Selection anti submarine sensor of helicopter using ELECTRE III method

Article *in* International Journal of Applied Engineering Research · January 2017

4 authors, including:

O.s. Suharyo
Sekolah Tinggi Teknologi Angkatan Laut STTAL

April Kukuh Susilo
Sekolah Tinggi Teknologi Angkatan Laut Surabaya

International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 9 (2017) pp. 1974-1981

Selection Anti Submarine Sensor of Helicopter Using ELECTRE III Method

Ahmadi[1], Siswo H. Sumantri [2], Okol S. Suharyo [3] and A. Kukuh Susilo[4]

[1]*Indonesian Naval Technology College, STTAL.*
Bumimoro-Morokrembangan, Surabaya 60187, Indonesia.

[1]*ORCID: 0000-0002-2859-3165,* [2]*ORCID:0000-0002-4456-5279,*
[3]*ORCID:0000-0003-4766-6662* [4]*ORCID:0000-0002-7012-7520*

Abstract

Indonesian Navy (TNI AL) is one of them component for Maritime Security and Defence in activities of warfare alert, basic training and operation at sea. It needs air power to support and covered sea power. Indonesian Naval Aviation as airpower will receive 11 helicopters to carry function about anti surface ship and submarine. The Helicopters needs sensor equipment to detect the submarine likes Magnetic Anomaly Detector (MAD), Sonobuoy, dan Dipping Sonar. The purpose this paper is giving alternatives for sensor equipments anti submarine in Helicopters at Indonesian Naval Aviation. For gives alternative sensor equipment, this paper used ELECTRE Methode in decision making. The result of choiced sensor equipment with type of dipping sonar, according the best rank is HELRAS DS 100, FLASH-S, AN/AQS-22 ALFS, VGS-3 dan AQS-18A. Alternative 1 dipping sonar sensor L3 Comm Helras DS 100 has 1 for value toward alternative 4, with 0,99 toward alternative A3, with 0,95 toward alternative A5 and 0,86 toward alternative A2. It result by compared with Concordance Global, alternative A1 has highest rank toward all alternatives. Alternative A3 (AN/AQS-22 ALFS) has 1 for Condordance Global value toward alternative A2 and A1, alternative A3 has 0,93 for Concordance Global value toward alternative A1, toward alternative A2 is 0,89 and alternative A5 is 0,94. So that, alternative A3 is second choiced.

Keyword: Anti Submarine, Helicopter, Dipping Sonar, ELECTRE Method.

INTRODUCTION

Today's, market for submarines over the coming decade is projected to exceed one hundred vessels of all types and more than half of these are destined for the Asia-Pacific region (1). Many countries develop their sea power with ability of submarine in the battle formation. To secure about battlespace from undersea threats by swiftly destroying enemy submarines, many countries needs Anti submarine operations (2).

Anti submarine warfare is handled by specialised ship equipped with low frequency long-range sonars and by helicopters with dipping sonar, the quality of performance depends largely on the efficiency and quality of sonar (3).

Indonesian Navy (TNI AL) is one of them component for Maritime Security and Defence in activities of warfare alert, basic training and operation at sea. For defence power, TNI AL needs air power to support and covered sea power. Because of these challenge in the Indonesia underwater region from border line, development of anti submarine warfare ability is response from TNI AL to counter and protect maritime area.

Indonesian Naval Aviation apart from Navy as airpower will receive 11 helicopters to carry function about anti surface ship and submarine. The Helicopters needs sensor equipment to detect the submarine likes *Magnetic Anomaly Detector (MAD), Sonobuoy, and Dipping Sonar*. Dipping sonar system have many criteria sensor equipment for helicopters. It needs decision making system to suitable choice for their option, one of ways is used Multi Criteria Decision Making (MCDM).

MCDM is the decision-making technique by considering some alternative option (4). MCDM approach handles both quantitative and qualitative choices and is able to combine the historical data and expert opinion by quantifying subjective judgement (5). There are two kinds of categories of MCDM, namely Multiple Objective Decision Making (MODM) and Multiple Attribute Decision Making (MADM) (4).

MADM can be defined as decision aids to help a decision maker identify the best alternatives that maximize his satisfaction with respect to more than one attribute (6). It can be solved by several method such as AHP, DEX, Macbeth, Pragma, SAW, Promethee, Topsis and ELECTRE (7).

This paper presents about alternatives for sensor of anti submarine in Helicopters at Indonesian Naval Aviation. To gives alternative sensor, this paper used ELECTRE Methode in decision making. The benefit is giving information and literature for Indonesian Naval Aviation in best decision making of anti submarine sensor procurement. Scope of paper is Dipping sonar for helicopter, decision making with ELECTRE III method.

This paper has many literature to support it, such as literatur about Anti submarine warfare, MCDM, MADM and ELECTRE Method. Literature of paper about Anti Submarine warfare likes Anti Submarine Warfare (ASW) Capability Transformation : Strategy of Response to Effect Based Warfare (2). Implementation of Contemporary technologies in The Modernisation of Naval Sonars (3). Under The Sea Air Gap : Australia's anti-submarine warfare challenge (1).

Paper literature explained about MCDM and MADM likes ELECTRE Methods in Solving Group Decision Support System Bioinformatics on Gene Mutation Detection Simulation (4). Hearing thresholds of a harbor porpoise

(Phocoena phocoena) for helicopter dipping sonar signals (1.43–1.33 kHz) (8). Applications of Multi-criteria Decision Making in Software Engineering (5). Selection of Cutting Tool Insert in Turning of EN 8 Steel using Multiple Attribute Decision (6). Reducing of Inconsistent Data Using Fuzzy Multi Attribute Decision Making for Accessing Data from Database (9). Land Suitability Analysis using Multi Attribute Decision Making Approach (10). Application of the Multi Criteria Decision Making Methods for Project Selection (11). Applications of Multi-criteria Decision Making in Software Engineering (5). A Qualitative Multi-Attribute Model for the Selection of the Private Hydropower Plant Investments in Turkey: By Foundation of the Search Results Clustering Engine, Hydropower Plant Clustering, DEXi and DEXiTree (7). Application of Multi-Attribute Decision Making Approach to Learning Management Systems Evaluation (12). A Multiple Attribute Decision Making Method Based on Uncertain Linguistic Heronian Mean (13). Applications and Modelling Using Multi-Attribute Decision Making to Rank Terrorist Threats (14). Research on the Multi-attribute Decision Making Model Based on the Possible Regret Degree of the Policy-maker (15). Multi Attribute Decision Making Techniques (16). Multi-attribute and Multi-criteria Decision Making Model for technology selection using fuzzy logic (17). A Multiple Attribute Decision Making for Improving Information Security Control Assessment (18). Comparison of Multi Criteria Decision Making Methods From The Maintenance Alternative Selection Perspective (19).

Some paper literature about ELECTRE method likes Application of ELECTRE Method for Sub-Contractor Selection using Interval-Valued Fuzzy Sets - Case Study (20). ELECTRE Methods in Solving Group Decision Support System Bioinformatics on Gene Mutation Detection Simulation (4). A Comprehensive Solution to Automated Inspection Device Selection Problem Using ELECTRE Method (21). The development and application of multi-criteria decision-making tool with consideration of uncertainty: The selection of a management strategy for the bio-degradable fraction in the municipal solid waste (22). Multiple Criteria Outranking Algorithm: Implementation and Computational Tests (23). Development of a Fuzzy Multi-Criteria Decision Support System for Municipal Solid Waste Management (24). Logistic Center Location : Selection using Multicriteria Decision Making (25). Hierarchical outranking methods for multi-criteria decision aiding (26). ELECTRE III as a Support for Partcipatory Decision-Making on the Localisation of Waste-treatment Plants (27). Selecting the Best Project Using the Fuzzy ELECTRE Method (28). A user-oriented implementation of the ELECTRE III method integrating preference elicitation support (29). ELECTRE I Decision Model of Reliability Design Scheme for Computer NUmerical Control Machine (30). An improved ranking method for ELECTRE III (31)

This paper is organized as follows : section 2 describes ELECTRE III method, flowchart diagram and data collecting. Section 3 explaines the result and discussion of this paper. Section 4 present about conclusion this paper.

MATERIAL & METHODOLOGY

Flowchart Diagram:

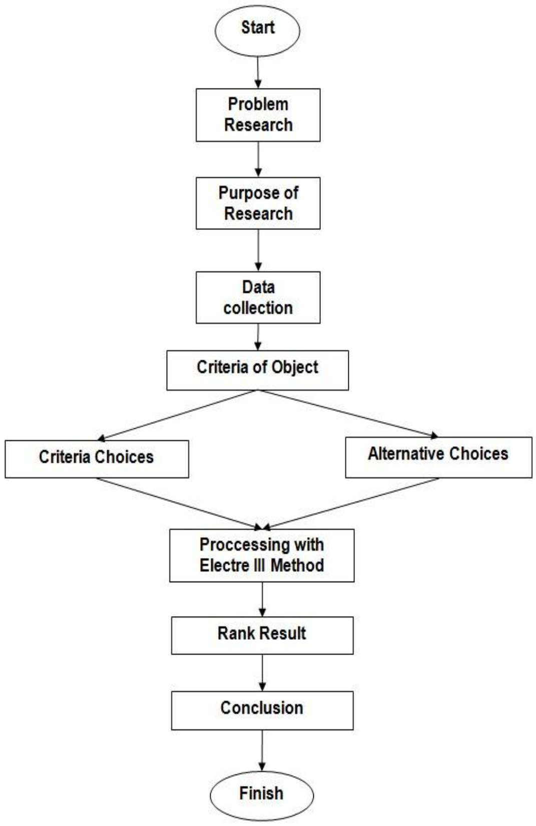

Figure 1. flowchart Diagram

ELECTRE Method:

ELECTRE was envisage by Bernard Roy (1991) to overcome some deficiencies of popularly used MCDM tools to deal with ordinal attributes without the need for transforming them into cardina values (21). ELECTRE (Elimination Et Choix Traduisant He realite) is based on the concept of ranking by paired comparison between alternatives on the appropriate criteria (4). An alternative is said to dominate th other alternatives if one or more criteria are met (compared with the criterion of other alternatives) and it is equal to the remaining criteria (4). A characteristic features of ELECTRE is the use of an outranking relation for the representation of decision maker's preferences (32). An advantage of using complementary ELECTRE is that the tradeoff among attributes is compensatory (24). The variants of the ELECTRE Method, namely ELECTRE II,IS,III,IV and TRI can be suitably applied in choosing the most efficien alternative that account for both the decision maker's intervention and other technical elements (21). ELECTRE methods establish a realistic representation of four basic situations of preference : indifference, weak preference, strict preference and incomparability (26).

The strenghts of ELECTRE methods include the following (26) :

a. ELECTRE methods are able to take into account the qualitative nature of some criteria, allowing the DM to consider the original data directly, without the need to make transformations into arti_cial numerical scales.
b. ELECTRE methods can deal with heterogeneous criteria scales, preserving the original scores of the alternatives on each criterion coded in an ordinal scale or a \weak" interval scale, without the need for nornamlization techniques or the assessment of a value function.
c. ELECTRE follows a the non-compensatory character in the aggregation.
d. ELECTRE methods incorporate the notion of incomparability between a pair of alternatives, referring to the case where one option is better that the other in some criteria and simultaneously is worse in other criteria, making impossible the establishment of a preference relation between them.

The main weaknesses of ELECTRE methods are as follows (26) :

a. When the aim is to calculate an overall score for each alternative, ELECTRE methods are not suitable and other scoring methods should be applied.
b. When all the criteria are quantitative, it is better to apply another method, unless we are dealing with imperfect knowledge or a non-compensatory process should be taken into account.

ELECTRE III Method.

ELECTRE III method was chosen from the different ELECTRE family methods, mainly in relation to the imprecision and uncertainty of some available data, and was explained to the commission in its overall logic (27). ELECTRE III method was chosen because it allows the use of inaccurate, indefinite, imprecise and uncertain data (25). ELECTRE III method follows the two outranking steps: first, the construction of an outranking relation over all the possible pairs of alternative ; second, the exploitation of this outranking relation to solve the ranking decision problem (26). In order to construct a outranking relation in the ELECTRE III method, three different threshold values, namely undifferentiated threshold (qj), strict superior threshold (pj) and rejection threshold (vj) are first introduced (21).

The evaluation procedures of the ELECTRE III method model encompass the establishment of a threshold function, disclosure of concordance and discordance indices, determination of credibility degree, and the ranking of the alternatives (33).

If g(a) ≥ g(b), then

$$g(a) > g(b) + p(g(b)) \Leftrightarrow aPb \qquad (1)$$

$$g(b) + q(g(b)) < g(a) < g(b) + p(g(b)) \Leftrightarrow aQb \qquad (2)$$

$$g(b) < g(a) < g(b) + q(g(b)) \Leftrightarrow aIb \qquad (3)$$

preference, *I* denotes indifference, and $g(a)$ is the criterion value of the alternative *a* (33).

The steps of ELECTRE III and calculations are presented below (33).

a. Step 1.

The The concordance index c(*a*, *b*) is computed for each pair of alternatives :

$$\mathrm{c(a, b\,)} = \frac{\mathrm{a}}{\mathrm{w}} \sum_{\mathrm{i=1}}^{\mathrm{m}} w_i\, c_i\,(\mathrm{a,b}) \text{ and } \mathrm{W} = \sum_{\mathrm{i=1}}^{\mathrm{m}} c_i \qquad (4)$$

Where $c_i(a, b)$ is the outranking degree of the alternative *a* and the alternative *b* under the criterion *i*, and

$$c_i(a,b) = \begin{cases} 0 & \text{if } g_i(b) - g_i(a) > p_i(g_i(a)) \\ 1 & \text{if } g_i(b) - g_i(a) \le q_i(g_i(a)) \\ & \frac{p_i + g_i(a) - g_i(b)}{p_i - q_i}\, otherwise \end{cases} \qquad (5)$$

Thus, $0 \le C_i(a,b) \le 1$,

The veto threshold $v_i(g_i(b))$ is defined for each criterion i as follows (33):

$$v_i\big(g_i(b)\big) = \alpha_v + \beta_v g_i(\mathrm{a}) \qquad (6)$$

The veto threshold, *vi*, allows for the possibility of a**S**b to be refused totally if, for any one criterion j. $g_i(b) > g_i(\mathrm{a}) + v_i$.

b. Step 2.

The discordance index *d*(*a*, *b*) for each criterion is then defined as follows (33):

Thus, $0 \le d_i(a,b) \le 1$,

$$c_i(a,b) = \begin{cases} 0 & \text{if } g_i(b) - g_i(a) \le p_i(g_i(a)) \\ 1 & \text{if } g_i(b) - g_i(a) > v_i(g_i(a)) \\ & \frac{g_i(b) - g_i(a) - p_i}{v_i - p_i}\, otherwise \end{cases} \qquad (7)$$

International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 9 (2017) pp. 1974-1981

c. Step 3.

Finally, the degree of outranking is defined by S(a,b) (33) :

$$S(a,b) = \begin{cases} \text{c(a, b) if } d_i(a,b) \leq \text{ c}(a,b)\ \forall \text{ j} \in \text{J} \\ \text{c(a, b) x } \prod_{j \in j(a,b)} \frac{1 - d_i\,(a,b)}{1 - c\,(a,b)} \quad otherwise \end{cases} \quad (8)$$

Where $J(a, b)$ is the set of criteria for which $d_j(a, b) > c(a, b)$

d. Step 4.

To obtain the complete ranking of the alternatives, the normal ranking method of ELECTRE III uses a structured al-gorithm via two intermediate ranking procedures: one is descending, where the alternatives are classified from the best to the worst (descending distillation), while the other is based on the ascending order from the worst to the best alternative (ascending distillation) (33).

A new ranking method based on the introduction of three concepts, including the concordance credibility degree, the discordance credibility degree and the net credibility degree (31).

1) The concordance credibility degree is defined by

$$\varphi + (x_i) = \sum_{x_j \in X} S\left(x_i, x_j\right),\ \forall x_i \in \text{X} \qquad (9)$$

The concordance credibility degree is a measure of the outranking character of x_i (showing how x_i dominates all the other alternatives of X).

2) The discordance credibility degree is defined by

$$\varphi^{-} + (x_i) = \sum_{x_j \in X} S\left(x_i, x_j\right),\ \forall x_i \in \text{X} \qquad (10)$$

The discordance credibility degree describes the outranked x_j (showing how x_j is dominated by all the other alternatives of X).

3) The net credibility degree is defined by

$$\varphi(x_i) = \varphi^{+}(x_i) - \varphi^{-}(x_i),\ \forall x_i \in \text{X} \qquad (11)$$

The net credibility degree represents the value function, where a higher value reflects higher attractiveness of the alternative x_i. Then, all the alternatives can be completely ranked by the net credibility degree.

Data Collection:

a. Sonar with type Helicopter Long Range Active Sonar (HELRAS) DS-100 from L-3 Communication, United State.
b. Sonar with type FLASH-S from Thales Underwater System, French.
c. Sonar with type AN/AQS 22 ALFS from Raytheon Integrated Defence System, United State.
d. Sonar with type AN/AQS 18 from L-3 Communication, United State.
e. Sonar with type VGS-3 Foal Tail from Rosonboronexport, Russian.

RESULT AND DISCUSSION

Result:

The result of choiced sensor equipment with type of dipping sonar, according the best rank is HELRAS DS 100, FLASH-S, AN/AQS-22 ALFS, VGS-3 dan AQS-18A. Alternative 1 dipping sonar sensor L3 Comm Helras DS 100 has 1 for value toward alternative 4, with 0,99 toward alternative A3, with 0,95 toward alternative A5 and 0,86 toward alternative A2. It result by compared with Concordance Global, alternative A1 has highest rank toward all alternatives. Alternative A3 (AN/AQS-22 ALFS) has 1 for Condordance Global value toward alternative A2 and A1, alternative A3 has 0,93 for Concordance Global value toward alternative A1, toward alternative A2 is 0,89 and alternative A5 is 0,94. So that alternative A3 is second choices.

Table 1. Result Of Sensor Selection

No	Sensor Name	Code	Ranking
1	*Helicopter Long Range Active Sonar (HELRAS)* DS-100	A 1	1
2	*Folding Light Acoustic System for Helicopters (FLASH) S*	A 2	2
3	ALFS *(Airborne Low Frequency Sonar)* AN/AQS 22	A3	3
4	VGS-3 *FoalTail*	A 5	4
5	AN/AQS 18	A 4	5

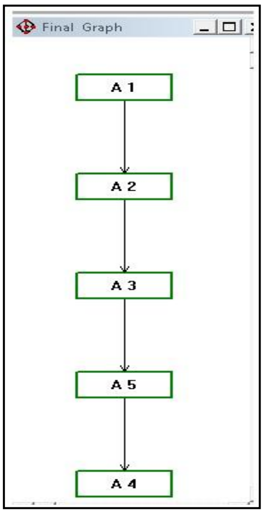

Figure 2. Result Of Sensor Selection

DISCUSSION

Assessment of each alternative in each criteria based from primer data (qualitative) in form of questionnaire to respondens from expert and quantitaive daat from references, technical specification of equipment from factory. Criteria Classification shows in table 2.

Table 2. Classification of Crtiteria

No	Criteria	Code	Data Clasification
1	Operational Depth	K1	Quantitative
2	Operational Mode	K2	Quantitative
3	Ability of Active Transmition	K3	Quantitative
4	Ability of Passive Receive	K4	Quantitative
5	Total of Target Tracked	K5	Quantitative
6	Overall Weight	K6	Quantitative
7	Readiness of Crew	K7	Qualitative
8	Readiness of Equipment	K8	Qualitative
9	Readiness of Support system	K9	Qualitative
10	Utilization of Local Component	K10	Qualitative
11	Prospect for Tansfer of Technology	K11	Qualitative
12	The First Purchase Costs	K12	Quantitative
13	Operational Costs	K13	Quantitative
14	Logistic Support	K14	Qualitative
15	Ease of Maintenance	K15	Qualitative
16	Reliability	K16	Qualitative

Table 3. Payoff Matrix

No	Criteria	Code	Alternative					
			A1	A2	A3	A4	A5	Units
1	Operational Depth	K1	500	750	777	290	500	Metre
2	Operational Mode	K2	3	3	5	3	3	Each
3	Ability of Active Transmition	K3	90	50	90	100	40	Nm
4	Ability of Passive Receive	K4	200	180	200	220	140	Nm
5	Total of Target Tracked	K5	10	10	8	6	8	Each
6	Overall Weight	K6	500	480	380	450	550	Kg
7	Readiness of Crew	K7	0,208633	0,194245	0,208633	0,208633	0,179856	-
8	Readiness of Equipment	K8	0,214815	0,192593	0,207407	0,207407	0,177778	-
9	Readiness of Support system	K9	0,210191	0,191083	0,210191	0,210191	0,178344	-
10	Utilization of Local Component	K10	0,222222	0,222222	0,177778	0,177778	0,2	-
11	Prospect for Tansfer of Technology	K11	0,188679	0,245283	0,188679	0,188679	0,188679	-
12	The First Purchase Costs	K12	4,2	4	4,1	4,5	3,9	$ (Million)
13	Operational Costs	K13	0,42	0,4	0,41	0,45	0,39	$ (Million)
14	Logistic Support	K14	0,209877	0,197531	0,209877	0,209877	0,17284	-
15	Ease of Maintenance	K15	0,246667	0,206667	0,24	0,2	0,106667	-
16	Reliability	K16	0,19883	0,204678	0,19883	0,19883	0,19883	-

In Rank of ELECTRE III method, to determine threshold value is based to compared in each criterion alternative. Threshold value have three part *indefference threshold* (q_j), *veto threshold* (v_j) dan *preference threshold* (p_j). Threshold value showed in table 4.

Table 4. Threshold Value of Each Criteria

No	Criteria	Code	q	p	v
1	Operational Depth	K1	162,333	324,667	487
2	Operational Mode	K2	0,66667	1,33333	2
3	Ability of Active Transmition	K3	20	40	60
4	Ability of Passive Receive	K4	2.666.667	5.333.333	80
5	Total of Target Tracked	K5	1.333.333	2.666.667	4
6	Overall Weight	K6	5.666.667	1.133.333	170
7	Readiness of Crew	K7	0,00959	0,01918	0,02878
8	Readiness of Equipment	K8	0,01235	0,02469	0,03704
9	Readiness of Support system	K9	0,01062	0,02123	0,03185
10	Utilization of Local Component	K10	0,01481	0,02963	0,04444
11	Prospect for Tansfer of Technology	K11	0,01887	0,03774	0,0566
12	The First Purchase Costs	K12	0,2	0,4	0,6
13	Operational Costs	K13	0,02	0,04	0,06
14	Logistic Support	K14	0,01235	0,02469	0,03704
15	Ease of Maintenance	K15	0,03111	0,06222	0,09333
16	Reliability	K16	0,00195	0,0039	0,00585

The table 5 showed that concordance value if global concordance index= 1, then alternative j absolute or more preferred than k in all criterion. If global concordance index site between 0 and 1, it has value almost 1 that is alternative j more preferred than k in all criterion and vice versa.

Table 6. Value Of Ranking Matrix

	A 1	A 2	A 3	A 4	A 5
A 1	I	P	P	P	P
A 2	P^-	I	P	P	P
A 3	P^-	P^-	I	P	P
A 4	P^-	P^-	P^-	I	P^-
A 5	P^-	P^-	P^-	P	I

Table 5. Value of Concordance Global

	A 1	A 2	A 3	A 4	A 5
A 1	1	0.863	0.99	1	0.95
A 2	0.727	1	0.727	0.778	0.987
A 3	0.933	0.889	1	1	0.937
A 4	0.831	0.846	0.898	1	0.937
A 5	0.714	0.627	0.727	0.727	1

Result from ranking matrix showed that I is alternative j and k indifference, that mean both of alternative must be choiced. P showed that alternative j more preferred than k, and alternative P^- more preferred than j.

CONCLUSION

The result of choiced sensor equipment with type of dipping sonar, according the best rank is HELRAS DS 100, FLASH-S, AN/AQS-22 ALFS, VGS-3 dan AQS-18A. Alternative 1 dipping sonar sensor L3 Comm Helras DS 100 has 1 for value toward alternative 4, with 0,99 toward alternative A3, with 0,95 toward alternative A5 and 0,86 toward alternative A2. It result by compared with Concordance Global, alternative A1 has highest rank toward all alternatives. Alternative A3 (AN/AQS-22 ALFS) has 1 for Condordance Global value toward alternative A2 and A1, alternative A3 has 0,93 for Concordance Global value toward alternative A1, toward alternative A2 is 0,89 and alternative A5 is 0,94. So that alternative A3 is second choices.

ACKNOWLEDGMENT

This research has been supported by Indonesia Naval Technology College (Sekolah Tinggi Teknologi Angkatan Laut/STTAL).

REFERENCES

[1] Pacey, Brice. Under The Sea Air Gap : Australia's anti-submarine warfare challenge. Canberra : Kokoda Foundation, 2011.

[2] Anti Submarine Warfare (ASW) Capability Transformation : Strategy of Response to Effect Based WArfare. Finch, David P. 2009, ICCRTS.

[3] Marszal, Jacek. Implementation of Contemporary technologies in The Modernisation of Naval Sonars. Poland : Gdansk University of Technology, 2014.

[4] Electre Methods in Solving Group Decision Support System Bioinformatics on Gene Mutation Detection Simulation. Ermatita, et al. 2011, International Journal of Computer Science & Information Technology (IJCSIT), hal. 40-52.

[5] Applications of Multi-criteria Decision Making in Software Engineering. Sehra, Sumeet, Brar, Yadwinder dan Kaur, Navdeep. s.l. : International Journal of Advanced Computer Science and Applications, 2016.

[6] Selection of Cutting Tool Insert in Turning of EN 8 Steel using Multiple Attribute Decision. K.G.Nikam dan S.S.Kadam. 2014, International Journal of Engineering Sciences & Research Technology, hal. 109-115.

[7] A Qualitative Multi-Attribute Model for the Selection of the Private Hydropower Plant Investments in Turkey: By Foundation of the Search Results Clustering Engine (Carrot2), Hydropower Plant Clustering, DEXi and DEXiTree. Saracoglu, Burak O. 2016, Journal of Industrial Engineering and Management, hal. 152-178.

[8] Hearing thresholds of a harbor porpoise (Phocoena phocoena) for helicopter dipping sonar signals (1.43–1.33 kHz) . Kasteleina, Ronald A. dan Hoek, Lean. 2011, The Journal of the Acoustical Society of America, hal. 679-682.

[9] Reducing of Inconsistent Data Using Fuzzy Multi Attribute Decision Making for Accessing Data from Database. Yusof, Mohd Kamir, Rahman, M. Nordin M dan Azlan, Atiqah. 2013, International Journal of Database Theory and Application.

[10] Land Suitability Analysis using Multi Attribute Decision Making Approach. Sudabe Jafar, Narges Zaredar. 2010, International Journal of Environmental Science and Development.

[11] Application of the Multi Criteria Decision Making Methods for Project Selection. Pangsri, Prapawan. 2015, Universal Journal of Management, hal. 15-20.

[12] Application of Multi-Attribute Decision Making Approach to Learning Management Systems Evaluation. Tanja Arh, Borka Jerman Blažič. 2007, Journal of Computers .

[13] A Multiple Attribute Decision Making Method Based on Uncertain Linguistic Heronian Mean. Xiaodi Liu,

Jianjun Zhu, Guodong Liu,Jingjing Hao. 2013, Hindawi Publishing Corporation.

[14] Applications and Modelling Using Multi-Attribute Decision Making to Rank Terrorist Threats. Fox, William P. 2016, Journal of Socialomics.

[15] Research on the Multi-attribute Decision Making Model Based on the Possible Regret Degree of the Policy-maker. Weibing, Peng. 2012, Journal of Computers.

[16] Multi Attribute Decision Making Techniques. Sharma, Manoj. 2013, International Journal of Research in Management, Science & Technology.

[17] Multi-attribute and Multi-criteria Decision Making Model for technology selection using fuzzy logic. Kalbande, Dhananjay R. dan G.T.Thampi. 2009, International Journal of Computing Science and Communication Technologies.

[18] A Multiple Attribute Decision Making for Improving Information Security Control Assessment . Nadher Al-Safwani, Suhaidi Hassan, Norliza Katuk. 2014, International Journal of Computer Applications.

[19] Comparison of Multi Criteria Decision Making Methods From The Maintenance Alternative Selection Perspective. Thor, Jureen, Ding, Siew-Hong dan Kamaruddin, Shahrul. 2013, The International Journal Of Engineering And Science, hal. 27-34.

[20] Application of Electre Method for Sub-Contractor Selection using Interval-Valued Fuzzy Sets - Case Study. Hassan Hadipour, Roozbeh Azizmohammadi, Abbas Mahmoudabadi, Mohammad Khoshnoud. Bali : s.n., 2014. International Conference on Industrial Engineering and Operations Management.

[21] A Comprehensive Solution to Automated Inspection Device Selection Problem Using Electre Method. Chatterjee, Prasenjit, Mondal, Suprakash dan Chakraborty, Shankar. 2014, International Journal of Technology, hal. 193-208.

[22] The development and application of multi-criteria decision-making tool with consideration of uncertainty: The selection of a management strategy for the bio-degradable fraction in the municipal solid waste. Ali El Hanandeh, Abbas El-Zein. 2009, Elsevier.

[23] Azziz, Mohamed Bou-Hamdan. Multiple Criteria Outranking Algorithm: Implementation and Computational Tests. Lisbon : s.n., 2015.

[24] Cheng, Steven KwokYam. Development of a Fuzzy Multi-Criteria Decision Support System for Municipal Solid Waste Management. Regina : University of Regina, 2000.

[25] Fagarasan, Maria dan Cristea, Ciprian. Logistic Center Location : Selection using Multicriteria Decision Making. s.l. : Annals of the Oradea university, 2015.

[26] Terrientes, Luis Miguel Del Vasto. Hierarchical outranking methods for multi-criteria decision aiding. Tarragona : Universitat Rovira Virgili, 2015.

[27] Electre III as a Support for Partcipatory Decision-Making on the Localisation of Waste-treatment Plants. Norese, Maria Franca. 2006, Elsevier, hal. 76-85.

[28] Selecting the Best Project Using the Fuzzy Electre Method. Babak Daneshvar Rouyendegh, Serpil Erol. 2012, Hindawi Publishing Corporation.

[29] A user-oriented implementation of the Electre III method integrating preference elicitation support. Mousseau, V., Slowinski, R. dan Zielniewicz, P. 2000, Elsevier, hal. 757-777.

[30] Electre I Decision Model of Reliability Design Scheme for Computer NUmerical Control Machine. Pang, Jihon, Zhang, Genbao dan Chen, Guohua. 2011, Journal of Software .

[31] An improved ranking method for ELECTRE III. Li, H.F. dan Wang, J.J. 2008. nternational Conferenceon Wireless Communications, Networking and Mobile Computing. hal. 766-776.

[32] Application of ELECTRE III and Shannon Entropy for Strategy Selection. Jafari, Hassan. 2013, International Journal of Innovation and Applied Studies, hal. 189-194.

[33] Multicriteria Group Decision Making with ELECTRE III Method based on Interval-valued Intuitionostic Fuzzy Information. Hashemi, Shide S., et al. 2013, elsevier, hal. 1554-1564.

[34] A Comprehensive Solution to Automated Inspection Device Selection Problem Using Electre Method. Prasenjit Chatterjee, Suprakash Mondal, Shankar Chakraborty. 2014, International Journal of Technology, hal. 193-208.