel approach to incorporate customer preference and perception into product. *Computer Standards & Interfaces,* Volume 35, pp. 549-556.

Wu, A. & Lee, Y., 2007. Selecting Knowledge Management Strategies by Using The Analytic Network Process. *Expert System With Applications,* 32(3), pp. 841-847.

Zandavi, S. M., 2017. SURFACE-TO-AIR MISSILE PATH PLANNING USING GENETIC AND PSO ALGORITHMS. *JOURNAL OF THEORETICAL AND APPLIED MECHANICS,* 55(3), pp. 801-812.

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MEASUREMENT OF PERFORMANCE OF ACADEMIC INFORMATION SYSTEM GOVERNANCE IN THE INDONESIAN NAVAL ACADEMY USING FRAMEWORK COBIT 5

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ABSTRACT

Information technology (IT) also has an important role in performing the function of college or university, so it can be trusted to improve the effiency and effectiveness of the academic process so that the academic services can be maximized as well as supporting the innovation of university business process to develop. The Naval Academy (AAL) is one of the educational institutions in the Indonesian National Defense Force and has the task of creating professional Navy officers, possessing current technological mastery and heading to the World Class Navy. With reference to the desired results above, AAL uses information technology in conducting teaching and learning activities. Academic Information System or SIAKAD is an information system that is built and developed with modules contain of the educational calendar and course materials. The use of Academic Information System is perceived not yet optimal among the factors of information content, ease of access and availability of systems that have not been in accordance with the wishes of its users. From the above problems, the authorconducted a research on "measurement of performance of academic information system governance in the Indonesian Naval Academy ". With the resulting maturity level, it is known that the current level of maturity (as-is) for the average APO (Align, Plan, and Organize) domain (3 – Defined Process) means that the process is at a fixed stage, stage of implementation of standardized processes, meaning that there is a standard IT process that applies everywhere in the scope of the organization means that the Academic Information system in terms of strategic order is already at a stable stage. While the Domain DSS (Deliver, Service, Support), the average level of maturity reach (Defined Process) which means also at a fixed stage means the agency has been running the task of the IT process and has achieved its goals in well managed through the stages of planning, evaluation and better tailored adjustments.

KEYWORDS : COBIT 5, IT Governance, Maturity Level.

1. INTRODUCTION

The development of information technology today has been adopted by many organizations from various fields, not least in the education world (Annwareen., 2008). Information technology (IT) also has an important role in performing the function of college or university, so it can be trusted to improve the effiency and effectiveness of the academic process so that the academic services will be maximized, and support the innovation of university business process to develop. To be able to maintain maximum IT utilization can occur when evaluated the extent to which information technology services are utilized, but the evaluation and control of the use of IT sometimes less attention by universities so that the availability of IT services to be less than the maximum and not appropriate (García, 2013). The function of information technology to be able to provide strategic opportunities for universities, required a good information technology governance. Evaluation has objectives in assessing, monitoring, and ensuring that academic service resources can operate effectively in line with the objectives of the university's strategic plan.

The Naval Academy (AAL) is one of the educational institutions in the Indonesian Defense Force and has the job of creating professional Navy officers, possessing current technological mastery and heading to the World Class Navy. With reference to the desired results above then AAL uses information technology in conducting teaching and learning activities. By using IT, students and lecturers will be able to provide the delivery of learning materials without limitation of time and space as well as place for teaching and learning activities. There are 3 information systems in Indonesian Naval Academy (AAL) that support teaching and learning activity, those are Siakad (Academic Information System), Smart Class and CBT (Computer Based Training) (Romuald Cwilewicz, 2003).

Academic Information System or SIAKAD is an information system that is built and developed with modules contain of education calendar and lecture materials that can be taken by learners and used at any time.Some factors which are perceived not yet optimal in the use of Academic Information System are information content, ease of access and the availability of systems that have not been in accordance with the wishes of its users.

From the mentioned problems it is necessary to have a governance that can solve current problems. Solving these problems are expected in order to improve the quality and performance of the Academic Information System system. Based on the background, the author intends to conduct a research entitled "Measurement of performance of academic information system governancein the Indonesian Naval Academy".

2. LITERATURE REVIEW

2.1. Basic Concepts of Information Systems

Information system is a system within an organization that brings daily transaction processing needs, support information, managerial and strategic activities of an organization and provide certain outside parties with reports required reports (Grembergen, 2008).

2.2. IT Governance

Information Technology governance is a policy framework, procedures and set of processes that aim to direct and control the company in order to achieve company goals by providing additional business value, through balancing the benefits and risks of IT and the processes in it (Ramlaoui, 2014). information technology governanceis defined as an integral part of organizational governance that consists of leadership, organizational structures and processes that ensure that organizational information technology continues as well as enhances organizational goals and strategies (IT Governance Institute, 2007). Information technology governance undertakes the specification of decision rights and accountability frameworks to guide the desired behavior in the use of information technology. Information technology governance is not just a specific decision-making but rather the determination of who systematically makes and contributes to the decision (Ron Webber, 1999).

In its implementation, IT governance can be interpreted as a process of control and performance improvement which is done continuously to the application of IT in the company (S.Elhasnaoui, 2013). The IT governance process begins with goal setting for enterprise IT. Goals will give direction. The carried-outIT activities must be based on those objectives. Finally, performance is measured and compared, the achieved results are compared to the previous results achievement and adjustments are made in relation to the intended purpose (Gerke, 2009).

2.3. COBIT Framework

COBIT is an IT governance standard developed by the IT Governance Institute (ITGI), an organization formed by ISACA that studies the US-based IT governance model (ISACA, 2012). COBIT is an IT governance framework and a set of tools that support and enable managers to bridge the gaps between controllable requirements, technical issues and business risks (ITGI, 2003). COBIT 5 is a strategic development that provides ISACA's next generation guidance on governance and management for organizational IT assets (ISACA, 2012).

One of the principles in COBIT 5 is the division between governance and management processes (Fröhlich, 2010). In line with this principle, each organization is expected to implement a number of governance processes and a number of management processes to achieve overall IT governance and management (ISACA, 2012). COBIT 5 is developed to address important needs, including (Nugroho, 2014):

a. Assist stakeholders in determining what to expect from relevant information and technologies.

b. Overcoming the increasingly pervasive information technology into the company. Information technology is increasingly becoming an important part of business.

c. Support the integration of business and information technology as a whole, and support all aspects that lead to effective corporate information technology governance and management.

2.4. COBIT 5 Process Dimensions

The COBIT 5 process model divides corporate governance and IT management processes into two process domains (ISACA, 2012):

a. Governance

The domain area contains 5 governance processes in the form of domain processes Evaluate, Direct, Monitor. Where there is a definition for each process.

b. Management

The domain area contains 4 domains, aligned with the responsibility areas of Plan, Build, Run, and Monitor (PBRM), providing end-to-end IT coverage. The domain is the structure of the COBIT domain and process 5:

1) Align, Plan, and Organize (APO)

Domains that discuss plans, strategies, and focus on achieving business objects. The realization of a vision strategy is needed to be planned, communicated, and managed to generate perspectives.

2) Build, Acquire, and Implement (BAI)

Provide solutions and services to use. To realize the information technology strategy, the required technology solution, has been built or obtained, or already implemented must be in accordance with the business object.

3) Deliver, Service, and Support (DSS)

Domains that address the delivery and support of required services, including operational support facilities for user support and security management.

4) Monitor, Evaluate, and Assess (MEA)

Observe all processes to ensure follow the directions provided. All information technology processes are needed to be assessed at all times to maintain quality and compliance with control needs. Domains include performance of management, internal control monitoring, related to governance (Sadikin, 2014).

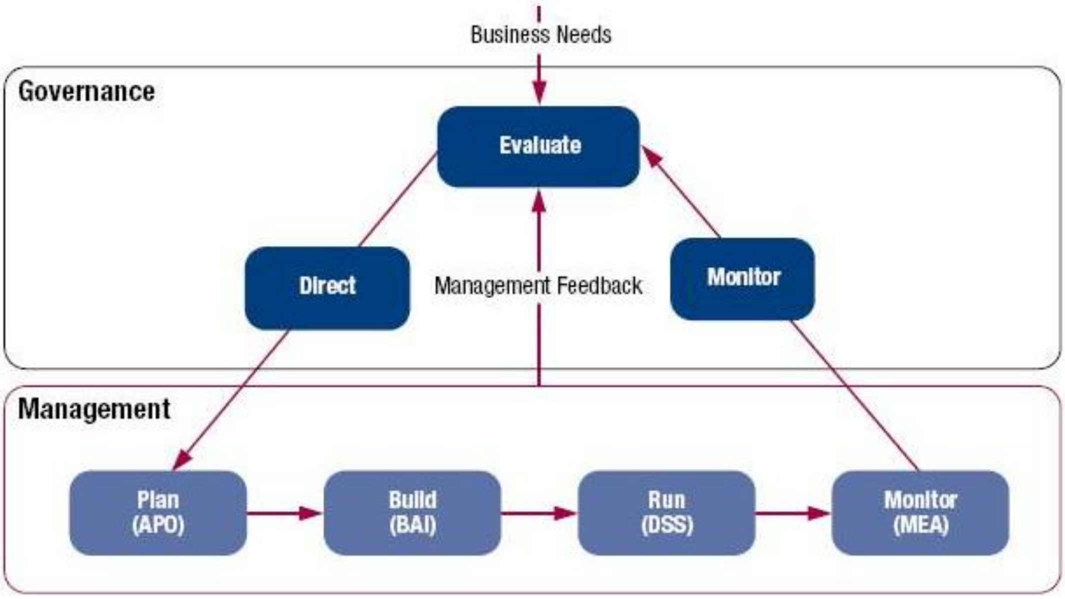

Fig. 1 COBIT 5 Governance and Management key area (ISACA., 2013)

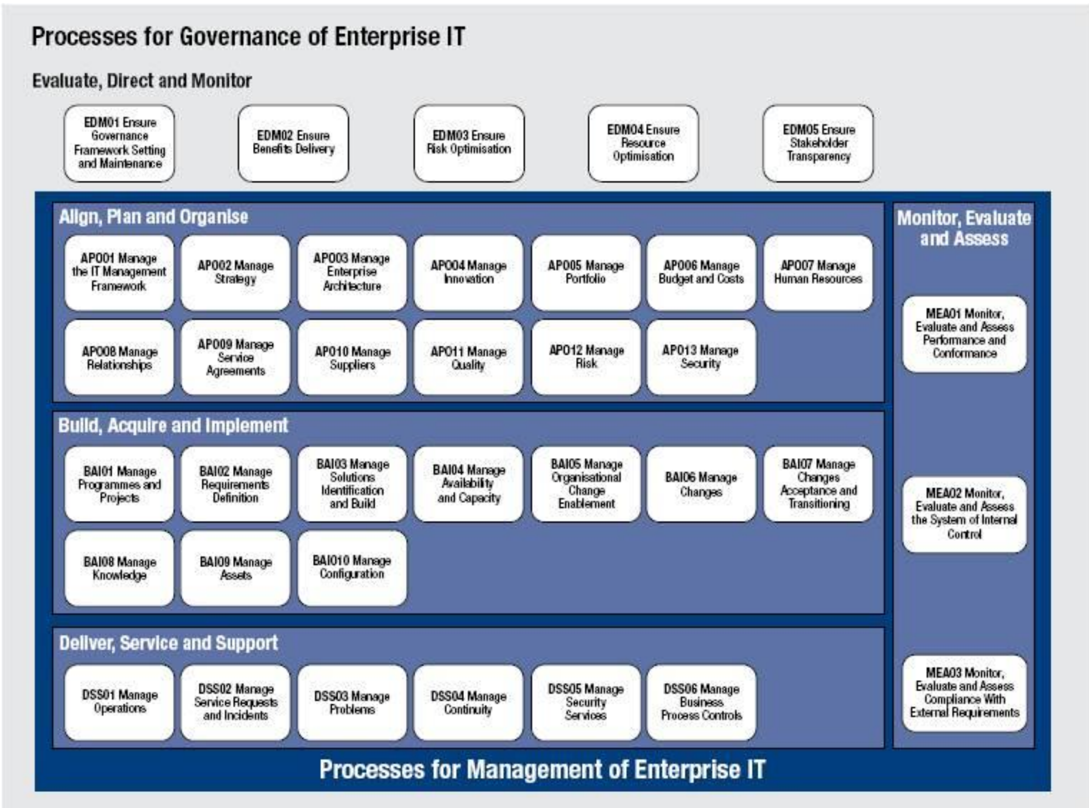

Fig. 2 Domain Process COBIT 5 (ISACA, 2012)

2.5. Maturity Model

The maturity model is used as a tool for benchmarking and self-assessment by IT management more efficiently (Rosmiati, 2016). Benchmarking process can be done gradually to control objectives, starting from processes and high-level control objectives on COBIT so that 3 (three) items can be obtained :

a. Relative size to current organizational conditions

b. Directions to decide directions and goals efficiently

c. Tool to measure progress towards achievement

The measurement scale is given in stages for each IT process represented by a value from 0 to 5 (Tanuwijaya, 2010). The scale is related to the description of the qualitative maturity model that ranges from "Non-existent" to "Optimized" as shown in Figure 2.

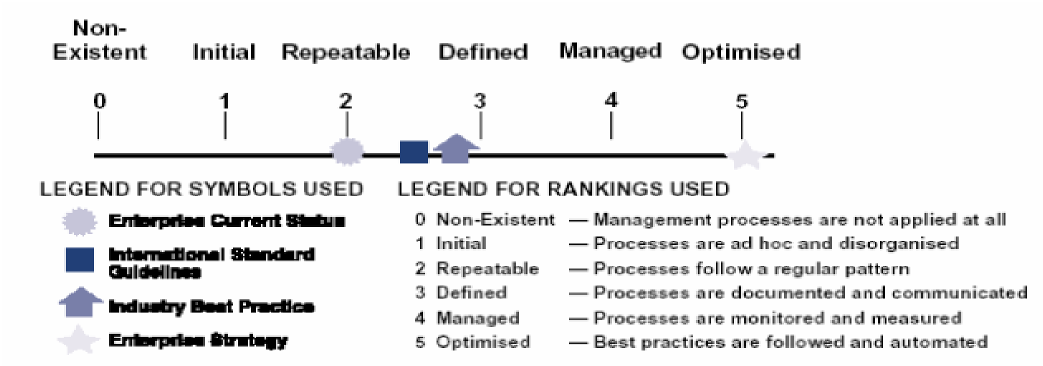

Fig. 3 COBIT Maturity Rate
(IT Governance Institute, 2007)

Table. 1 Maturity Index
(Krisanthi, 2014)

NO	MATURYITY INDEX	MATURITY LEVEL
1.	0 – 0,50	0 – Non-Exist
2.	0,51 – 4,50	0 - Initial/ad Hoc
3.	1,51 – 2,51	2 – Repeatable but Inuituve
4.	2,51 – 3,50	3 – Define Process
5.	3,51 – 4,50	4 – Managed and Measureable
6.	4,51 – 5,00	5 - Optimized

3. RESEARCH METHODS

Stages of workmanship Performance Measurement Governance Academic Information System at the Naval Academy using FRAMEWORK COBIT 5 includes the following stages:

The followings are explanation of the research methodology stages of COBIT 5:

a. Research Objects

The study was conducted on SIAKAD users and Sub directorate of information and data processing(Subditinfolahta)staffs of Naval Academy.

b. Library Studies

It is expected to be able to explore all the information related to the research, both the problems studied and the object of the research objectives.

c. Selection of COBIT Domains 5

Selection is done based on the selection of the functioneddomain.

d. Data Collection

The process of collecting data in the form of observation, questionnaires, and interviews. Observation is done by observing directly the activities undertaken. Observations were made at the Naval Academy Subditinfolahta. Questionnaires were conducted with a maturity level questionnaire. The selected respondents were 10 Subditinfolahta staffsat the Naval Academy. Interview conducted to obtain information in the form of question and answer with the respondent as supporting the result of questionnaire. Interviews were used to obtain more complete information on the issues studied that were not in the questionnaire.

e. Data Processing

Data related to the study were collected, with maturity level analysis adopted by COBIT 5 from ISACA. This step is done to facilitate the translation and interpret the required evidence.

f. Data Analysis

The process of data analysis is done after data processing, data analysis is done analysis of current maturity level (as is), expected maturity level (to be), and gap analysis (gap analysis).

g. Verify Results

The result of the capability analysis is then done in the form of verification process against the facts.

h. Repair Strategy

After the verification process, then process improvement strategy based on data.

i. Recommendations

After doing the improvement strategy process then made recommendations based on the related domain of COBIT 5.

4. RESULT AND DISCUSSION

4.1. Results of Assessment of Maturity Rates of Each Domain

Based on the result of questionnaire of Performance Measurement of Academic Information System at Naval Academy using FRAMEWORK COBIT 5 with 10 respondents from Navy Academic Data and Management Information Division, the result of maturity assessment of each domain as follows:

Table. 2 Maturity Level Calculation Results

NO	DOMAIN	PROCES		Maturity Level
1	APO	APO01	Manage the IT Management Framework	3,20
2		APO02	Manage Strategy	3,37
3		APO04	Manage Inovation	3,13
4		APO07	Manage Human Relation	3,17
5		APO012	Manage Risk	3,45
6		APO13	Manage Security	3,26
7	DSS	DSS01	Manage Operation	3,46
8		DSS03	Manage Problems	3,49
9		DSS04	Manage Continuity	3,22
		The Average Of Maturity Level		3,31

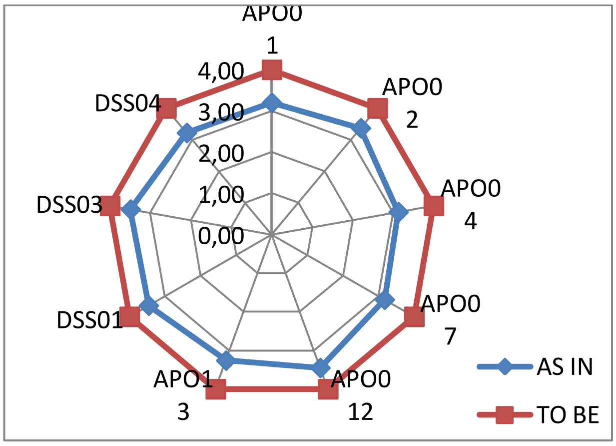

Fig. 3 Graph of Maturity Level Calculation

Based on the results of the Maturity Level calculation, questionnaires and recap of each domain questionnaire, the level of Maturity Level on measurement of performance of academic information system governance in the Indonesian Naval Academy is currently level 3 with the maturity of 3.31 (Defined Process).

In the table and graphic image, the current maturity level shows that the APO04 (Manage Inovation) domain has the lowest current maturity level of 3.13 and is at level 3 of "Defined Process ", Which means managing innovation has been standardized. For the highest current maturity level in the domain DSS03 (Manage Problems) that has a value of 3.49, and is at level 3 is "Defined Process", which means have to identify the problem-solving data access, assets IT has been managed and has been measurable.

4.2. Preparation of Recommendations

From the results of the Measurement of Performance of the Academic Information System governance at the Naval Academy, the following recommendations are given:

Table. 3 APO01 Manage domain The IT Management FrameworkRecommendations

APO01 MANAGE THE IT MANAGEMENT FRAMEWORK			
CURRENT CONDITION	**VALUE**	**TARGET**	**RECOMMENDATION**
Academic information system has no regular maintenance.	3,20	4	To get to level 4 Academic Information System needs a periodic maintenance so that can be monitored and minimize errors that may occur such as damage to the server, and backup data on a regular basis.

Table. 4 domain APO02 Manage StrategyRecommendations

APO02 MANAGE STRATEGY			
CURRENT CONDITION	**VALUE**	**TARGET**	**RECOMMENDATION**
Academic Information System is still running separately from the existing information system in the Naval Academy and has not been widely used by faculty, academic staff and cadets	3,37	4	The need for integration of information systems that have been running in the Naval Academy, and also need to be socialized with the guidebook in using academic information system.

Table. 5 APO04 Manage Innovation domainRecommendations

APO04 MANAGE INOVATION			
CURRENT CONDITION	**VALUE**	**TARGET**	**RECOMMENDATION**
The features contained in the Academic Information System are difficult to use	3,13	4	It needs innovation and evaluation of the features contained in the Academic Information System.

Table. 6 domain APO07 Manage Human RelationsRecommendations

APO07 MANAGE HUMAN RELATION			
CURRENT CONDITION	**VALUE**	**TARGET**	**RECOMMENDATION**
Unmet IT staff needs, and no performance evaluation.	3,17	4	To get to level 4, IT staff needs to be fulfilled and job sharing, as well as performance evaluation to IT staff.

Table. 7 APO12 Manage Risk domainRecommendations

APO12 MANAGE RISK			
CURRENT CONDITION	**VALUE**	**TARGET**	**RECOMMENDATION**
For the handling of incidents occurring against current IT use is not done routinely, but is done at any time in case of a complaint from the user.	3,45	4	IT staff should be effective and periodic responses to inputs and issues requiring design and either from the help desk or incident management process. And for handling incidents that occur against the use of IT should be routine.

Table. 8 APO13 Domain Manage Security recommendations

APO13 MANAGE SECURITY			
CURRENT CONDITION	**VALUE**	**TARGET**	**RECOMMENDATION**
Already using anti-virus but rarely updated, and for user passwords are also never changed.	3,26	4	Installation of antivirus should always be updated in order to maintain system security. To avoid the use of the program by unauthorized users, users' password should always be changed at least once a month

Table. 9 domain DSS03 Manage Operations Recommendations

DSS01 MANAGE OPERATIONS			
CURRENT CONDITION	**VALUE**	**TARGET**	**RECOMMENDATION**
Maintenance or implementation of operational procedures and activities SIAKAD does not have a measurement report at any time.	3,46	4	To go to level 4, a report on the outcome of the procedure is made every month and there is an appropriate allocation of responsibilities and resources.

Table. 10 Domain DSS03 Manage Problem Recommendations

DSS03 MANAGE PROBLEM			
CURRENT CONDITION	**VALUE**	**TARGET**	**RECOMMENDATION**
The problem identification is directly done by the technician and there is no specific support group for identification and root cause analysis.	3,49	4	Create support group of experts to identify and analyze the root of the problem so that problem identification can be done quickly and precisely so that the splitting process can be done immediately.

Table. 10 Domain DSS04 Manage Continuity Recommendations

DSS04 MANAGE CONTINUITY			
CURRENT CONDITION	**VALUE**	**TARGET**	**RECOMMENDATION**
There is already a continuity plan but has no documentof what to do.	3,22	4	Createdocumentation and then monitor and analyze what things should be done.

5. CONCLUSIONS AND SUGGESTIONS

5.1. Conclusions

Based on the research conducted on Measurement of Performance of Academic Information System Governance in Indonesian Naval Academy from the result of IT Maturity Level, the conclusion of this research are:

a. From the results of the resulting maturity level is known that the level of maturity (as-is) for the APO (Align, Plan, and Organize) averaged average level (3 - Defined Process) means the process is at a fixed stage, has been in the implementation phase of standardized processes, meaning that there is a standard IT process that applies everywhere in the scope of the organization means that the Academic Information system in terms of strategic order is at a stable stage. While the Domain DSS (Deliver, Service, Support), the average level of maturity reach (Defined Process) which means also at a fixed stage means the agency has been running the task of the IT process and has achieved its goals in well managed through the stages of planning, evaluation and better tailored adjustments.

b. Every subdomain process in both domains is given improvement recommendation which later can affect the current maturity level to go to the level of improvement and to the maturity to be achieved below to improve the process of the performance of the institution towards the better.

c. Recommendation is based on COBIT level 5 and also refers to the function of Governance that ensures that IT process owned by agency really gives added value for organization, and Management.

5.2. Suggestions

The suggestions that can be submitted after this research is as follows:

a. Current condition of Information Technology and Information Systems in AAL is no alignment between one existing information system with other information systems, so it is expected that there is an alignment of information systems with information technology.

b. Development of Human Resources Competence SI / IT in the form of improving the quality of competence through education planning and training IT human resources both internally and externally of AAL organizations.

6. REFERENCES

Annwareen., 2008. *Information Technology in an Organization's Management..* s.l.:s.n.

Fröhlich, M. J. W. d. W., 2010. *IT-Assurance with CobiT, in Enterprise IT Governance, Business Value and Performance Measurement.* s.l.:N. Shi and G. Silvius, Editors..

García, V. V. D. E. J. F. V. .. D. L. U. A. .., 2013. Maturity Model for IT Service Outsourcing in Higher Education Institutions. Volume 4, No. 10.

Gerke, L. R. G., 2009. *Tailoring COBIT for Public Sector IT Audit : An Australian Case Study.* New York: IGI Global.

Grembergen, W. V. D. H., 2008. *T Governance Implementation Guide.* s.l.:ITGI.

ISACA, 2012. *COBIT 5 Introduction.* s.l.:s.n.

ISACA, 2012. *Enabling Process," in Control Objective for Information and Related Technology (COBIT 5).* USA: ISACA.

ISACA, .., 2012. *COBIT 5 : A Business Framework for the Governance and Management of Enterprise IT.* USA: ISACA.

ISACA., 2013. *: Introduction COBIT 5.* USA: ISACA.

IT Governance Institute, .., 2007. *COBIT 4.1.* s.l.:IT Governance Institute.

ITGI, 2003. *Board Briefing on IT Governance 2nd Edition.* s.l.:IT Governance.

Krisanthi, G. S. I. M. d. B., 2014. Governance Audit of Application Procurement Using COBIT Framework. Volume 59.

Nugroho, H. s., 2014. Conceptual Model of IT Governance for Higher Education Based on COBIT 5 Framework.. Volume 60.

Ramlaoui, S. d. S., 2014. Comparative study of COBIT with other IT Governance Frameworks.. Volume 11, hal. 95-101. .

Romuald Cwilewicz, .., 2003. The Development and Application of Computer-Based Training Programs in Maritime Engineering Education. 7 (2).

Ron Webber, .., 1999. *Information Systems Control and Audit.* s.l.: Prentice Hall.

Rosmiati, R. I., 2016. A Maturity Level Framework for Measurement of. Volume 141.

S.Elhasnaoui, H. M. A. S., 2013. Multi-agents modeling platform for IT governance based on ITIL.

Sadikin, M. H. H. d. H. W. H., 2014. IT Governance Self Assessment in Higher Education Based on COBIT Case Study: University of Mercu Buana..

Tanuwijaya, H. d. S. R. s., 2010. Comparation of CobiT Maturity Model and Structural Equation Model for Measuring the Alignment between University Academic Regulations and Information Technology Goals. Volume 10.

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PERFORMANCE ANALYSIS OF PROJECT THE MEDIUM REPAIR OF XXX BUILDING BY USING EVA AND CPM METHODS

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ABSTRACT

Scheduling on project implementation plan is necessary process to avoid delays in the completion of work and decline budget loss for contractors and users. Medium Repair implementation of The of XXX Building which has delay of completion can cost the contractor a penalty fine. Action should be taken to minimize the loss. This research purposed to determine contractor performance, predict time and budget and give solution if there are delayed work in implementation. This analysis using Critical Path Method (CPM) and Earned Value Analysis (EVA), combined with Crashing Project. EVA calculations analysis of the work give result that there will be delayed completion progress from scheduled 120 days stretch to 192 days. The contractor can gain loss reduction on amount of Rp. 41.148.869,- in the effect of delay from initial loss Rp. 130,329,288,- to Rp. 89,180,419,-.

KEYWORDS : CPM, EVA, crashing project, contractor performance

1. INTRODUCTION

Project scheduling is one element of project planning results. It can provide general information of project schedule and progress of resource usage performance that contain costs, labors, equipment, materials and project completion time. In the industrial world, especially in construction sector, a lot of projects implemented can't fulfil planned budget and scheduled time. It an indication there was errors in project management (Khamooshi & Golafshani, 2014). Delay is one of the biggest problems often experienced on construction project location (Iwawo, 2016). Delays can trigger negative impact as increased costs , lost productivity and income many lawsuits between the owner and contractor and cessation of contract (Owolabi, et al., 2014). In addition, the delay can decrease contractor reputation and affected opportunity loss in future. For user, the delay can cost idle time because postpone them to use the project result.

It found delay in implementation of Medium Repair on XXX Building**.** It need an action to analyze the delay factors and the predict impact caused by these problems. This analysis calculates estimation of time and cost for project completion, and provide solutions to minimize losses by contractors.

The purpose of this study are to find the factors that affect the delay of the implemented project, determine which factors give most influence on delay, estimate time and cost to finish the project, and decide action to be done in case to reduce losses caused from delayed project. The result of this research can use by contractor as suggestion for the next project to avoid delay.

Critical Path Method is one of Networking Methods used to determine the critical line of project should be taken to avoid idle time. Earned Value Analysis is a technique to analyze the schedule, costs, and project performance achieved periodically to help user predict the cost and time required to complete the project. Crashing Project is a method to shorten the project time by adding more resources to finish the important project activities.

Valle and Soares implemented study of Earned Value Analysis on an indoors amusement Monica Park, in Rio de Janeiro, Brazil (Valle & Soares, 2004). They reported that EVA had relevant role in the unified management of scope, time, progress, cost and project risk and procurement of major project supply and services.

This paper is organized as follows. Section 1 is introduction, section 2 literature review, section 3 further material and research methodology. In the fourth section is result and discussion, and last section is conclusion.

2. LITERATURE REVIEW

Building are a results physical of construction work that is fused to the domicile of good that was over , under the ground or on water (Ismael, 2013). The existence of a construction project is necessary to realize the building. Project activities are temporary with a limited timeframe and have a specific source of funding certain to implementing the tasks and target appointed. Three important goal of any project are time, cost and quality (Bindu, 2015) . The success of the construction process depends on the interconnection between the parties involved in the construction process in accordance with their respective roles. Three criteria to measuring the success of a building project should include categories of project management success, product success, and market success. (Al-Theemy, et al., 2011). To obtain a success in the project completion process must adhere to the triple constraint: time, cost and technical specifications as per specified specification (Larson & Gray, 2011)

S-Curve is a graph the relationship between the time of project implementation with the accumulated progress project from start to finish the project (Fatimah, et al., 2015). It explain the describing types and volume of work in units of time and ordinate the number of activities presentations on the time line. The project use s-curve for planning and monitoring schedule for implementing projects.

A graph or network is defined by two sets of symbols, they are nodes and arcs (Winston, 2004). The principle Network Planning is the relationship between work variables described in network diagrams. The function of network planning is:

a. Planning, scheduling, and control of overall activities.
b. It can make time, cost, and resources.
c. The project documentation.
d. To know the critical activities.
e. As a means of data communication, problems, and project goals.

Critical Path Method (CPM) is the basis for planning and control progress on the job based on network. Cpm is the order of elements network terminal project with a whole longest duration, determining shortest time to finish the project (Stelth, 2009). CPM was first developed by the Du Pont company in 1957 to build a chemical factory. They have the purpose of determining costs and timetable with intent work is scheduled to be resolved in a timely and proper costs. The CPM is ideally suited to projects consisting of numerous activities that interact in a complex manner. CPM is used for monitoring a project, many superintendents find CPM not practical for use (Shailla, 2014)

According to (Razdan, et al., 2017) the critical path method (CPM) is a step-by-step project management technique for process planning that determines critical and unimportant tasks with the goal of preventing the problem of time frames and process bottlenecks. CPM is ideal for projects that consist of various activities that interact in a complex way.

In the CPM known EET (Earliest Event Time) and LET (Last Event Time), Total Float, Free Float, and Float Interferen, EET is the earliest event or the fastest time of the event. LET is the last event or the slowest time of the event.

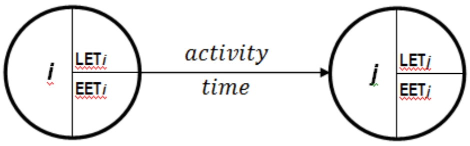


Fig. 1. EET and LET in an activity

Earned Value is a project management famous use information regarding costs, schedule and performance to define the current project status. Earned Value Analysis is the method industry standards of measuring a project's progress at any given point of time, foreseeing date of settlement and the final costs, analysing variances in the schedule and budget budget when the project had been running (Dubey, 2015). With some simple levels, it allows managers to estimate hot today to predict the likelihood of the final effect. This method is basically a simplified project, but it proves to be useful in cost control. It was developed to take into account the schedule and a great time (Czarnigowska, 2008).

The important variables in this methodology are: schedule, cost, work. The goal is an efficient project, which means completing a job on time by minimizing the cost or materials spent on the project. Costs always align with the work done but the work done is not always exactly the job scheduled. The solution is the control, measurement and costing of the budgeted from the work done and then compare this with the actual cost (Valle & Soares, 2004).

This technique is often used to find activities that cause delay in the project with as early as possible, so that the parties concerned can overcome the affecting the activity way of the project. Monitoring and measuring progress periodically aim to control project risk.

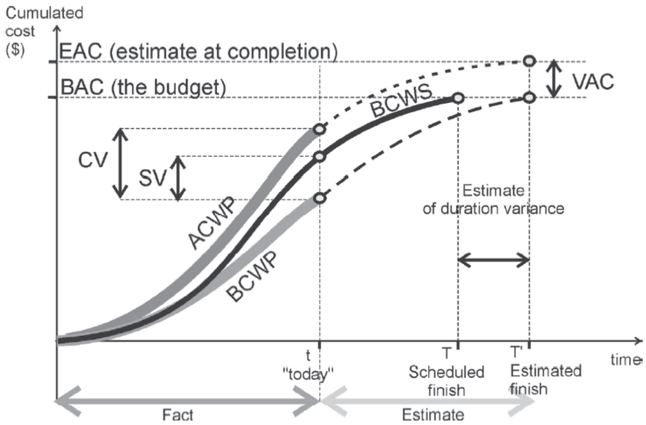


Fig. 2. Earned Value Curves

From the picture can be explained:

- BCWS – Budgeted Cost of Works Scheduled or Planned Value (PV) : basis for analysis, is a description of the cost link to the planned time.;
- BCWP – Budgeted Cost of Work PerformedI or Earned Value (EV) : The physical advancement by accumulated the budget is actually done with regard to time.
- ACWP – Actual Cost of Work Performed or Actual Cost (AC) : The accumulated actual costs paid for work related to time.
- BAC – Budget at Completion : the total planned cost of the entire project.
- T : The duration of the planned project

Crashing Project is a time acceleration to anticipate the delay of work if it happens.. Crashing project can be interpreted as project acceleration which reduction of the normal time activity. Acceleration is obtained by providing more resources for activities that will be reduced in time. In carrying out the time reduction calculated all the overall duration of the activity in order to optimize the working time at the lowest cost. The basic and proper crashing method is the manual method, where the activity is crashing every day. This method, while producing the correct results, takes time and requires repetitive effort and testing. This method needs the key data to perform. They are normal cost, normal time, crashing cost, and crushing time combined with the project network diagram (Georges, et al., 2014).

The cost estimate is made by humans and not by means, it is a tool used by analysts while a reliable expert system that can estimate costs is still unfounded. All estimates are based on comparisons based on the company's data base. To estimate the technical knowledge of the context, tools, products, technology and production tools used should be made because the handbook on the cost of allowing database-making related to its activity still does not exist. (Challal & Tkiouat, 2012). Analysis of cost estimates and project completion time can use the formula:

a. Estimate to Complete (ETC)

The ETC is a cost estimate for the remaining jobs in the review week. assuming that the project performance trends will remain the same until the end of the project. Estimates include:

1) Remnant work requires costs a budget.

2) The performance is the same until the end of the project

3) Mixed

The approach used combines both ways :

If the percentage of work under 50% uses the formula:

ETC = (Budget **– EV)**

EV = Earned Value (Rp)

If the percentage of work above 50% uses the formula:

ETC = (Total budget **– EV) / CPI**

CPI = Cost Performance Index

b. Estimate at Completion (EAC)

EAC is an estimate of the total cost of the total cost incurred from the commencement of work until the end of the project.

EAC = AC + ETC

AC = Actual Cost (Rp)

Crashing Project is a method to shorten the length of project time by reducing the time important project activities into less than normal time of activity (Ashok, et al., 2011). Crashing Project is an action to reduce the overall duration of the project after analyzing the existing alternatives (from networking). The aim to optimize working time with lowest cost. The usual manner used is the addition of working time, then the cost for labor will increase from the budget. Based on the Decree of the Minister of Manpower and Transmigration of the Republic of Indonesia Number KEP. 102 / MEN / VI / 2004 that the wages for employment additions is different, for the addition of the first hour work time, workers get an additional wage of 1,5 times the normal hourly wage, and for the addition of the next working time the worker gets 2 times the normal hourly wage.

The calculation of additional costs of workers can be formulated as follows (Syahrizal & Ridho:, 2014), namely:

Normal wages per day workers = Daily Productivity x Unit price of Worker's Wage

Normal hourly workers' wage = Productivity Per Hour x Unit Price of Workers' Wages

Overtime costs = (1.5 x Normal hourly wage for the first overtime) + (2 x n x normal hourly wage for overtime working hours).

Where n = the number of additional hours worked

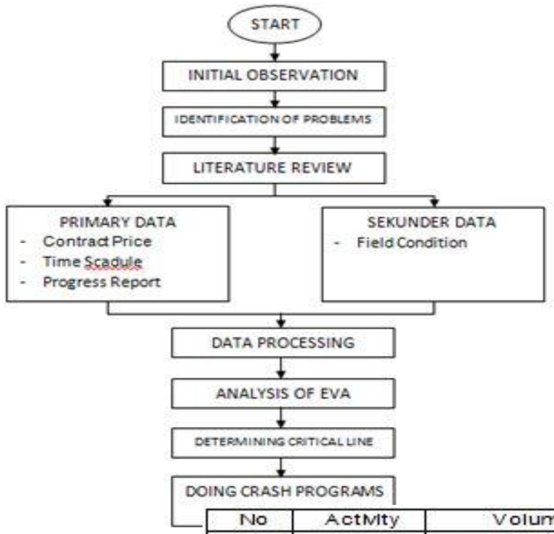
Crash Cost workers per day = (normal cost per day worker) + (n x hourly overtime fee)

Cost Slope (Added direct cost to speed up a time union activity)

$$= \frac{\text{crash cost} - \text{normal cost}}{\text{normal duration} - \text{crash duration}}$$

3. MATERIAL/METHODOLOGY

A scientific study requires a systematic framework in order to facilitate the research. The research framework should be arranged based on the issues reviewed. The research framework is expected to process and the results obtained in accordance with the desired goals. For more details the research methodology is shown in figure 2.



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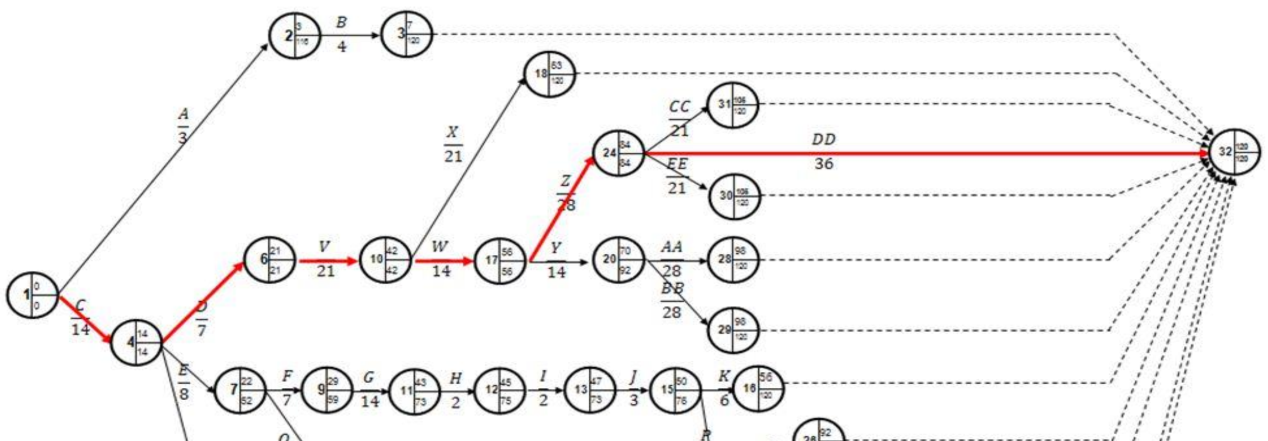
At this stage of the methodology, the data was collected in the form of primary data quantitative determenistik by direct review of the field . The necessary data are physical progress of work, spectacle, wage and material analysis and time schedulle. Based on data obtained in the field. Contract price of the medium repair of XXX building as follows table 1.

1. Contract Price

No	Activity	Volume		Unit Price	Total Price
1	A	1,600.00	m²	4,400	7,040,000
2	B	12.96	m²	725,000	9,396,000
3	C	2,135.10	m²	6,800	14,518,680
4	D	90.50	m	13,100	1,185,550
5	E	2,135.10	m²	26,700	57,007,170
6	F	2,135.10	m²	25,700	54,872,070
7	G	2,135.10	m²	84,700	180,842,970
8	H	45.25	m	66,750	3,020,438
9	I	8.00	bh	4,375,000	35,000,000
10	J	90.50	m	203,400	18,407,700
11	K	192.00	m²	100,800	19,353,600
12	L	960.00	m³	244,800	235,008,000
13	M	1,600.00	m²	2,800	4,480,000
14	N	320.00	m³	1,708,250	546,640,000
15	O	1.00	packet	21,138,900	21,138,900
16	P	2,135.10	m²	25,200	53,804,520
17	Q	256.00	m²	36,800	9,420,800
18	R	1,120.00	m²	30,800	34,496,000
19	S	960.00	m²	54,400	52,224,000
20	T	160.00	m²	36,800	5,888,000
21	U	1.00	packet	36,916,920	36,916,920
22	V	1.00	packet	43,345,000	43,345,000
23	W	1.00	packet	12,728,180	12,728,180
24	X	1.00	packet	27,054,870	27,054,870
25	Y	1.00	packet	26,233,746	26,233,746
26	Z	1.00	packet	45,200,480	45,200,480
27	AA	1.00	packet	18,319,200	18,319,200
28	BB	1.00	packet	26,338,200	26,338,200
29	CC	1.00	packet	9,111,050	9,111,050
30	DD	1.00	packet	13,736,800	13,736,800
31	EE	1.00	packet	22,843,000	22,843,000
	Amount				**1,645,571,844**
	PPN 10%				164,557,184
	Total				1,810,129,028

4. RESULT AND DISCUSSION

The data processing is used to analyze the contractor's performance in carrying out the medium repair of XXX building works. The initial steps are prepared in the implementation stage of work with Critical Path Methode (CPM). From the analysis obtained an initial trajectory and chart of activity with the time duration suittable with time schedulle. The path with the initial conditions can be seen in Figure 4.



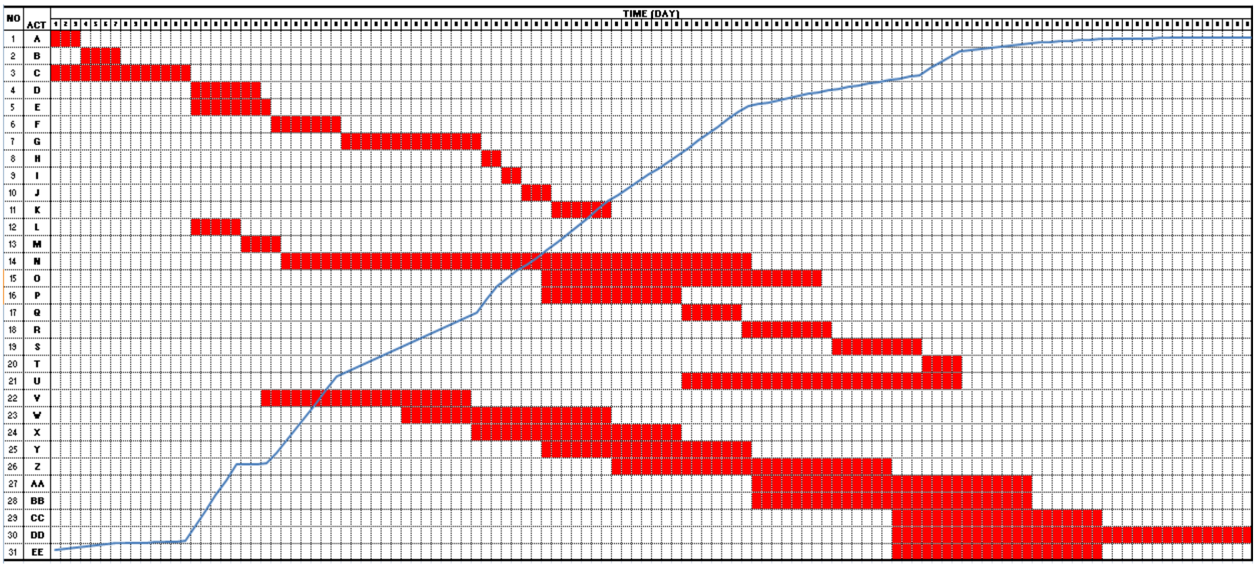


Fig 5. Project Schedule and S-Curve

Further analysis is using the method of earned value analisys (EVA). It will know project postponed or not. The solution used time acceleration (Crashing projectt) to reduce the losses experienced by the contractor. The calculation by EVA method is obtained from the 1st month up to the 4th month. In table 2 below.

Table 2. Earned Value Analisys 1st Month up to 4th h

PD = 120 Day	MONTH			
	1st	2nd	3rd	4th
PV	33.00%	69.00%	93.00%	100.00%
EV	23.25%	52.80%	71.93%	80.65%
SV = EV - PV	-9.75%	-16.20%	-21.07%	-19.35%
AT	30	60	90	120
SPI = EV/PV	70.45%	76.52%	77.34%	80.65%
ETD = PD/SPI	170 day	157 day	155 day	149 day
ETC = ETD-AT	140 day	97 day	65 day	29 day
ES	22 day	47 day	64 day	75 day
SV(t) = ES-AT	-8 day	-13 day	-26 day	-45 day
SPI(t) = ES / AT	73.33%	78.33%	71.11%	62.50%

ETD(t) = PD/SPI(t)	164 day	153 day	169 day	192 day
ETC(t) = ETD(t)-AT	134 day	93 day	79 day	72 day

Table 3. Calculating ES

I	-27.08%	55.00%	12.21%	49%
PVn(t)	30 day	30 day	60 day	60 day
PVn+1(t)	60 day	60 day	90 day	90 day
ES	22 day	47 day	64 day	75 day

PD = Planned Duration
PV = Plan Value
EV = Earned Value
SV = Schedule Variance (Cost Based)
AT = Actual Time
SPI = Schedule Performance Index (Cost Based)

ETD = Estimate Time Duration (Cost Based)
ETC = Estimation Time to Complate (Cost Based)
ES = Earned Schedule
SV(t) = Schedule Variance (Time Based)
SPI(t) = Schedule Performan Index (Time Based)
ETD(t) = Estimation Time Duration (Time Based)

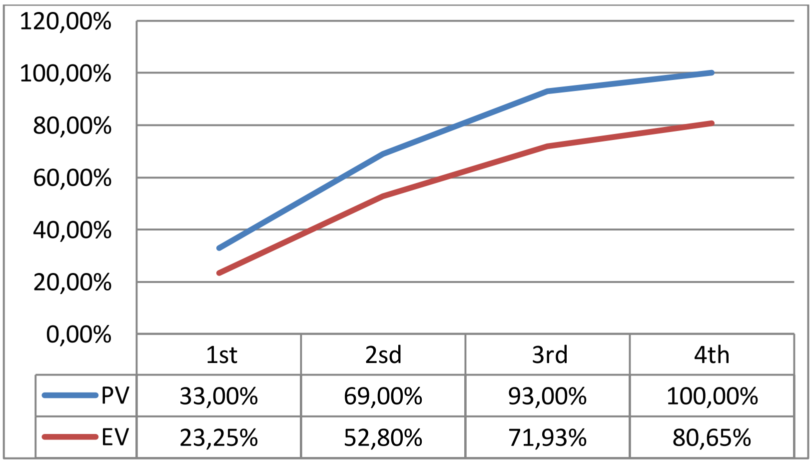


Fig. 6. PV and EV Graphics per Month

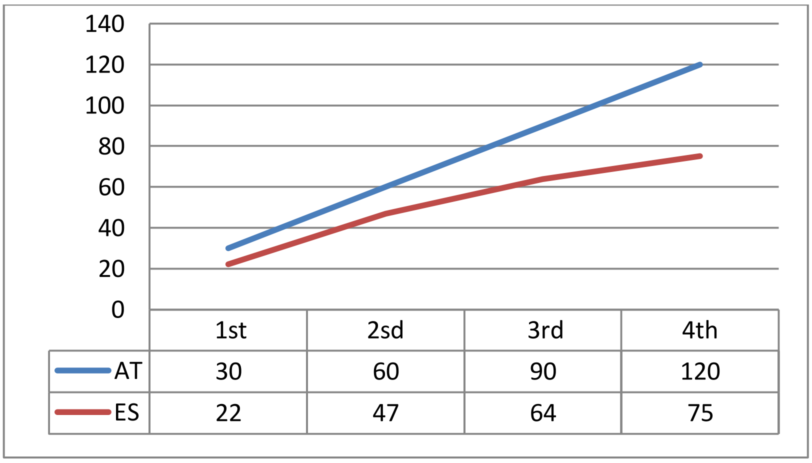


Fig. 7. AT and ES Graphics per Month

From data processing by earned value anlisys method are known that the medium repair of XXX Building experiencing delay from 120 to 192 days. So it is necessary to calculate the cost to complete project so that the contractor will not experience many losses.

Analysis of the costs completion of projects

Cost estimation.

Calculates the amount of ETC, EAC and TE that occur due to delays occurring.

***Estimate To Complete* (ETC)**

The ETC calculation at the end of the 4^{th} month is

ETC = Rp. 1.810.129.000 – 1.459.896.038,50 = Rp. 350.259.961,50

Estimate At Completion

The ETC calculation up to the completion of the project is :

EAC = Rp. 1.459.869.038,50 + Rp. 443.296.294,48 = Rp. 1.894.165.332,98

The fee does not include a fine of 1/1000 of the contract value (Perpres, 2010) amounting to Rp. 130.329.288,-.

If the cost estimates to complete the project is known, it need to find solutions for a big losses because delays including pay fines agreed in contract agreement. To overcome this is done crashing project. The assumptions used are:

a. Activities undertaken can be accelerated implementation.

b. The human resources is not an obstacle in project implementation

Based on the report that has been created by the contractor at the end of the 4^{th} month, the delays occurred include several activities.

Table 4 Accelerated cost of activities that have not been done

NODE	Weight	Day	Acceleration cost per day (RP)	Maximum Day of Acceleration
P	3.17%	14	2,220,504	10
Q	2.10%	6	621,227	4
S	0.36%	9	1,553,067	6
U	2.24%	28	405,663	20
X	1.66%	21	328,064	15
Y	1.59%	14	272,590	10
Z	2.75%	28	1,025,601	20
AA	1.11%	28	194,021	20
BB	1.60%	28	427,225	20
CC	0.55%	21	212,980	15
DD	0.83%	36	180,382	25
EE	1.39%	21	119,626	15
Total	19.35%			

From the data rescheduled activities that are not yet done. By determining critical path can be known activities that must be implemented on time so that project no delayed anymore.

With regard to the schedule, selected activities considered that are considered influential effective to reduce time. From the data of acceleration cost taken a few activities that can reduce the implementation time in accordance table 5.

Table 5 Accelerated cost of activities

NODE	Weight	Day	Acceleration cost per day (RP)	Maximum Day of Acceleration
P	14	2,220,504		
Q	6	621,227		
S	9	1,553,067		
U	28	405,663		
X	21	328,064		
Y	14	272,590		
Z	28	1,025,601	20	13,819,970
AA	28	194,021	20	2,614,439
BB	28	427,225	20	5,756,857
CC	21	212,980		
DD	36	180,382	25	3,125,122
EE	21	119,626		
Total				25,316,387

By implementing acceleration on the activities of Z, AA, BB, CC and EE, the contractor have to spend a budget of Rp. 139.981.151,-. for accelerate the estimated time of project implementation from 192 day to 165 day. While without accelerating the contractor have to spend budget of Rp. 130.446.408,-. So the loss budget must be incurred by the contractor can be calculated as follows :

a. Losses without overtime:

Cost = penalty per day x day of delay

= Rp. 1.810.129 per day x 72 day

= Rp. 130.329.288,-

b. Losses with overtime (crashing project) *:*

Cost = additional cost of crashing project + (penalty per day x day of delay)

= Rp. 9.534.743,- + (Rp. 1.810.129 per day x 45 day)

= Rp. 9.534.743,- + Rp. 79.645.676,-

= Rp. 89.180.419,-

So the losses of the contractor can be minimized for: :

= Cost Losses without overtime – Cost Losses with overtime

= Rp. 130.329.288,- – Rp. 89.180.419,-

= Rp. 41.148.869,-

5. CONCLUSION

From the results of data processing can be taken for the following conclusion:

a. When a critical path method is used in the planning of a project, information about activities that should be given special attention to avoid delays completion of projects.

b. The earned value analisys method is known the medium repair of XXX building has been delayed from schedule which the completion time of 120 days. It is exceeded from contract agreement with the estimate finished on 192 days.

c. Critical Part Method is used to preparation schedule which activity are not yet done, and the results combained with crashing project. Finally the time schedule can be minimized to 165 days from 192 days. Contractors can minimize losses to Rp. 89.180.419,- with minimize the time delay of the

REFERENCES

Al-Theemy, S. M. H. M., Abdul-Rahmad, H. & Harun, Z., 2011. Future criteria for success of building projects in Malaysia. *International Journal Of Project Management,* 29(3), pp. 337-438.

Ashok, M., Biswajit, S. & Jibitesh, M., 2011. Activity Crashing in Shutdown Maintenance Throught Qualitative Assessment. *Advances in Production Engineering & Management,* 6(4), pp. 239-248.

Bindu, D., 2015. Approach of Crashing Critical Activity (CCA) and Stretching Non-critical Activities (SNA) of Time Cost Trade off problem using Critical Part Method. *International Journal of Scientific and Research Publications,* 5(2), pp. 1-10.

Challal, A. & Tkiouat, M., 2012. The Design of Cost Estimating Model of Construction Project: Application and Simulation. *Open Journal of Accounting,* Volume 1, pp. 15-26.

Czarnigowska, A., 2008. Earned value method as a tool for project control. *Budownictwo i Architektura,* Volume 3, pp. 15-32.

D., O. J. et al., 2014. Cause and Effect of Delay on Project Construction Dilevery Time. *International Journal of Education and Research,* 2(4), pp. 197-208.

Dubey, A., 2015. Earned Value Analysis for a Construction Project. *International Journal of Civil Engineering and Technology,* 6(6), pp. 53-66.

Fatimah, S., Laongko, A. & Tombolotutu, M., 2015. Borda Application of selection Planning Scheduling Methode In Dock Engginering Consultans in Central Province Indonesia. *Role, Duties & Composition,* 11(1), pp. 131-136.

Georges, N., Semaan, N. & Rizk, J., 2014. Crash: An Automated Tool For Schedule Crushing. *International Journal of Science, Environment and Technology,* 3(2), p. 374 – 394.

Ismael, I., 2013. Delay building construction project the causes of and the act of prevention. *Jurnal of Momentum,* Volume 14, pp. 46-55.

Iwawo, E. R. M., 2016. Implementation of CPM Method on Construction Project (Case Study of New Building Building of Eaben Haezar Manado Complex. *Static Civil,* Volume 4, pp. 551-558.

Khamooshi, H. & Golafshani, H., 2014. EDM: Earned Duration Management, a new approach to schedule performance management and measurement. *International Journal of Project Management,* 32(6), pp. 1019-1041.

Larson, E. & Gray, C., 2011. *Project Management The Managerial Process.* s.l.:s.n.

Perpres, R. N. 5., 2010. *Tentang Pengadaan Barang dan Jasa Pemerintah.* Jakarta: Setpres.

Razdan, S. et al., 2017. Application of Critical Path Method for Project Scheduling – A Case Study. *Conference Paper.*

Shailla, 2014. Comparative Study of Management Operation System Techniques (MOST) and CPM in Construction Scheduling. *International Journal of Engineering Trends and Technology (IJETT),* 18 (8), pp. 371-379.

Stelth, P., 2009. Projects' Analysis through CPM (Critical Path Method). *School of Doctoral Studies (European Union) Journal,* pp. 10-51.

Syahrizal & Ridho:, M. R., 2014. *Evaluationof Time Schedule and Project Cost With PERT and CPM.* Medan: s.n.

Valle, J. A. & Soares, C. A. P., 2004. The Use of Earned Value Analysis (EVA) in The Cost Management of Construction Projects.

Winston, W. L., 2004. *Operations Research Aplications and Algoritms.* 4 penyunt. s.l.:Thomson Brooks/Cole.