Analysis and Planning of a Supplementary Inventory System

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Abstract

PT. XYZ is a service company in the field of marine expeditionary, precisely on shipping or ferry ship with a line on track Merak - Bakauheuni. In the registration of spare parts, this process is still manual, and reparations of broken or damaged spare parts are still using the official report form. This study analyses the process of recording parts running at the Munic Line. Then the analysis will be done to provide safety stock inventory and Reorder points based on the lowest total cost, which will also be supported by the inventory system design. The method used to analyze the model inventory analysis is the EOQ model, EOI, and Min-Max Inventory. The system's design will use the concept of Unified Modeling Language (UML) and the concept of Object-Oriented Analysis and Design (OOAD) and design analysis based on the model Satzinger with Unified Process Life Cycle stages. It is intended to support the process of recording and registering spare parts inventory in the future.

Keywords
Inventory, UML, OOAD, Inventory Control, Registering and Recording Inventory

1. Introduction
Inventory is one of the most expensive assets of many companies, reflecting as much as 50% of the total invested capital (Heizer and Render, 2014). Operations managers worldwide have long recognized that good inventory is a very important and major part of the balance sheet and is often an estimate of considerable value that involves large working capital. Without the availability of goods, the Company will face the risk that, at one time, it could not fulfill the desires of its customers. Therefore, inventory is a decision that must be optimal to satisfy customers and suppliers. Because when the Company also has a stock of goods that are piling up and not being used, it will certainly be a storage cost which will cost considerable inventory because Heizer and Render (2014) explain that the Company can reduce inventory costs by reducing inventory, but if the inventory does not match demand, then the Company will lose customers. To realize the inventory is carried out properly and stably, the Company must apply the concept of inventory management that is appropriate and acceptable to various parties. In terms of the amount of inventory, each Company has a different amount, and usually, the amount is in accordance with the needs of the Company itself.

The Company needs supply with effective demand. This has been explained by Mikaelsen (2006) in an online article titled "MANAGING THE DEMAND FOR SPARE PARTS", which explains that the arrangement of spare parts is very important and needed by production companies and service companies. It is quoted from Mikaelsen's article (Mikaelsen, 2006) that managing spare parts appropriately can make companies reach their service targets without incurring high inventory costs. Parts have several periods in which there is no demand mixed with a sudden surge in demand. The following is an example drawing of a lumpy request diagram on several items (Figure 1):

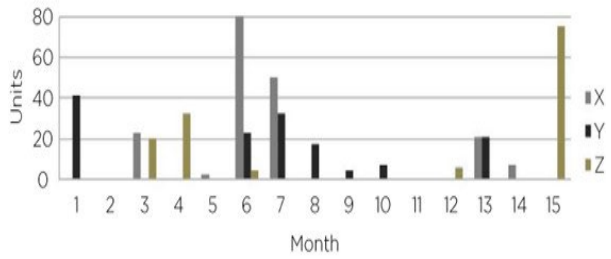

Figure 1. Lumpy Demand

Because the patterns of demand for spare parts are uncertain and varied, inventory management is very necessary because the procurement of spare parts alone can reach 70% of the total cost of procuring materials. On the other hand, the pattern of spare parts usage is influenced by technical aspects that need to be considered (changing and unpredictable field conditions). Companies are often faced with a culture of storing spare parts in large quantities to maintain the availability of spare parts, so operational activities are not stopped due to shortages, but with large amounts of storage, companies will incur storage costs because these spare parts that will be useful for operational activities and then useful for providing output processes namely services to customers (Pampa et al., 2011).

The reason researchers chose the topic of spare parts inventory is:

- One of the main problems in operational management, in the case of parts, spare parts purchases are not routinely purchased every month but are made routinely for each part. Demand arises every time a component fails or requires replacement. In other words, this type of request can be characterized as "intermittent", which means that requests arrive rarely and are spread out over a period of time with no requests at all, and thus can be very rare. Therefore, there is no excessive extra stock and the point of ordering when the spare parts stock has touched the minimum number is very much needed (Mikaelsen, 2006).

- Inventory Management also aims to avoid excessive expense in managing inventory by reducing inventory, but if it turns out that inventory reduction and it turns out the Company requires inventory does not match the reduction, then the Company is threatened not to satisfy its customers. Therefore, inventory management is needed by the Company and must pay attention to planning and controlling (Heizer and Render, 2014).

PT.XYZ is a national shipping company engaged in sea transportation that serves domestic shipping routes in the archipelago. PT. XYZ has an inventory that is divided into two types, namely inventory for consumables (Paint, Lubricants, Oil, Aquaproof, etc.) and also has inventory for items that are not used or can be called spare parts (NOZZLE, Ring service KIT, Cylinder Head, and others). PT. XYZ has not yet had an analysis of the purchase of spare parts, so far PT. XYZ only makes routine purchases according to the routine parts replacement schedule they have made and schedules for each spare part to be purchased quarterly. There are also purchases every six months, so they do not encounter any problems with demand because of PT (Lysons 2004, Gubala and Popielas 2005, Ballou 1998, Wei et al. 2013, Smith 2011, Nallusamy 2015). XYZ has overcome this by scheduling routine purchases to make replacements and routine maintenance of spare parts. PT. XYZ also does not have an interrelated inventory system for all kinds of goods, or it can also be said that it still has a manual system. This often creates problems such as stockout or loss of goods, or multiple records when taking parts that are being repaired. The following is an example of data that PT (Christopher 2016). XYZ experienced a stock out, so the ship that was owned could not sail and carry out operational activities and was very forced to experience anchor (floating) because it was unable to carry out shipping activities due to damage to parts that caused the ship could not sail and also did not have spare parts stock. Carried on the damaged parts, so the staff must bring the parts to the floating ship and repair them on the ship (Table 1).

Table 1. Anchor Ship Form

PERMINTAAN PERBAIKAN						
Tanggal		: 02 Oktober 2016				
Nama Kapal		: KM. Elysia				
Posisi		: Selat Sunda Menuju Merak				
Sifat		: Urgent / Perawatan				
No	Jenis Kerusakan		Pelaksana	Lokasi	Lama Perbaikan	Keterangan
1	Turbo Charger Main Engine No.1		Workshop dan Crew mesin	Terapung (Anchord)	3 (Tiga) Jam	Mulai dikerja jam 13.20 s/d 16.40
						Siap Operasi
	Team Workshop		Nahkoda		Operasi	

What can be seen in Table 1 is a repair request form from one of the vessels owned by PT. XYZ, where the ship is named KM. Elysia is required to anchor due to damage to the main engine turbo charger lid and the unavailability of other parts to be able to directly replace the damaged parts. This is caused by the lack of structured recording in the inventory section and also because the Company does not yet have a minimum stock to prevent the occurrence Parts damage that is naturally occurring cannot be predicted or known; therefore, the Company needs to have a minimum stock of spare parts. Following is the listing Table 2 of PT. XYZ about ships forced by the anchor.

Table 2. Anchor ship form

Pencatatan Kapal Anchord 2014 - 2016				
Tanggal	Nama Kapal	Jenis Kerusakan	Posisi	Keterangan
28 Maret,2014	Km. Elysia	Nozzle ME	Selat Sunda ke Bakauheni	Terapung 3 hari menunggu parts
17 Juli,2014	Km. Munic	Nozzle AE	Selat Sunda ke Merak	Menunggu masuk dock
9 Oktober,2014	Km. Munic	Nozzle ME	Selat Sunda ke Bakauheni	Terapung 1 hari menunggu parts
3 Januari,2015	Km. Caitlyn	Cylinder Head	Selat Sunda ke Merak	Terapung 2 hari menunggu parts
11 Februari,2015	Km. Caitlyn	Housing Valve	Selat Sunda ke Merak	Mulai Kerja 09.00 - 18.00
30 Juni,2015	Km. Munic	Nozzle AE	Selat Sunda ke Merak	Mulai kerja 19.00 - 08.00(Pagi harinya)
9 September,2015	Km. Caitlyn	Turbo Engine	Selat Sunda ke Bakauheni	Terapung Sampai parts tiba(belum diketahui)
10 Desember,2015	Km. Elysia	Nozzle ME	Selat Sunda ke Bakauheni	Terapung 1 hari menunggu parts
4 Maret,2016	Km. Caitlyn	Turbo Charger Head	Selat Sunda ke Bakauheni	Mulai Kerja 11.40 - 14.00
5 Agustus,2016	Km. Munic	Nozzle AE	Selat Sunda ke Merak	Terapung 3 hari menunggu parts
12 Oktober,2016	Km. Elysia	Housing Valve	Selat Sunda ke Merak	Mulai Kerja 13.20-16.40

Of course, this affected the Company's income because the ship could not sail temporarily and the income from PT. XYZ is also hampered because the ship cannot fulfill the shipping request.

In addition to the problem of unstructured inventory, the Company also has other problems related to an inaccurate inventory data collection system and using a system that can still be fairly manual, namely using Excel, and sometimes the system has a record that is not in accordance with the availability of available stock in the inventory. Here are some examples of parts that are still in data using Excel (Table 3):

Table 3. Example of Spare Parts Inventory

NO	ITEMS	POSISI			PART NAME	PART NUMBER	STOCK AWAL	AGUSTUS		SEPTEMBER		SUMMARY			KET.
								IN	OUT	IN	OUT	IN	OUT	[illegible]	
[illegible]	[illegible]				[illegible]	-	2					0	0	2	Pcs
[illegible]	[illegible]				Globe Valve	[illegible]	6					0	0	6	Pcs
[illegible]	[illegible]				[illegible]	[illegible]	6					0	0	6	Pcs
[illegible]	[illegible]				[illegible]	-	2					0	0	2	Pcs
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12					0	12	[illegible]	Pcs
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12					0	0	12	Pcs
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	6					[illegible]	0	[illegible]	Pcs
[illegible]	[illegible]				Ring Piston Set Compressor	[illegible]	1					0	0	1	Set

If one of the spare parts is damaged, PT. XYZ will try to make repairs in advance to avoid new purchases, which cost and time. If the item is still possible to be repaired, the spare parts will be unloaded from the ship to be repaired at the

workshop, and the crew keeps a record of the minutes of the repaired parts at PT. XYZ still uses the official report form to record the items that will be entered for repair, and there is no integrated or related system to record spare parts inventory with a system that records spare parts that are being repaired. By using this official report, several times, there was a loss of goods or multiple or same data for an item that was repaired. There was a buildup of data while the data did not match the stock repairs in the workshop because the data collection was done inaccurately or this official report was lost so that several times the crew re-checked what kind of parts were repaired for the Elysia, or munic or caihtlyn ships. Using this manual system is less efficient because the crew has to check several times at the workshop and check the stock availability on the ship to ensure there is no error in data information.

The explanation of the data above data shows the existing system at PT. XYZ currently, especially in managing spare parts inventory, can still be considered not good, because by using a system that runs at this time, stock out often results in Anchor ships, which cause the ship to stop in shipping activities and, of course, the Company suffers losses because the ship cannot sail so PT. XYZ requires a minimum stock calculation on spare parts in accordance with the needs of PT. XYZ to avoid stock Out and excess inventory, which will result in large inventory costs. Besides that, there is a process of doubling reports on the receipt of spare parts, which will make the crew re-check the minutes to avoid reporting errors because buying the goods is not necessarily available in the market. Although available, the goods take time long enough to be delivered. Of course, the effect will also affect the Company's finances because the shipping target is not achieved due to unfinished or unavailable parts. Meanwhile, buying parts that suddenly will certainly take a long time and a high cost.

Based on the description of the problems above, the Company needs a new system that can provide efficiency, a system that can minimize the misinformation about goods that are repaired and also a system that can provide precise information about the stock of spare parts available. And also to provide a structured inventory of data collection and provide a warning to the system if the spare parts stock has touched a minimum of stock. For reasons and problems, the researchers intend to conduct research entitled "Analysis and Planning of Supplementary Inventory System at PT. XYZ".

1.1 Formulation of the problem

Based on the background and problems stated above, the formulation of the problem can be taken as follows:

- What is the right spare parts inventory model for PT. XYZ to be able to overcome the problems that occur?
- How Inventory Systems can help and assist PT. XYZ going forward?

1.2 Research purposes

The aim of this research is:

- To find out the right spare parts inventory model to overcome the problem at PT. XYZ.
- To find out how the new Inventory System can help and assist PT. XYZ in the future business process.

1.3 Benefits of Research

The benefits of this research are:

- For companies, it is helped by the existence of this Inventory system in terms of data collection and repair of spare parts. It improves the efficiency of the Company's performance and the calculation of Safety Stock and Reorder Point Parts.
- For readers, know the data collection problems and the process of providing information on spare parts efficiently that occur along with solutions to overcome these problems so that they can be used as study material for scientific development.
- For researchers get in-depth knowledge and understanding, both in theory and in the application of Inventory systems in the Company's operational activities.

2. Research Methods

The method used in this paper includes:

2.1 Data Collection

In collecting data there are a number of things needed, including:

2.1.1 Literature research
The researchers use a method based on several books as sources for references that support research needs.

2.1.2 Field Research
- Observation
  The researchers made direct observations on PT. XYZ.
- Interview
  The researchers directly conducted interviews with related parties from PT. XYZ which aims to capture data.

2.2 Data analysis method
2.2.1 Tif Descriptive Analysis
In achieving the first goal, which is to identify weaknesses and what is needed by the Company in the Inventory system process, a descriptive analysis method will be used, namely by grouping information to illustrate the weaknesses of the existing system and Inventory system requirements for the Company going forward. The methods used in this inventory management analysis are Economic Order Quantity (EOQ), Economic Order Interval (EOI), Re-Order Point (ROP), Safety Stock (SS), and Minimum-Maximum Inventory.

2.3 Design Method
System Design Method Done by making several designs. The design is made using UML (Unified Modeling Language) tools and also with the help of the OOAD (Object Oriented Analysis Design) approach.

3. Result and Discussion

Table 4. Cylinder Head Calculation Results

	EOQ	EOI	Min-Max Inventory
Q	13	6,496	1.064
Safety Stock	11	8	2
Re Order Point	28		224
Order Frequency	2,15	4	0,125
Total Cost	1.933.682,500	1.936.442.499,31	*1.938.990.000*

After knowing the comparison in inventory, the next best order amount by using the EOQ method can be used as a basis for ordering cylinder head parts on the system to be made because it has the lowest total cost (Table 4), which is certainly useful for companies to avoid excessive costs. With the above data calculation results, the calculation of Safety Stock and Reorder Points will be used as a minimum stock and alerts on the system that will be made later to avoid stock out and make a warning or a warning like a notification on the system if later the spare parts stock has touched the minimum number and are required to buy back stock to avoid stock out. Here are the calculations from the four other parts tables (Table 5).

Table 5. ME Nozzle Calculation Results

	EOQ	EOI	Min-Max Inventory
Q	79	17,6	320
Safety Stock	11	11	3
Re Order Point	36		323
Order Frequency	0,5	2	0,125
Total Cost	470.771.509,49	470.707.190,9	*470.453.750*

The ME Nozzle calculation shows that the best method in terms of the total cost is the appropriate min-max inventory method applied for Main Engine Parts Nozzle inventory (Table 6).

Table 6. Results of Calculation of AE Nozzle

	EOQ	EOI	Min-Max Inventory
Q	49	22,62	572
Safety Stock	15	15	4
Re Order Point	47		264
Order Frequency	1,06	2	0,09
Total Cost	509.367.028,06	510.104.089,94	509.635.454,54

In the calculation of the Nozzle AE, it can be seen that the best method in terms of total cost is the proper EOQ method applied for inventory Nozzle Auxiliary Engine Parts (Table 7).

Table 7. Calculation of Valve Settings

	EOQ	EOI	Min-Max Inventory
Q	213	6,64	128
Safety Stock	7	7	1
Re Order Point	17		129
Order Frequency	0,075	2,4	0,125
Total Cost	451.405.606,8	439.758.245,52	*439.097.750*

In the Valve Setting calculation, it can be seen that the best method in terms of total cost is the appropriate min-max inventory method applied for Parts Valve Setting inventory (Table 8).

Table 8. Calculation of Valve Housing

	EOQ	EOI	Min-Max Inventory
Q	9	3,68	184
Safety Stock	9	5	2
Re Order Point	23		186
Order Frequency	2,25	6,25	0,125
Total Cost	1.049.671.944,444	1.051.093.625	*1.051.779.625*

In the calculation of the Valve Housing, it can be seen that the best method in terms of total cost is the proper EOQ method applied for inventory of Valve Housing Parts (Table 9).

Table 9. Results of Calculation of Total Costs

Spareparts	EOQ	EOI	Min-Max Inventory	Minimum Cost
Cylinder Head	1.933.682,500	1.935.961.383,15	1.938.990.000	1.933.682,500
Nozzle ME	470.771.509,49	470.707.190,9	*470.453.750*	*470.453.750*
Nozzle AE	509.367.028,06	510.104.089,94	509.635.454,54	509.367.028,06
Setting Valve	451.405.606,8	439.758.245,52	*439.097.750*	*439.097.750*
Housing Valve	1.049.671.944,444	1.051.093.625	*1.051.779.625*	1.049.671.944,444

Of the five parts that have been sampled for inventory calculations, three parts use the EOQ method, and also two parts use the min-max inventory method. The choice of method is based on the lowest total cost because it can help the Company's finances in arranging the purchase, maintenance, and management of spare parts for its ships. From the five calculations, each Safety Stock and Reorder Point will be used and then synchronized to the system to be made and record the stock of the spare parts with the record that each part has its Safety Stock and Re-Order Point selected respectively based on the inventory calculation method the most appropriate for each part.

3.1 System Planning

Based on the OOAD and UML approaches used for system design, the new Inventory system has been produced as follows (Figure 2):

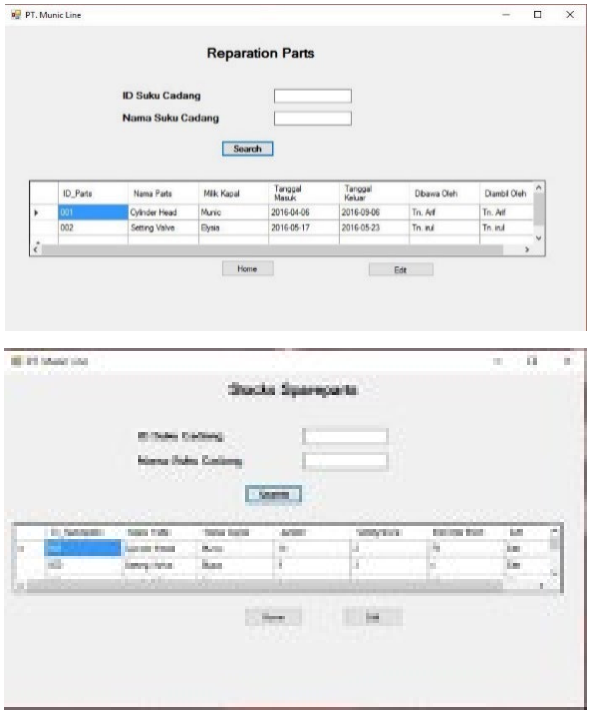

Figure 2. System User Interface

The result is to create a system for inventorying parts that have alerts for a minimum stock taken from the results of the inventory analysis calculation from the Company's annual parts purchase list. Use safety stock as a minimum stock alert and Reorder point as an alert to buy back parts that have touched the minimum stock number. This can be useful to prevent the occurrence of stock out, which causes the ship anchor, and also make a special form menu for the 'Repair Parts' menu to eliminate the use of the news form.

4. Conclusion and Suggestion

4.1 Conclusion

Based on data analysis and discussion that has been done in the previous chapter, the researchers can draw conclusions:

- Inventory system processes that run on PT. XYZ has been done manually so far using the official report form and does not have an exact calculation of the minimum stock of spare parts in the Company's inventory system of PT. XYZ, which can still be calculated using a manual system.
- The calculation method for controlling spare parts inventory used is the EOQ Model, EOI Model, and Min-Max Inventory. Based on the calculation of 5 crucial parts used as samples, the results show that three parts use the EOQ model method, and two use the Min-Max Inventory method.
- Designing an inventory system at PT. XYZ can assist companies in data collection and recording of spare parts and can avoid stocking out of parts due to ReOrder Points and SafetyStock in the new inventory system that makes the inventory system provide alerts or notifications that the parts have touched the minimum numbers and requires a reorder to avoid running out of stock of these parts.

4.2 Suggestion

Based on the analysis of the data that has been done and the discussion that has been explained in the previous chapter, the researchers can draw conclusions:

- The Company must conduct training in some of the divisions involved and will be tasked with using the new inventory system to avoid misuse of the system.
- There needs to be monitoring or supervision regularly so that the system can run optimally, and it is necessary to evaluate at a certain time periodically to make the Company more optimal.
- The inventory system can run optimally with alerts or notifications on each part if the parts have touched a minimum number and require the purchase of these parts.

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