Strategy in Optimizing Mastery of Loitering Munition Technology to Face the Threat of Future War

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***Abstract*—** In the face of the type of threat of future warfare, it is necessary to procure a type of defense equipment that is following the development of current technological trends to improve national security in the field of UAV-type autonomous weapons, namely loitering munition. For the benefits of the loitering munition procurement program to be implemented optimally by Indonesian government agencies, a strategy is needed. The strategy of optimizing the procurement of loitering munitions can be done by conducting forward engineering, reverse engineering, production / licensing cooperation, or procurement from abroad. so that in addition to contributing to the TNI as a user and the national defense industry. Optimization of loitering munition procurement obtained Technology Readiness Level (TRL) loitering munition in Indonesia is still low, at level 2 because Indonesia has not mastered the technology of guidance, navigation, and control system which is the key technology of loitering munition. Based on the analysis of the advantages and disadvantages of each strategy and the calculation of the priority scale using the Simple Additive Weighting (SAW) method, a priority scale can be made by placing the production / licensing cooperation strategy as the top priority and can be used as Indonesia strategy in accelerating the mastery of loitering munition technology and being able to provide a deterrent effect for potential enemy countries.

***Keywords*—** Optimization strategy, Loitering Munition, Technology Readiness Level, Simple Additive Weighting (SAW).

I. INTRODUCTION

Human civilization can evolve by creating and mastering science and technology. Thus, war is carried out according to the human ability in mastering science and technology. The emergence of the Internet of Things (IoT) is one of the developments of human civilization in the field of science and technology today. IoT is driven by two irresistible technological trends namely Machine Intelligent and Networked Communication where these technologies are more useful and effectively used today.

In the military world, it is often known as the Internet of Military Things (IoMT) and the Internet of Battlefield Things (IoBT). The IoMT concept is the idea that future military battles will be dominated by Artificial Intelligence & Cyber Warfare and will likely take place in urban environments. IoMT includes devices that have intelligent physical sensing, learning, and actuation capabilities via virtual or cyber interfaces integrated into the system. IoMT devices such as sensors, vehicles, robots, UAVs, human wearables, biometrics, ammunition, armors, weapons, and other smart technologies [1].

Internet of Battlefield Things (IoBT) is an innovative technology used to increase the operational effectiveness of military systems. IoBT can help soldiers on the battlefield and can connect with other soldiers. In some ways, IoBT is already a reality but is likely to become a dominant presence in warfare for decades to come.

IoMT and IoBT technologies can be integrated with Autonomous Weapons. An autonomous Weapon is a weapon system that utilizes a series of sensors and computer algorithms to identify and attack targets without manual human control of the system [2]. As a result of these developments, all countries are trying to modernize their defense systems to deal with threats caused by technological advances. For Indonesia current defense system, it is both a challenge and an opportunity [3]. After improving the expertise of human resources, mastery of technology is the next most important stage in producing the latest technological instruments. Mastery of technology cannot be done by one institution, and vice versa; mastery of technology requires close collaboration across several organizations, including academic institutions, the defense sector, and R&D institutions.

Based on the national defense equipment development roadmap, there are 10 national priority programs, one of which is the development of the Unmanned Aerial Vehicle (UAV). In the face of the type of threat of future warfare, it is necessary to procure a type of defense equipment that is by the development of current technological trends to improve national security in the field of UAV-type autonomous weapons that have

deadly capabilities, such as loitering munition. The ability to loitering munitions that can acquire targets and can immediately hunt and destroy targets is an important ability that is superior in this weapon so that it is classified as an Unmanned Combat Aerial Vehicle (UCAV).

A loitering munition is a type of unmanned aerial vehicle designed to strike ground targets beyond the line of sight with an explosive warhead. Loitering munitions are portable and many are intended to provide ground units such as infantry with precision-guided ammunition. They are equipped with high-resolution electro-optical and infrared cameras that allow targets to find, monitor, and guide targets. The defining characteristic of loitering munitions is the ability to "loitering" in the air for long periods before striking, giving the target time to decide when and what to strike [4].

Since 2019, it has been reported that the Houthi rebels in Yemen have used a new type of loitering munition with a delta wing configuration for several attacks. Examples are the attacks on Saudi Arabia's oil pumping stations in Dawadimi and Afif and the infamous attack on the Abqaiq oil installation on September 14, 2019. The vehicle carries an 18 kg warhead which is stored in the nose cone and appears to be designed to penetrate heavy armor [5][6]. Loitering munitions the example above is a concept of a future war that has occurred where the use of an autonomous weapon of the UAV type, the name has been used in a conflict which has had a significant impact and can acquire precise targets. The war strategy using aerial vehicles has proven to be very effective where weapons have a broad view for target acquisition.

The development of autonomous weapon technology and the increasing trend of warfare requires a defense equipment technology procurement program, namely loitering munitions. For the benefits of the loitering munition procurement program to be implemented optimally by Indonesian government agencies, a strategy is needed. This strategy aims to optimally improve national security. The type of strategy must be chosen in such a way that in addition to contributing to the TNI as a user and the national defense industry as a developer it can have a deterrent effect on potential enemy countries.

II. METHOD

The method used in this research is the literature study method which aims to formulate concepts and theories as a basis for research through a study of books, state legislation, as well as standards used by the defense industry and the TNI. In addition, data sources were obtained from related information through interviews and discussions. In addition, it also uses the Simple Additive Weighting (SAW) method, which gives a weighting value on a priority scale to determine the strategy you want to choose so that later you can determine the optimal strategy choice.

The flow of thinking in research is described in the following figure 1.

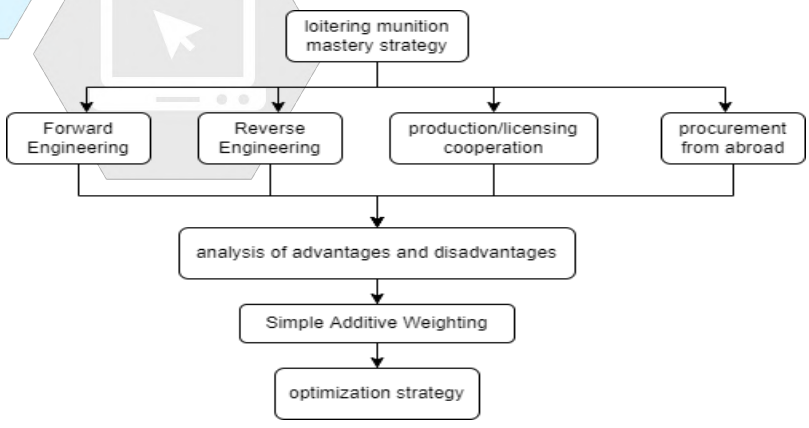

Figure 1. *The Frame of Mind in Research*

In determining the priority scale using the Simple Additive Weighting (SAW) method. According to [7][8]. This method is one method that can be used to make a decision. This method is the best known and most widely used by people in dealing with MCDM (Multiple Criteria Decision Making) situations. This method requires the decision-maker to determine the weight of each attribute.

The total score for an alternative is obtained by adding up all the multiplication results between the rating (which can be compared across attributes) and the weight of each attribute. The rating of each attribute

must be dimension-free, which means that it has passed the previous normalization process.

The completion steps using the SAW method are as follows:

1. Determine the criteria that will be used as a reference in decision making, namely Ci.
2. Determine the suitability rating of each alternative on each criterion.
3. Make a decision matrix based on the criteria (Ci), then normalize the matrix based on the equation that is adjusted to the type of attribute (profit attribute or cost attribute) to obtain a normalized matrix R.
4. The final result is obtained from the ranking process, namely, the addition of the normalized matrix multiplication R with the weight vector so that solution is obtained [9]. The equation below used to perform the normalization is as follows:

$$Rij = Xij \frac{Max}{Max\ Xij}$$

Where Rij is the normalized performance rating of alternative Ai on attribute Cj; j=1,2,…,m and j=1,2,…..n.

The preference value for each alternative (Vi) is given as the equation below:

$$Vi = \sum_{j=1}^{n} Wj\ Rij$$

A larger value of Vi indicates that alternative Ai is preferred.

III. RESULT AND DISCUSSION

1. Technology Readiness Level (TRL) Loitering Munitions in Indonesia

Since the issuance of Law Number 16 of 2012 concerning the Defense Industry, the government has demonstrated its commitment to building a strong, independent, and competitive Defense Industry. To realize this, the Directorate General of Defense Potential of the Ministry of Defense of the Republic of Indonesia (Ditjen Pothan Kemhan) has an important role in preparing all industrial potentials to be directed and prepared to become part of defense capabilities, including in the context of meeting the needs of Defense and Security Equipment Equipment (Alpalhankam) independently including one of them is in terms of mastery of Unmanned Aerial Vehicle (UAV) technology, which is a loitering munition.

The key technology of loitering munition itself consists of guidance, navigation, and control systems. These three technologies make loitering munitions move automatically and the target acquisition system is assisted by Artificial Intelligence (AI) technology. There are also other technologies needed for loitering munition, such as explosives, airframes, and mobility using electric motors and batteries.

The key technology owned by loitering munition is the same as the key technology owned by missiles where the readiness system of the three technologies, namely guidance, navigation, and control systems [10] is classified as a Technology Readiness Level (TRL) is still in the TRL-2 range because the technology is still under research, not yet in the form of experiments, and the research is still in small quantities.

2. National Loitering Munition Technology Mastery Strategy

a. Forward Engineering

Forward Engineering is a method of creating or creating platforms using the given requirements. Forward Engineering is also known as Renovation and Reclamation. Forward engineering requires high proficiency skills. It takes more time to build or develop the platform. Forward engineering is the technique of creating high-level models or designs to be made in low-level complexity and information. In creating a new model of loitering munitions, it will take a long time to research because, in Indonesia, there is still no technology development in loitering munitions. One of the modern technologies owned by loitering munitions is Artificial intelligence which in Indonesia itself is still in the study stage to be developed.

Loitering munition technology is a modern technology so the investment cost is very expensive which uses automatic and artificial intelligence. The government must allocate a large budget from the state budget to develop national strategic industries. This makes forward engineering for loitering munitions not widely carried out in Indonesia.

One example of Indonesia success in developing UAV is the PTTA Wulung produced by PT Dirgantara Indonesia. The initial development of PTTA Wulung was started by BPPT together with Balitbang Kemhan RI as a research institution that carried out research and development of PTTA Wulung from initial design, prototype to flight test. The PTTA as a result of the BPPT development is then submitted to PT DI as an industry that has a Design Organization Approval Certificate to be produced following standard procedures for the aviation industry.

b. Reverse Engineering

Reverse engineering (RE) is a method of examining existing products to build similar items to reduce costs and improve quality. The performance principle of a tool, item, or system can be determined via the reverse engineering process by evaluating its structure, function, and operation [11].

If RE is applied, the time required to master the technology will be able to be implemented faster than from the start and independently but also takes a long time to learn it. Therefore, RE is one of the strategies chosen in mastering loitering munition that is by Indonesia.

However, Indonesia itself does not yet have a loitering munition to be used in a defense system by the military, so in RE requires an object to be studied, Indonesia must have an object or object from a loitering munition so that later the technology used can be investigated.

c. Production/licensing cooperation

According to the ToT CODE (International Code of Conduct on Transfer of Technology), every way of transferring technological rights, both in the form of property rights and non-proprietary rights, is to include every way of transferring technological rights, both in the form of property rights and non-proprietary rights, without questioning the legal form of the way of transfer, including transnational and e-commerce [12].
As for the countries that are cooperating with Indonesia regarding defense equipment, which includes the Transfer of Technology (ToT) cooperation. Indonesia is collaborating with the South Korean Ministry of Defense and the Korea Aerospace Industry (KAI). This collaboration includes the Indonesian Ministry of Defense's equity participation with KAI as well as the PT Dirgantara Indonesia contract with KAI. This work contract is related to the development of the Korea Fighter Experimental (KF-X) fighter jet project by the Korean and Indonesian governments. Furthermore, PT PAL took part in the construction of the Daewoo Shipbuilding and Marine Engineering (DSME) 209/1400 submarine. Indonesia ordered three submarines from Daewoo Shipbuilding, South Korea. However, as part of the technology transfer, the installation of the third submarine was carried out by Indonesia. In 2017, PT Pindad and Turkey FNNS worked together to make the prototype of the medium battle tank. The second prototype will be carried out in Bandung, West Java and at that time it is targeted to be mass-produced in 2018. From several collaborations with these countries, it is possible to work together for the development of loitering munitions by working in Indonesia.

Cooperating with friendly countries and the Transfer of Technology (ToT) of the developing country loitering munitions which are currently cooperating with Indonesia, namely Turkey, and South Korea under the name loitering munitions for each country, namely. Turkey Alpagu and South Korea Devil Killer. The local industry for ToT/Offset partners, namely PT DI/PT LEN which has been involved in making the UAV prototype needs government regulations so that the loitering munition can be carried out properly [13].

From the above armament needs, PT DI is a STATE-OWNED that already has experience in UAV development and has a Design Organization Approval Certificate, so that it can improve technology to compete with the global. The following are the recommended strategies to support PT DI capacity building as follows:

- Develop loitering munitions based on the current needs of the TNI for national security by collaborating with government agencies in friendly countries that can ToT.
- Optimizing the existing ToT so that the national defense industry can develop loitering munitions independently so that it can meet the needs of the TNI. The goal is to achieve the optimal level of economies of scale.

d. Procurement from Abroad

Increase local content and offsets as a method of mastering technology in the procurement process directly from abroad. Article 43 paragraph (3) of Law 16 of 2012 stipulates that any acquisition of Alpalhankam from abroad must involve the participation of the defense industry in the form of Local Content and Offset (KLO) and Transfer of Technology (ToT), which are important links in industrial capacity development. So that the defense has qualified expertise [14]. The Defense Industry is expected to develop independently as a result of these activities and become an important part of Alpalhankam global supply chain.

Due to various constraints, such as the readiness of human resources, budgetary capacity, and other resources, such as important loitering munition technology, Indonesia defense offset practice has not been able to fully meet the needs of defense weapons. Due to budget constraints and resistance from technology owners, offsets in the form of licensing purchases, co-production, and co-development are rarely used as alternatives to offsets. According to [15] through Law 16/2012 and government regulation

76/2014, Indonesia has launched an offset program, local content, and trade offsets of up to 85% of the purchase contract value. The principle of counter-trade following UNCITRAL, the principle following the agreement under Article 1320 of the Civil Code, and the concepts of international contracts can all be accommodated in the Standard Bidding Document which contains Offset provisions, as regulated in Article 50 of the Minister of Defense 17/2014. By observing Foreign Investment (FDI) milestones and including a sizable compensation clause for non-performance in the offset liability, defense contracts with indemnity clauses can preclude non-performance of Foreign Investment (FDI) commitments. Furthermore, the Minister of Defense Regulation Number 30 of 2015 has also been issued regarding the Mechanism of Trade, Local Content, and Offset (KLO) in the procurement of defense equipment from abroad. IDKLO is used to procure Alpalhankam from outside using the Foreign Loan Strategic Plan budget for the 2016-2019 period. IDKLO proposals from 28 Alpalhankam procurement programs from around the world allocated to TNI and Army Headquarters have been discussed, and IDKLO commitments are outlined in the main procurement contract.

The method that can be used in IDKLO starts with mapping local content and potential content, as well as offset operations that are not fully regulated by the domestic defense industry [16].

3. Strategy for Accelerating Mastery of Loitering Munition Technology

Based on the four strategies described previously, the advantages and disadvantages of each can be seen in table 1:

Table 1. *Advantages and Disadvantages of the Strategy Method*

NO	Strategy Method	Advantages	Disadvantages
1	Forward Engineering	● Able to produce technology independently loitering munition to reduce dependence on other countries ● The technology produced is by Indonesian defense conditions because it is designed according to the needs of users of national ● Not bound by other country's politics such as embargo and licensing politics	● Requires a long time and large resources ● Requires strong engineering basic ● Cost is an expensive investment that requires a large budget ● Unavailability of manufacturing facilities and infrastructure and technology testing
2	Reverse Engineering	● Similar to forward engineering, reverse engineering can also reduce dependence on the State other ● The required time is relatively shorter than forwarding engineering	● Requires a large budget ● Unavailability of manufacturing facilities and infrastructure and technology testing ● Sometimes produces technology that cannot meet the desired requirements
3	Production/License Cooperation	● Does not require strong basic engineering in mastering technology ● Building facilities and the same manufacturing infrastructure and technology testing as the original manufacturer ● Produces a product of the same quality.	● The big challenge in inviting partners who want to work together ● The budget to meet the needs of national loitering munitions is still small ● Not all loitering munition technology from partner countries will be distributed to the national defense industry
4	Procurement from abroad	● Easier than the previous method because it does not require strong basic engineering and power level bargaining in inviting partners is relatively easy ● Faster in meeting the needs of national loitering munitions compared to	● Vulnerable to politics of importing countries such as embargo politics ● Creates dependence on producing countries ● Requires a large budget The

		producing independently but in terms of low technological mastery	• implementation of IDKLO is sometimes not by core technology needs in the country.

Then the advantages and disadvantages of each of the above are tabulated to determine the priority level of loitering munition based on defense conditions and the availability of national resources using the SAW method as follows:
Scale 5 = highly recommended
Scale 4 = recommended
Scale 3 = moderately recommended
Scale 2 = less recommended
Scale 1 = not recommended

Previously classified the predetermined strategic methods as follows:
A1 = Forward Engineering
A2 = Reverse Engineering
A3 = Production/licensing cooperation
A4 = Procurement from Abroad

Classify criteria based on defense conditions and availability of national resources as follows:
C1 = Efficiency of costs incurred
C2 = Speed of time for Mastery of Technology
C3 = Ease of implementation
C4 = Success rate of conformity of results to user specifications
C5 = Availability of facilities within the country
The following is a calculation of decision-making to determine the type of optimization strategy using the SAW method.

At this stage, the writer fills in the weight value of an alternative with the criteria that have been described previously by comparing the value of the variable with the criteria on a scale value of 1 to 5. Then the alternative weighting value against the criteria can be seen in Table 2:

Table 2. *Alternative Weighting of Criteria*

Variable	Criteria				
	C1	**C2**	**C3**	**C4**	**C5**
A1	0,8	0,6	0,4	0,4	0,4
A2	0,8	0,6	0,6	0,6	0,4
A3	0,6	0,8	0,8	0,8	0,8
A4	0,6	0,2	1	1	0,8

The next stage is to do priority weighting; this priority weighting is priority weighting on a criterion. The criteria chosen by the author are considered to have the same priority weight and are possible to be applied to Indonesia with a maximum value of 1, which can be seen in Table 3:

Table 3. *Priority Weighting Against Criteria*

Criteria	Priority Weights
C1	0,2
C2	0,2
C3	0,2
C4	0,2
C5	0,2
Total	1

Furthermore, normalization is carried out for each of the criteria. All sub-criteria are attributed to profit, where criteria with a greater value mean that they are prioritized, then the maximum value is used for normalization calculations.
The following is the normalization calculation using the SAW method:

$$R11 = \frac{0,8}{0,8} = 1 \qquad R21 = \frac{0,8}{0,8} = 1$$
$$R12 = \frac{0,6}{0,8} = 0,75 \qquad R22 = \frac{0,6}{0,8} = 0,75$$
$$R13 = \frac{0,4}{1} = 0,4 \qquad R23 = \frac{0,6}{1} = 0,6$$
$$R14 = \frac{0,4}{1} = 0,4 \qquad R24 = \frac{0,6}{1} = 0,6$$
$$R15 = \frac{0,4}{0,8} = 0,5 \qquad R25 = \frac{0,4}{0,8} = 0,5$$

$$R31 = \frac{0,6}{0,8} = 0,75 \qquad R41 = \frac{0,6}{0,8} = 0,75$$
$$R32 = \frac{0,8}{0,8} = 1 \qquad R42 = \frac{0,2}{0,8} = 0,25$$
$$R33 = \frac{0,8}{1} = 0,8 \qquad R43 = \frac{1}{1} = 1$$
$$R34 = \frac{0,8}{1} = 0,8 \qquad R44 = \frac{1}{1} = 1$$
$$R35 = \frac{0,8}{0,8} = 1 \qquad R45 = \frac{0,8}{0,8} = 1$$

Then the ranking is carried out using the normalized weights that have been obtained as follows:

$$V1 = (1\ x\ 0{,}2) + (0{,}75\ x\ 0{,}2) + (0{,}4\ x\ 0{,}2) + (0{,}4\ x\ 0{,}2) + (0{,}5\ x\ 0{,}2) = 0{,}61$$

$$V2 = (1\ x\ 0{,}2) + (0{,}75\ x\ 0{,}2) + (0{,}6\ x\ 0{,}2) + (0{,}6\ x\ 0{,}2) + (0{,}5\ x\ 0{,}2) = 0{,}69$$

$$V3 = (0{,}75\ x\ 0{,}2) + (1\ x\ 0{,}2) + (0{,}8\ x\ 0{,}2) + (0{,}8\ x\ 0{,}2) + (1\ x\ 0{,}2) = 0{,}87$$

$$V4 = (0{,}75\ x\ 0{,}2) + (0{,}25\ x\ 0{,}2) + (1\ x\ 0{,}2) + (1\ x\ 0{,}2) + (1\ x\ 0{,}2) = 0{,}8$$

From the results of the calculation above, the largest value was obtained, namely V3 with a value of 0.87, then the final ranking was obtained for determining the optimization strategy, namely using a production/license cooperation strategy, so that it is appropriate if it is used as an alternative in taking a policy strategy in accelerating the mastery of loitering munition.

The factor affecting the success of cooperation is high bargaining power. Bargaining power can be increased by increasing the quantity of demand for goods so that production cooperation can run. With this strategy, it is also possible to license by co-producing and developing loitering munition technology by attracting partners to operate domestically. In addition, another benefit is an opportunity to improve the quality of human resources through integrated triple helix cooperation.

IV. CONCLUSION

Loitering munition mastery strategy can be done by conducting forward engineering, reverse engineering, production / licensing cooperation, or procurement from abroad. Based on the analysis of the advantages and disadvantages of each strategy, the level of importance can be analyzed using the Simple Additive Weighting (SAW) method, so that it can make decisions by placing the production / licensing cooperation strategy as the main choice and can be used as Indonesia strategy in accelerating mastery of loitering munition technology. So that the benefits of the loitering munition procurement program can be implemented optimally by Indonesian government agencies, namely cooperating products/licenses with foreign partners in co-producing loitering munitions that can optimally improve national security and can contribute to the TNI and defense industry so that they can have a deterrent effect on potential enemy countries.

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