Spare parts for fisheries surveillance vessels inventory management in Ministry of Marine Affairs and Fisheries

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ABSTRACT

This study aims to identify problems and formulate a model for managing spare parts inventory of fisheries supervisory vessels in the Directorate of Fleet Monitoring and Operations, Ministry of Marine Affairs and Fisheries to be optimal. The research method is carried out using a qualitative approach. Data collection is done by interviews, field observations and analysis of data and documents. Water inventory management theory (2003) is a theory used to determine the cycle or process of managing spare parts inventory and the Economic Order Quantity (EOQ) method of Horngren (2016) to determine the optimum order quantity and Analysis of ABC Chin (2017) in Putra (2020) to classify inventory into 3 (three) classes, namely A (very important items), B (items that are quite important), and C (relatively unimportant). This study concluded that the management of spare parts in the POA Directorate has not been optimal due to several factors, namely: 1). Human Resources: operators do not have inventory background, and inventory recording with the SAKTI application requires operator involvement, 2). Method: procurement of spare parts is carried out periodically only once a year, so it cannot anticipate changes in needs, and 3), Machinery (Tools): Parts inventory is still done manually with Ms. Excel. Researchers develop a business process model that includes procurement, inventory, storage, delivery, and use of spare parts to improve the efficiency of parts inventory management. This model is expected to be an input in the determination of the Decree of the Minister of Marine Affairs and Fisheries. The application of the management model with the EOQ method can increase efficiency by Rp100,180,381.

INTRODUCTION

Indonesia is the largest archipelagic country in the world, with about 17,504 islands in Indonesia, 16,056 of which are standardized and registered with the United Nations. Indonesia's sea area is 6.4 million square kilometers, covering 290,000 square kilometers of territorial waters, 3.11 million square kilometers of inland waters and archipelago waters, and 30,000 square kilometers of Indonesia's exclusive economic zone. Indonesia also has a coastline of 108,000 kilometers, a continental shelf that stretches 2.8 million km2, and additional waters that stretch 270,000 km2 (Coordinating Ministry for Maritime, 2018). Based on these data, Indonesia has abundant marine wealth, and the fisheries sector plays an important role in the country's economy. To maintain sustainability and sustainable management of fishery resources, the Ministry of Marine Affairs and Fisheries is responsible for carrying out supervision and law enforcement in the marine and fisheries sector, one of which is through the operation of fisheries supervisory vessels.

Given the large area of sea area that must be monitored, a commensurate number of fisheries supervisory vessels are needed to supervise each Fisheries Management Area-State of the Republic of Indonesia (WPPNRI). Based on the grand design calculation of fisheries supervisory vessel needs made by the Directorate of POA, it is known that the total number of fisheries supervisory vessels needs is at least 55 (fifty-five) units of Fisheries Supervisory Vessels. As for fact, there are 30 (thirty) Fisheries Supervisory Vessels that are still operable and 4 (four) Supervisory Vessels have been granted to Local Governments and Educational Institutions.
Based on Regulation of KP Number 4 of 2021 Article 2, it is stated that fisheries supervisory vessels have an important function to carry out supervision and law enforcement in the marine and fisheries sector through patrols and supervision in the waters, ensuring compliance with fisheries regulations, preventing illegal, unreported, and unregulated (IUU) fishing activities, and protecting vulnerable fishery resources.

In carrying out its function, fisheries supervisory vessels not only involve operational responsibilities but also require adequate resource allocation, especially in terms of budget. Suharnoko (2019) stated that efficient and effective budget implementation has an effect on performance achievements. In terms of vessel operations, the planning and implementation of the operational budget and maintenance of fisheries supervisory vessels need to be optimized so that vessels can operate optimally and achieve the set supervisory objectives.

Throughout 2018 – 2022, the remaining value of spare parts inventory balances at the Directorate of Fleet Monitoring and Operations, Directorate General of PSDKP has increased significantly from around Rp483,124,540.00 to Rp13,568,249,798.00. Graph 1.1 below shows the remaining value of spare parts inventory balance at the Directorate of Fleet Monitoring and Operations, Directorate General of PSDKP.

In 2018 the initial balance was Rp833,075,100, with significant purchases amounting to Rp9,258,941,863.00, despite large purchases, the balance at the end of this year was quite low, namely Rp483,124,540.00 due to high usage. In 2019 the initial balance was Rp483,124,540.00 there were significant purchases of Rp3,688,346.100 and considerable usage also amounted to Rp1,862,255,240.00, outgoing transfers reached Rp428,218,700.00 which affected the final balance to Rp1,880,996,700.00. In 2020, the initial balance was IDR 1,880,996,700.00, there was a large purchase of IDR 7,662,920,846.00 and usage of IDR 705,521,300.00, the balance at the end of 2020 became IDR 9,543,917,546.00. In 2021, there was no initial balance due to the transition to one DIPA, there were large purchases of IDR 13,179,633,766.00 and incoming transfers of IDR 9,543,917,546.00. A very large usage occurred of Rp14,428,915,310.00 resulting in a lower year-end balance, which was Rp8,294,636,002.00. 2022 began with a significant initial balance, namely IDR 8,294,636,002, large purchases of IDR 16,310,450,506.00, incoming corrections of IDR 542,188,400.00 and large purchases of IDR 9,504,154,283.00. There was a fairly large outflow of Rp1,957,573,800.00 and an outgoing correction of Rp117,297,030.00, so that the balance at the end of 2022 was Rp13,568,249,795.00.

Spare parts management at the POA Directorate still needs to be improved, as evidenced by corrections and balances that tend to increase as well as the findings of the Audit Board (BPK) in 2018. BPK's findings include differences between inventory application records and physical conditions in warehouses, remaining 2017 procurement items worth Rp3,816,670,000.00 that are not inputted per item, differences in information in the Handover Minutes (BAST) and stock in the warehouse, the condition of goods exceeding the amount of procurement, recorded goods but no stock in the warehouse, mismatch of inventory control cards, and errors in recording spare parts brands. All these findings indicate the need for improvement in the management and recording of spare parts inventory in the POA Directorate.

The management of spare parts inventory for fisheries supervisory vessels faces various challenges and problems, including limited storage of spare parts on board, so that warehouse rental in Jakarta costs Rp360,000,000.00 / year and the distribution of spare parts is constrained because the position of ships is always moving and scattered throughout WPPNRI (warehouse location is in Jakarta). In addition, there are still storage errors and delivery of spare parts to the surveillance ship.

Based on Presidential Instruction Number 2 of 2022 concerning the Acceleration of Increasing the Use of Domestic Products and Products of Micro Enterprises, Small Businesses and Cooperatives in order to Succeed the National Movement of Pride in Made in Indonesia in the Implementation of Government Procurement of Goods/Services, government agencies are required to use domestic products that have a Domestic Component Level (TKDN) value of at least 25% (twenty-five percent) if there are domestic products with sums TKDN value and Company Benefit Weight value of at least 40% (forty percent). The procurement of spare parts is generally imported so that it is constrained by the Policy for Increasing the Use of Domestic Products (P3DN). Imported spare parts cause high external factors in the procurement of spare parts. One example of the impact is the delay in the procurement of MTU Main engine parts, proposing an additional extension of contract time for the procurement of spare parts (2 types of spare parts: CATRIDGE RACOR (PNXPS9408300054) and OIL FILTER ELEMENT (PN. XP52618300032) because spare parts are hampered by global problems, the COVID-19 pandemic and the Ukraine-Russia war (material from Ukraine). In addition, in 2022 the work of Top General Overhoul Main Engine KP was carried out. Orca 03, constrained by the stock of certain types of spare parts not available at the engine maker and unpredictable damage, so manufacturing must be done and Pre-Order (PO) takes 5 (five) weeks. This greatly hampered the work process and needed an extension of time in completing the work of the Top General Overhoul Main Engine. The unavailability of spare parts needed can hamper the operation of surveillance ships and impact the unpreparedness of the surveillance ship fleet to carry out supervisory tasks. Inaccurate estimation of needs can
lead to excess or shortage of spare parts inventory that has the potential to disrupt the operations of surveillance vessels. This can be due to the inability to accurately estimate the needs of parts or limitations in the supply and distribution of such parts.

In addition to problems in identifying needs, recording spare parts is also a problem in itself. In 2022, there was a discrepancy between inventory data in the warehouse and the Inventory Application in the disclosure of the 2022 Financial Statements, where there was an added mutation in the form of physical hospitalization results of spare parts of IDR 377,420,000, - which was found to be more physical during the implementation of physical hospitalization and there was a detailed error in the Inventory Module, resulting in a correction in recording the quantity of spare parts both added mutations of IDR 55,500,000 and less than Rp16,589,960,- on the inventory module, caused by the discrepancy of source documents (receipts, contracts) with those recorded in the Sakti application mismatch in the amount of spare parts usage with the inventory balance.

In 2023, there is a recording error in the Inventory Account on the Sakti Application, namely the mismatch between the inventory shopping account and the shopping account for inventory handed over to the public, so it is necessary to reclassify inventory with the appropriate item code (Directorate General of PSDKP there is no inventory account to be handed over to the public) as shown in Table 1.1 Reclassification of Entry at the Directorate of Fleet Monitoring and Operations.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Quantity</th>
<th>Rupiah</th>
</tr>
</thead>
<tbody>
<tr>
<td>1010312999</td>
<td>Supporting Tools/Materials for Other Security Activities</td>
<td>217</td>
<td>393,340,600</td>
</tr>
<tr>
<td>000002</td>
<td>SART Cadangan/Man Over Board (MOB) Good Brother QYCD 15-2-2-POA</td>
<td>10</td>
<td>40,182,000</td>
</tr>
<tr>
<td>000003</td>
<td>EPIRB NSR NEB2000 POA</td>
<td>8</td>
<td>77,700,000</td>
</tr>
<tr>
<td>000004</td>
<td>Smoke Signal Good Brother</td>
<td>72</td>
<td>31,968,000</td>
</tr>
<tr>
<td>000005</td>
<td>Parachute Signal Good Brother HGS40-3000 POA</td>
<td>72</td>
<td>31,968,000</td>
</tr>
<tr>
<td>000006</td>
<td>Red Hand Flare Signal Good Brother HHY60-15000 POA</td>
<td>48</td>
<td>15,717,600</td>
</tr>
<tr>
<td>000007</td>
<td>Rope PP Multi Cir 6 POA</td>
<td>3</td>
<td>60,273,000</td>
</tr>
<tr>
<td>000008</td>
<td>Rope PP Multi Cir 8 POA</td>
<td>4</td>
<td>134,532,000</td>
</tr>
</tbody>
</table>

Source: Inventory Sakti Dit App. POA 2023

Based on the findings of the problems described above, it is very visible that there are problems in the management of spare parts inventory of fisheries supervisory vessels at the Ministry of Marine Affairs and Fisheries. The author intends to find the root cause of spare parts management at the Ministry of Marine Affairs and Fisheries, especially Supervisory Ship Spare Parts at the Directorate of Fleet Monitoring and Operations (Directorate of POA). The root of the problem found will be used as the basis for the preparation of a spare parts management business process model at the POA Directorate by combining it with the Spare Parts Management Model based on the EOQ Method and ABC Classification which is commonly proven to improve inventory management efficiency according to Pakpahan (2022), Baihaqi (2022), and Rahmatullah (2020). Therefore, the author will raise a thesis entitled "Management of Fisheries Supervisory Vessel Spare Parts Inventory at the Ministry of Marine Affairs and Fisheries".

This study aims to find the root of the problem in the management of spare parts inventory of fisheries supervisory vessels at the Ministry of Marine Affairs and Fisheries, and formulate an optimal model of fisheries supervisory ship spare parts inventory management at the Ministry of Marine Affairs and Fisheries. This research can contribute significantly to knowledge in the field of inventory management and public administration. Research results can be a reference source for researchers, students, and academics interested in this topic. The results of the research can be the basis for further research in the development of theory and practice of inventory management, especially in government ministries / agencies that are still limited.

**METHOD**

This research method emphasizes the importance of finding the right research subject, building relationships with informants, and collecting qualitative data descriptively, both through writing, words, and observations. Qualitative research is used to understand the experience and practice of informants in the management of spare parts inventory of fisheries supervisory vessels at the Ministry of Marine Affairs and Fisheries. In addition, this study also involves quantitative data analysis to compile a spare parts management model using the Economic Order Quantity (EOQ) and ABC Classification methods, as well as conducting Monte Carlo simulations to improve the efficiency of the resulting model. Primary data were collected through...
unstructured interviews with purposively selected informants, while secondary data included regulations, financial statements, and literature related to inventory management.

Data collection techniques used include systematic observation, in-depth interviews, and documentation. The observation was made to record real phenomena related to inventory management in the spare parts warehouse of the Directorate of Fleet Monitoring and Operations in Central Jakarta. Unstructured interviews were conducted to obtain in-depth information from key informants, consisting of various parties related to the planning, budgeting, and operation of surveillance vessels. Documentation involves the collection and analysis of relevant historical and archival documents. This research was conducted at the Directorate of Fleet Monitoring and Operations, Directorate General of PSDKP-KKP, which is tasked with carrying out surveillance fleet operations, including maintenance and logistics management of surveillance vessels. With the increase in fleet, this study aims to find the root of the problem in the management of spare parts inventory and compile improvement recommendations based on the results of the analysis.

RESULTS AND DISCUSSION

Root Cause Analysis

Human Resource Factor Analysis

Human resource factors have an important role in inventory management, as mentioned by Makarim (2020), Idayanti (2017), and Chan (2017). The author collects information through interviews and documentation to identify problems in spare parts management at the POA Directorate, and uses Root Cause Analysis with the 5 Why method to analyze the root of the problem. The results of interviews and documentation show that recording errors often occur due to human error, such as differences in recording quantities and inventory codes between applications and physical goods received. This is acknowledged by the KI-5 and KI-1, which attribute the error to the factor of the operator not understanding the substance of the goods recorded.

Data triangulation through financial statements and correction letters notes that the misinput of the item code by the commitment operator led to the correction in the 2023 financial statements. Root Cause Analysis shows that recording errors stem from the operator's lack of understanding of the substance of the goods recorded. Committed operators who generally do not have a background in recording inventory must be involved in this process due to changes in the recording mechanism with the SAKTI system. As a result, there are differences in perception between operators and warehouse officers, as well as the lack of adequate source documents for recording codes and inventory quantities. In conclusion, the human resource factor in parts management is still not optimal due to limited technical understanding by the commitment operator.

Method Factor Analysis

The factor of spare parts procurement method plays a crucial role in inventory management. Studies by Makarim (2020) and Idayanti (2017) show that the application of good methods has a positive impact. Analysis using Root Cause Analysis with the 5 Why Method approach found that the procurement method carried out periodically once a year could not anticipate changes in needs and caused a buildup of spare parts. Data from the Financial Report shows a significant increase in spare parts inventory balances in 2022 and 2023, after experiencing a decline in the previous year.

This increase is due to the gap between parts procurement and discharging, as well as unpredictable changes in operating days. In 2022 and 2023, there is a deviation between the planned operating day and its realization, caused by budget blocks and fluctuations in fuel prices. Procurement methods that are only carried out once a year are unable to adjust to these changes, resulting in a buildup of spare parts. Further analysis shows that periodic procurement is less efficient and has the potential to increase storage costs. Therefore, it is necessary to adjust the procurement method to be more flexible in dealing with changing spare parts needs.

Machine Factor Analysis (Assistive Device)

The results of the physical hospitalization of spare parts show a discrepancy between recording and physical condition caused by an unclear system, as conveyed by KI-10. The author verified by triangulation techniques in the 2023 financial statements and found a balance correction of IDR 377,420,000 due to differences in physical data and applications. This happens because there are two storage locations, namely the central warehouse and the ship warehouse, which affects the method of inventory and recording. Stock taking reports from ships are used as the basis for recording on the SAKTI Application, but often this recording is not synchronized with physical conditions in the field because application operators do not always master actual conditions.

The SAKTI application, which is used for inventory recording, is not sufficient for real-time monitoring because it can only be accessed from the office. The POA Directorate tries to overcome this problem by using a recording tool in the form of Excel, but there are often recording errors due to human error. This manual tool
results in a mismatch in the number of spare parts after stock-taking. The author summarizes this problem using Root Causes Analysis (RCA) and finds that manual inventory recording with Excel and data asynchronousness between the application and physical condition are the main root problems in parts management.

**Environmental Factor Analysis**

Environmental factors in the management of spare parts are mainly related to storage areas, namely spare parts warehouses. The mechanism for storing and using spare parts is regulated in Circular Number B.1550/SJ/PL.930/XII/2018 concerning the Administration of State Property in the form of Inventory, which describes three subactivities: storage, security and maintenance, and distribution. This Circular emphasizes the importance of adequate storage facilities, including standard-compliant warehouses, as well as the need for responsible inventory management officials and the use of control cards for each use of spare parts. Direct observation by the author in the spare parts storage warehouse of the POA Directorate confirmed compliance with these standards, indicating the existence of complete facilities such as air conditioning, iron racks, and adequate security systems.

Observations also show that the warehouse on Jln. Kemayoran Station has complete facilities including security systems and air conditioners that maintain the quality of spare parts. Recording is still done manually and recapitulated in Excel, with codification and card stock to avoid mistakes. The storage and distribution process is carried out with double inspection to ensure the conformity of specifications and quality of goods. This warehouse meets the requirements stipulated in the Circular, with completeness such as goods cards, location plans, security equipment, and other tools. There were no reports of damage or loss of parts from the period 2020 to 2023, demonstrating the effectiveness of parts management and safety in the POA Directorate. Root cause analysis in spare parts management identifies challenges in aspects of Human Resources, Procurement Methods, and Machines (Tools) that are still manual.

**Recommendations for Optimization of Spare Parts Management**

Following up on the root cause of spare parts management based on *Root Causes Analysis*, the author proposes several recommendations for optimizing spare parts management as follows.

**Human Resources**

Changes in the mechanism of recording spare parts using SAKTI, require that the recording of spare parts is preceded by the recording of BAST by the Commitment Operator. The previous Commitment Operator was not involved in the management of spare parts, so it is necessary to improve the competence of the commitment operator so that it can close the competency gap they have. In addition, to ensure the accuracy of recording spare parts, it is necessary to verify the inventory recording code by the person in charge of the activity before being recorded by the commitment operator as a control of recording BAST spare parts.

**Method**

The procurement of spare parts is currently carried out with the type of unit price contract for a number of spare parts needs of 1 (one) year through a direct appointment mechanism. This method cannot anticipate changes in the number of operating days, especially when there are price fluctuations or budget cuts. Therefore, the author recommends changing the unit price contract to an Umbrella Contract.

According to LKPP Regulation Number 9 of 2021, an Umbrella Contract is a unit price contract in a certain period that cannot be determined by the volume and time of procurement. Umbrella contracts provide flexibility in the procurement of spare parts and ease of procurement methods because the preparation of contracts is only carried out once and is valid for more than 1 (one) year. According to the KI-12 statement: "umbrella contracts for the procurement of spare parts are possible for work because they are routine and repetitive, vary in time and quantity, and standard goods." This is very suitable for the work of procuring spare parts. The umbrella contract method can also minimize lead-time by adding clauses for distributors to ensure the availability of certain parts stocks, especially fast-moving parts.

The determination of the amount and time of procurement becomes more flexible with the use of umbrella contracts. This allows the implementation of *Economic Order Quantity* in the procurement of spare parts and in line with Martono (2018: 142) mentioned that EOQ is a method of inventory management to achieve a balance between storage costs and ordering costs. The number of parts stored is based on the calculation of *Safety Stock*, *Reorder Point*, and *Maximum Stock* of each part based on an optimal point that balances order costs and storage costs. Procurement of spare parts will be carried out periodically when entering the *Reorder Point* (ROP). The use of EOQ *Single Order Multiple Product* is proven to increase efficiency according to Rahmatullah (2020).

In general, heavy equipment and machinery manufacturers have authorized distributors in Indonesia, as Caterpillar has PT Trakindo Indonesia as the only authorized distributor and MTU has PT Altrak 1978 as an

*Spare parts for fisheries surveillance vessels inventory management in Ministry of Marine Affairs and Fisheries*
authorized distributor. LKPP Regulation Number 12 of 2021 states that if special goods or services that can only be produced by people or companies who have exclusive rights to patents, or who have obtained permission from patent owners, or who have won tenders and obtained permits from the government, then procurement can still be carried out through direct appointment.

**Machine (Assistive Device)**

Digitization and integration of spare parts inventory process to ensure the value of spare parts recorded in the SAKTI application is in accordance with the physical. KI-1 mentions that: “The POA Directorate is in the stage towards digitizing spare parts inventory”. This is in line with Al-Bawi's (2015) research which states that the application of management computer programs can streamline information processes and significantly reduce order processing time, provide real-time inventory status and improve decision making. Combining digital systems and paper-based systems can provide the best of both systems, depending on the needs of each inventory manager.

**Parts Management Model (Parts Calculation based on EOQ Method and ABC Classification)**

Based on research by Rahmatullah (2020), Indriastiningsih (2019), and Abbas Al-Bawi (2015), the EOQ (Economic Order Quantity) Method has been proven to increase the efficiency of spare parts management in various entities. Indriastiningsih (2019) highlights that the EOQ Method helps anticipate future changes in demand and inventory, enabling more accurate inventory planning. In the POA Directorate, this method can be used to correct the number of spare parts needed in a year, adjusting to dynamic changes in operating days. As a follow-up to the identification of the root of the problem, the POA Directorate will develop a business process that integrates the use of the EOQ Method as the main key.

The EOQ method ensures procurement is carried out when the inventory level reaches the Reorder Point (ROP) to maintain smooth operations without inventory vacancies. The number of spare parts is kept in the Safety Stock and Maximum Stock ranges to avoid over-buildup. Reorder Point is determined by the formula $\text{ROP} = \text{Safety Stock} + (\text{Lead Time} \times Q)$, where Lead Time is the waiting time from the order until the goods arrive and $Q$ is the maximum order amount. The implementation of the EOQ Method is preceded by the Always Better Control (ABC) classification, which groups inventory based on its use value into high, medium, and low. The author recommends ABC classification to identify large-value and fast-moving parts, and will perform EOQ calculation simulation and Monte Carlo Simulation for A-classification and fast-moving parts.

ABC analysis is a method used to classify inventory into 3 (three) classes, namely A (very important items), B (items that are quite important), and C (relatively unimportant). According to Ida (2016), group A is spare parts with sales of 80% of 20% types of spare parts, while group B spare parts have a sales value of 15% of 30% types of spare parts, and the rest are included in group C. To get the value of annual spare parts needs. The complete calculation of ABC classification of spare parts of the POA Directorate is in annex 1. The recapitulation of the number and value of spare parts of each group is as follows:

<table>
<thead>
<tr>
<th>Classification</th>
<th>Total Item</th>
<th>Need Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification A</td>
<td>52</td>
<td>4,995,970,901</td>
</tr>
<tr>
<td>Classification B</td>
<td>79</td>
<td>750,803,421</td>
</tr>
<tr>
<td>Classification C</td>
<td>132</td>
<td>173,971,725</td>
</tr>
</tbody>
</table>

Based on these calculations, spare parts in the Directorate of Fleet Monitoring and Operations can be divided into classifications A, B, and C.

**Classification A Spare Parts**

Spare Parts with classification A consist of 52 (fifty two) items of Spare Parts. The A classification indicates that these spare parts are critical to the Directorate of Fleet Monitoring and Operations and require special management, given the very large number and rapid turnover or high demand for these parts. The majority of spare parts that are in high demand are Racor and Filter types. This is in line with the results of an interview with the Directorate's spare parts management team. "But for parts that are often replaced, for example filters, insert elements, rafts, injectors are mostly available, available at distributors". (KI-5).

**Classification B Parts**

These spare parts are quite important and have considerable value for the Directorate of Fleet Monitoring and Operations, so they require fairly strict management after classification A.
**C Classification Parts**

The spare parts owned by the Directorate of Fleet Monitoring and Operations are quite a lot, but the value is low so it does not require special management such as groups A and B. Therefore, the focus of research will be focused on calculating the EOQ method and monte carlo simulation of fast-moving parts and having a classification A. The EOQ (Economic Order Quantity) method will determine the optimal amount of spare parts inventory by considering storage costs and ordering costs so as to minimize overall inventory costs. The EOQ formula takes into account spare parts needs per period, ordering costs, and storage costs.

Spare parts storage costs consist of warehouse rental costs, warehouse management personnel honorarium, and opportunity costs. Opportunity costs include potential revenue lost due to inefficient purchase of parts, such as loss of potential interest that can be earned by the State General Treasurer. The cost of ordering spare parts includes the cost of coordination and completeness of administration in the procurement of goods and services. By taking these costs into account, EOQ can be calculated for each part.

Furthermore, the calculation of Reorder Point (ROP) and Safety Stock is used to determine the procurement time and the minimum amount of stock that must be available in a period. Safety Stock is a spare part reserve during the procurement lead-time period, while Maximum Stock is the maximum number of parts that are still efficient. By applying the EOQ Method, the availability of spare parts stock will be measured according to Safety Stock as the lower limit and Maximum Stock as the upper limit, allowing the POA Directorate to manage spare parts stock efficiently and avoid unwanted shortages or excess stocks.

**Spare Parts Management Business Process**

Based on LKPP Regulation No. 12 of 2021 concerning the procurement of goods and services, Circular Number B.1550/SJ/PL.930/XII/2018 concerning Administration of State Property in the Form of Inventory, and Regulation of the Director General of PSDKP Number 10 of 2022 concerning Technical Guidelines for Maintenance and Maintenance of Fisheries Supervisory Vessels, Researchers compile a spare parts management business process at the POA Directorate with the application of the EOQ Method.

A business process is a structured set of activities that describe effective and efficient working relationships to produce value-added performance and outputs in accordance with organizational objectives. The absence of a spare parts management business process at the Ministry of Marine Affairs and Fisheries creates uncertainty in the implementation of its management, so the researcher compiled a business process model consisting of 2 (two) main activities including the business process of procurement, inventory, and storage of spare parts, as well as the business process of shipping and using spare parts. The explanation of the business process is as follows:

**Procurement, Inventory and Storage of Spare Parts**

<table>
<thead>
<tr>
<th>Proses Bisnis</th>
<th>Nakhoda Kapal</th>
<th>Direktur POA/ Pegawai Pembuat Komisian</th>
<th>Penanggung Jawab Suku Cadang</th>
<th>Operator SAKTI</th>
<th>Petugas Gudang</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pengadaan, Invenarisasi, dan Penyimpanan Suku Cadang</td>
<td>Missing undian kebutuhan suku cadang</td>
<td>Rencana Perubahan Order</td>
<td>Menghitung Economic Order Quantity, Reorder Point dan, Safety Stock</td>
<td>Rencana Umum Pengadaan</td>
<td>Pengadaan Suku Cadang melalui Surat Pemohon</td>
</tr>
<tr>
<td></td>
<td>Suku Kebutuhan Suku Cadang</td>
<td>Rencana Perubahan Order</td>
<td>Menghitung Economic Order Quantity, Reorder Point dan, Safety Stock</td>
<td>Rencana Umum Pengadaan</td>
<td>Pengadaan Suku Cadang melalui Surat Pemohon</td>
</tr>
<tr>
<td></td>
<td>Suku Kebutuhan Suku Cadang</td>
<td>Rencana Perubahan Order</td>
<td>Menghitung Economic Order Quantity, Reorder Point dan, Safety Stock</td>
<td>Rencana Umum Pengadaan</td>
<td>Pengadaan Suku Cadang melalui Surat Pemohon</td>
</tr>
</tbody>
</table>

**Figure 1.** Parts Procurement, Inventory, and Storage Business Process

*Spare parts for fisheries surveillance vessels inventory management in Ministry of Marine Affairs and Fisheries*
The picture above illustrates the business process flow of procurement, inventory, and storage of spare parts, involving several parties such as the Ship Skipper, POA Director/Commitment Making Officer, Person in Charge of Spare Parts, SAKTI Operator, and Warehouse Officer. The process begins with the Ship Master submitting a request for spare parts based on the operational needs of the ship to the Director of POA/PPK for analysis. Furthermore, the Director of POA/PPK analyzes spare parts needs, determines needs using the EOQ, ROP, and Safety Stock methods, then submits them to the Person in Charge of Spare Parts for inventory.

After that, the Person in Charge of Spare Parts takes inventory of parts in the warehouse, orders the necessary parts if they have reached the ROP, and encodes the parts for identification. SAKTI operators record incoming spare parts according to BAST and code, then conveyed to the Warehouse Officer for classification and storage. Finally, the Warehouse Officer classifies and stores spare parts according to their type and group to facilitate management and search in the future.

**Delivery and Discharging of Spare Parts**

The picture above is a diagram of the business process flow of shipping and using spare parts involving the Ship Skipper, POA Director/Commitment Making Officer, Person in Charge of Spare Parts, SAKTI Operator, and Warehouse Officer. The process begins with the Ship Skipper submitting a spare parts request through a form submitted to the POA Director or Commitment Making Officer. Upon receipt of the form, the Director of POA/KDP makes a disposition to the Person in Charge of Spare Parts for verification. If verification is appropriate, the request is forwarded to the Warehouse Officer for delivery; otherwise, the request is returned to the Ship Skipper for repair.

The Warehouse Officer sends the verified parts to the Ship's Skipper, who then stores and uses the parts as needed. After usage, the Ship Master makes a Minutes of Use report and submits it to the SAKTI Operator for recording in the system. The Person in Charge of Spare Parts takes inventory to ensure all data is recorded correctly. This business process model, including procurement, inventory, storage, delivery, and use of spare parts, is categorized as a level 3 business process and will be proposed to the Secretariat of the Directorate General of PSDKP to be determined through the Decree of the Minister of Marine Affairs and Fisheries in accordance with PERMENKP Number 3 of 2024.

**Monte Carlo Simulation of the EOQ Method**

Ardiansyah (2018) explained that Monte Carlo Simulation is a simulation method that generates random values based on the distribution of factual data. In Monte Carlo Simulation, Random Demand Number Generation is used by utilizing the normal distribution. Hakim (2017) mentioned that the process of generating random demand numbers can be done using Microsoft Excel with the formula =
ROUNDUP(NORMINV(RAND(); Mean; Standard Deviation); 0), based on the mean and standard deviation of parts requirement data.

To carry out random demand number generation, a data normality test using SPSS is needed. SPSS, capable of managing big data, provides descriptive and inferential functions, including the Shapiro-Wilk normality test for data under 30 samples. The normality test hypothesis is that H0 (normally distributed data) is accepted if the Sig value ≥ 0.05 and H1 (non-normally distributed data) is accepted if the Sig value is < 0.05. Based on the results of the normality test with SPSS, the spare parts requirement data is normally distributed because the Sig value is above 0.05.

After confirming the normal distribution, it is generated random numbers in Excel for each part using the predetermined distribution, mean, and standard deviation. Monte Carlo simulation is applied to the EOQ method in parts management in the POA Directorate. The results of this simulation will compare the total cost between the EOQ method and periodic procurement, taking into account storage costs (opportunity costs, warehouse rent, warehouse staff costs) and ordering costs (procurement costs of goods and services).

Simulasi Monte Carlo terhadap Insert Element Pre Fuel Filter Racor Parker 2010

Through Random Demand Number Generation, spare parts requirement data was obtained to simulate the use of the EOQ method on Insert Element Pre Fuel Filter Racor Parker 2010 spare parts. This simulation shows the initial stock, reorder point (ROP), order quantity (Q), procurement amount, monthly needs, and ending stock for each month. An example of the result is that in the first month, with an initial stock of 76 and a need of 92, 128 units were procured so that the final stock became 112. The 12-month simulation shows a pattern of procurement and use of spare parts adapted to the EOQ method.

After the simulation, the authors compared the total cost of using the EOQ method with the periodic procurement method. For the EOQ method, the storage cost was recorded at 13,574,003 and the order fee was 7,881,556, so the total cost was 21,455,560. As for the periodic procurement method, the storage cost reached 62,677,208 and the order cost 1,125,000, for a total cost of 63,802,208. This comparison shows that the EOQ method is more efficient with a much lower total cost compared to periodic procurement.

Monte Carlo Simulation of Fuel Filter Spin On IR-0751

Through Random Demand Number Generation, spare parts requirement data was obtained to simulate the use of the EOQ method on Fuel Filter Spin On IR-0751 spare parts. This simulation includes initial stock, reorder point (ROP), order quantity (Q), procurement, monthly needs, and final stock each month. For example, in the first month, the starting stock is 21, with the need for 14% and the procurement 47%, bringing the final stock to 54. During the 12-month simulation, the pattern of procurement and use of these parts was adjusted to the EOQ method to maintain optimal stock.

After simulation, the authors compared the total cost of the EOQ method with the periodic procurement for Fuel Filter Spin On IR-0751 parts. Based on the EOQ method, the storage cost was recorded at 5,901,717 and the order cost was 3,375,000, so the total cost was 9,276,717. As for the periodic procurement method, the storage cost reached 9,529,277 and the order cost 1,125,000, for a total cost of 10,654,277. This comparison shows that the EOQ method is more efficient with lower total cost compared to periodic procurement.

Simulasi Monte Carlo terhadap Insert Element Pre Fuel Filter Racor Parker 2020 10 Mic

Through Random Demand Number Generation, a simulation was carried out using the EOQ method for Insert Element Pre Fuel Filter Racor Parker 2020 10 Mic parts. The simulation data shows the initial stock, reorder point (ROP), order quantity (Q), procurement, monthly needs, and final stock each month. For example, in the first month, the starting stock is 35, with the need for 18% and the procurement 55%, bringing the final stock to 72. For 12 months, the pattern of procurement and use of these parts was adjusted to the EOQ method to maintain optimal stock.

After simulation, the authors compared the total cost of the EOQ method with the periodic procurement for these parts. Based on the EOQ method, the storage cost was recorded at 8,141,780 and the order cost was 4,500,000, so the total cost was 12,641,780. As for the periodic procurement method, the storage cost reached 12,705,794 and the order cost 1,125,000, for a total cost of 13,830,794. This comparison shows that the EOQ method is more efficient with lower total cost compared to periodic procurement.

Monte Carlo simulation of Oil Filter IR-1808

Through Random Demand Number Generation, a simulation of the use of the EOQ method for IR-1808 Oil Filter spare parts was carried out. The simulation data shows the initial stock, reorder point (ROP), order quantity (Q), procurement, monthly needs, and final stock each month. As an example of the result, in the first month, the initial stock is 35 with a requirement of 7, so the final stock becomes 28 without procurement. For
12 months, the pattern of procurement and use of spare parts was arranged according to the EOQ method to maintain optimal stock, with a total demand recorded at 159 units.

After simulation, the authors compared the total cost of the EOQ method with the periodic procurement for these parts. Based on the EOQ method, the storage cost was recorded at 3,090,552 and the order cost was 5,625,000, so the total cost was 8,715,552. As for the periodic procurement method, storage costs reached 12,438,204 and order costs 1,125,000, for a total cost of 13,563,204. This comparison shows that the EOQ method is more efficient with lower total cost compared to periodic procurement.

**Monte Carlo Simulation of Spin On X57508300091 Fuel Filter**

Through Random Demand Number Generation, a simulation was carried out using the EOQ method for Spin On X57508300091 Fuel Filter spare parts. The simulation data shows the initial stock, re-order point (ROP), order quantity (Q), procurement, monthly needs, and final stock each month. For example, in the first month, the initial stock is 16 with a requirement of 3, so the final stock becomes 29 after the procurement of 22 units. For 12 months, the pattern of procurement and use of spare parts was arranged according to the EOQ method to maintain optimal stock, with a total demand recorded at 212 units.

After simulation, the authors compared the total cost of the EOQ method with the periodic procurement for these parts. Based on the EOQ method, the storage cost was recorded at $5,042,868 and the booking cost was $4,500,000, bringing the total cost to $9,542,868. As for the periodic procurement method, storage costs reached 26,165,827 and order costs 1,125,000, for a total cost of 27,290,827. This comparison shows that the EOQ method is more efficient with lower total cost compared to periodic procurement.

**Monte Carlo Simulation of FO Racor XP59408300054 Cartridge**

Through Random Demand Number Generation, a simulation was carried out using the EOQ method for FO Racor XP59408300054 Cartridge spare parts. The simulation data includes initial stock, reorder point (ROP), order quantity (Q), procurement, monthly needs, and ending stock each month. For example, in the first month, the initial stock was 26 with a requirement of 22, so the final stock becomes 29 after the procurement of 25 units. For 12 months, the pattern of procurement and use of spare parts was arranged according to the EOQ method to maintain optimal stock, with a total demand recorded at 161 units.

After simulation, the authors compared the total cost of the EOQ method with the periodic procurement for these parts. Based on the EOQ method, the storage cost was recorded at $13,276,747 and the booking cost was $7,875,000, bringing the total cost to $21,151,747. As for the periodic procurement method, the storage cost reached 40,218,827 and the order cost 1,125,000, for a total cost of 41,343,828. This comparison shows that the EOQ method is more efficient with lower total cost compared to periodic procurement.

**Monte Carlo Simulation of FO Racor FBO-60337 Cartridge**

Through Random Demand Number Generation, a simulation was carried out using the EOQ method for spare parts of the FO Racor FBO-60337 Cartridge. The simulation data includes initial stock, reorder point (ROP), order quantity (Q), procurement, monthly needs, and ending stock each month. For example, in the first month, the initial stock was 16 with a requirement of 3, so the final stock became 37 after the procurement of 24 units. For 12 months, the pattern of procurement and use of spare parts was arranged according to the EOQ method to maintain optimal stock, with a total demand recorded at 136 units.

After simulation, the authors compared the total cost of the EOQ method with the periodic procurement for these parts. Based on the EOQ method, the storage cost was recorded at 6,941,391 and the order cost was 5,625,000, so the total cost was 13,691,391. As for the periodic procurement method, the storage cost reached 24,539,285 and the order cost 1,125,000, for a total cost of 25,664,285. This comparison shows that the EOQ method is more efficient with lower total cost compared to periodic procurement.

**Monte Carlo simulation of Air cleaner 243-6350**

Through Random Demand Number Generation, a simulation was carried out using the EOQ method for Air cleaner spare parts 243-6350. The simulation data includes initial stock, reorder point (ROP), order quantity (Q), procurement, monthly needs, and ending stock each month. For example, in the first month, the initial stock is 11 with a requirement of 5, so the final stock becomes 30 after the procurement of 24 units. For 12 months, the pattern of procurement and use of spare parts was arranged according to the EOQ method to maintain optimal stock, with a total demand recorded at 62 units.

After simulation, the authors compared the total cost of the EOQ method with the periodic procurement for these parts. Based on the EOQ method, the storage cost was recorded at 5,532,289 and the order cost was 3,375,000, so the total cost was 8,907,289. As for the periodic procurement method, the storage cost reached 8,288,862 and the order cost 1,125,000, for a total cost of 9,413,862. This comparison shows that the EOQ method is more efficient with lower total cost compared to periodic procurement.
Comparison of EOQ Method with Existing Method

After conducting Monte Carlo Simulation with Random Demand Number Generation, there is a cost comparison between the EOQ Method and the Existing Method for various types of parts. The results are recorded in Table 4.38, which shows the costs based on the EOQ Method and the periodic procurement costs (Existing) for each spare part. It can be seen that the application of the EOQ Method consistently results in lower total costs compared to the periodic procurement method. Overall, there was an increase in inventory cost efficiency of Rp100,180,381 through the use of the EOQ Method in the management of spare parts of the POA Directorate. This shows the importance of implementing more efficient methodologies in inventory management to reduce operational costs significantly.

Simulation and Discussion of Spare Parts Management Model at POA Directorate

To validate the reliability of the spare parts management model that has been prepared, the author carried out a series of discussions and simulations of the Spare Parts Management Model involving various related parties. Discussions and simulations were conducted based on the EOQ (Economic Order Quantity) method and involved the Person in Charge of Spare Parts, the Maintenance and Maintenance Work Team for Supervision Facilities, Financial Management Staff from the POA Directorate, and the Goods and Services Procurement Team of the Secretariat of the Directorate General of PSDKP. These steps are important to ensure that the model drawn up is not only theoretical, but also practical and can be applied well in the context of parts management.

In the discussion, the author conveyed several root problems found based on data and information that had been obtained and analyzed through Root Causes Analysis. Then, the author conveys the Spare Parts Management Model by including the EOQ Method in it. Based on the meeting, several things were obtained as follows:

a. Changes in the type of contract from unit price to umbrella contract as well as the use of the EOQ method are possible. Especially, the POA Directorate has experience in the implementation of umbrella contracts;

b. The EOQ method should be assigned to fast-moving parts considering that stock parts are unpredictable in use and are generally scarce; and

c. This spare parts management model may be used but coordination will be re-carried out with related parties such as providers.

CONCLUSION

Based on the results of the study, it was concluded that the management of spare parts at the POA Directorate was not optimal due to several factors, including the lack of operator involvement in recording inventory, the use of procurement methods that are not adaptive to changing needs, and the use of manual inventory tools. This finding shows that the management of spare parts in MMAF as a whole is also not optimal due to the absence of established business processes. Therefore, researchers develop a business process model for the management of spare parts for fisheries supervisory vessels, which includes procurement, inventory, storage, delivery, and discharging of spare parts. This model is expected to be an input in the determination of decisions of the Ministry of Marine Affairs and Fisheries. The application of the EOQ method in the model can increase the efficiency of spare parts management by Rp100,180,381. Suggestions include measures such as controlling parts code recording, procurement through umbrella contracts under EOQ, and digitization and integration of inventory processes using inventory management computer programs to improve the efficiency and accuracy of parts management.

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Spare parts for fisheries surveillance vessels inventory management in Ministry of Marine Affairs and Fisheries


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