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Research article

Improve TAT Refurbishment Process Excavator 20 Tons in Heavy Equipment Workshop

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A B S T R A C T

This study discusses the turnaround time (TAT) process in the 20 Tons Excavator refurbishment process carried out by a heavy equipment repair shop in Palembang City. TAT is the time range for the completion of the work, starting from when the tool arrives at the workshop until the job is completed. In this study, the employer is the owner of the heavy equipment, and the work recipient is the workshop where the heavy equipment is carried out. Based on the workshop records, during the 20 Tons TAT Excavator's refurbishment process, the best time was achieved was 56 working days. At the same time, the entrepreneur felt that 56 days was too long and the entrepreneur asked that this repair could be completed within a maximum of 30 working days. This delay causes huge losses for entrepreneurs resulting in lost business opportunities. This research aims to increase the TAT for the completion of the 20 Tons Excavator refurbishment work completion time following the work completion agreement. For this reason, it is necessary to conduct a study to determine the causes of delays in repair work. In this study, the authors use the method used in this analysis: Define, Measure, Analyze, Improve and Control (DMAIC). Based on the research, it was found that three things significantly affect the delay in completing the work, namely the limited area for painting, work agreements as a result of the availability of spare parts and completion of work from third parties. In the process of reconditioning heavy equipment, namely setting up the painting area, availability of spare parts and ensuring the completion of work submitted to third parties, to achieve the fastest time for completion of work.

1. INTRODUCTION

Heavy equipment is an integral part of the construction of facilities and infrastructure [1]. However, heavy equipment is needed for infrastructure development and by other parties, the mining, agriculture, forestry, and industrial sectors to mobilize goods and services. The limited national supply of heavy equipment manufacturers affects the availability of heavy equipment [2]. The tight competition makes construction service companies have to maximize each company's potential and capabilities, especially in managing human resources and operational resources such as heavy equipment machines, transportation machines, and so on.

Productivity is one aspect that determines a company's success in increasingly fierce competition. The level of productivity the company achieves indicates its efficiency and effectiveness in processing its economic resources. One of them is managing heavy equipment, which is the main support in the smooth production process [3]. Production of heavy equipment members of the Indonesian Heavy Equipment Industry Association

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(Hinabi) throughout 2021 increased significantly compared to 2020. In 2022, heavy equipment business players are optimistic that the demand increase will continue. Launching data on the production of Hinabi construction and heavy mining equipment, the total production of heavy equipment in 2021 is 6,740 units, up 96.6% YoY from the previous 3,427 units in 2020 [2].

Customers can achieve optimal use of heavy equipment if the factors that affect the work of heavy equipment can be carried out efficiently [1]. The dependence on heavy equipment for the smooth running of the production process is very high and vital. A structured maintenance system is needed for heavy equipment to be guaranteed to operate correctly and optimally. An unstructured maintenance system causes equipment to be easily damaged and the production process will be hampered or even stopped [4].

Although the demand for heavy equipment is increasing, heavy equipment business players still need to pay attention to several challenges. The development of the COVID-19 pandemic also influences the materials available for heavy equipment production and human resource factors. The demand for heavy equipment is mainly met through imports. This shortage of heavy equipment becomes an opportunity to rejuvenate used equipment.

In general, turnaround time (TAT) is the interval from submitting a process to the completion time of the process [5]. In this study, TAT is specifically used to present the targeted time limit agreed by the employer and the job recipient for 30 working days; in fact, there is a delay in completing the work to 56 working days, this can result in great disappointment and loss for the equipment owner. Including the opportunity to sell the tool or take advantage of it in getting a new work contract. This study discusses the TAT in the refurbishment process of the 20-ton excavator heavy equipment carried out at a heavy equipment workshop in Palembang. The analysis is carried out on the factors that cause delays in the refurbishment work using the Define, Measure, Analyze, Improve, Control (DMAIC) method [6]. The data was taken during the first and second weeks of January 2021. Based on the results of this study, problems were obtained, including the availability of spare parts and work carried out by third parties (vendors) for rejuvenating heavy equipment and the inaccuracy of the work completion time. Therefore, this study aimed to identify and analyze the factors causing the delay in the TAT in the refurbishment process of the 20 Tons class excavator in an effort to achieve the expected time target.

2. METHODOLOGY

2.1. Research Design

The method in this study is observational with retrospective data collection using 2020 data. This data is in the form of refurbishment data from several 20 Tons class excavator heavy equipment carried out by a workshop in Palembang City.

2.2. Heavy Equipment Criteria

The criteria for heavy equipment are the 20 Tons class excavator owned by a heavy equipment rental business with the same use, maintenance, and management culture.

2.3. Scope of Work Criteria

The criteria for the refurbishment process in this study are repairs carried out by the functions and completeness of heavy equipment following the results of checking, measuring, and testing heavy equipment according to their specifications so that each tool will have different components, spare parts, and duration of work.

2.4. Data Collection

The data collected is in the form of heavy equipment refurbishment process chain data consisting of receiving, disassembling tools and components, administration and approval of work, procurement of spare parts and work carried out by outside parties, installation of equipment components, and testing of equipment performance.

This research begins with a preliminary study carried out by field and literature studies. The field study was conducted in a heavy equipment workshop using the Six Sigma principle with the

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Define, Measure, Analyze, Improve, and Control (DMAIC) method. In general, Six Sigma is a methodology used to make continuous improvement efforts and process improvements (Continuous Improvement). [7].

Six Sigma uses five stages in problem-solving known as the DMAIC method, namely:

1. Define – Stages to define and select the problems to be solved.
2. Measure – The measurement stage of the problem that has been defined to be solved in the data collection stage, which then measures the characteristics and capabilities of the current process to determine what steps must be taken to make improvements and further improvements.
3. Analyze – Stages to find solutions when solving problems based on root causes that have been identified.
4. Improve – This stage takes corrective action against these problems by conducting tests and experiments to optimize the solution so that it is beneficial to solve the issues experienced.
5. Control – This stage is to set standardization and control and maintain the process that has been improved and improved in the long term and prevent potential problems that will arise in the future or when there is a change of process, workforce, or management change.

In this study, only two stages of DMAIC were carried out, namely Define and Measure

3. RESULTS AND DISCUSSIONS

Table 1. Project Plan

DMAIC	W 1-2	W 3-4	W 5-6	W 7-10	W 11-16
Define					
Measure					
Analyze					
Improve					
Comtrol					

The schedule for the refurbishment process of heavy equipment is in Table 1, namely the Define stage in the first (W1) and second (W2), measure stages in the third (W3) and fourth (W4), analyze stages in the fifth (W5) and sixth (W6), the improve stage is in the seventh week (W7) to the tenth week (W10), the control stage is in the eleventh week (W11) until the sixteenth week (W16).

3.1. Define

At this stage, we map out the current process as it is, along with the chain of heavy equipment rejuvenation processes [8].

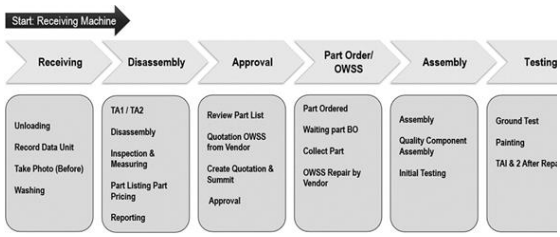

Figure 1. Heavy equipment process refurbishment chain

In Figure 1, the heavy equipment refurbishment process has six stages, namely Receiving (Acceptance stage), Disassembly (component inspection stage), Approval (Work approval stage), Parts order, and OWSS (Stage for supplying spare parts and work carried out by parties outside the heavy workshop equipment), Assembly (Assembling heavy equipment components), and Testing (The stage of testing the performance of the tool refers to the standard specifications of the tool.

The first stage in the chain of refurbishment processes on a 20 Tons excavator heavy equipment workshop, namely Receiving (Stage of receiving heavy equipment), includes Unloading (Receiving and unloading goods from sending equipment to storage locations), Record Data Unit (Making records of item list data), Take photos (Documenting pictures of goods), and Washing (Washing tools).

If the employer sends the tool to the workshop area, the workshop staff will unload the tool from the carrier to a storage location in the workshop area. A good process for receiving goods by a repair shop clerk must verify that he has received the right goods, in the right quantity, in the right condition

and at the right time. Failure to do so will have a consequential impact on all subsequent stages.

To ensure which goods or components are received by the workshop when the goods are received, it is necessary to record and the results need to be known by both parties, namely the sender of the goods and the recipient of the goods. This is closely related to the need for goods or components that need to be completed if they are not found in the goods received.

Documentation in the form of photos of the goods or components received is necessary so that both parties, the sending party, and the receiving workshop, have evidence and data similarity.

The next job in the form of washing tools or components needs to be done so that the following stages are more comfortable and enjoyable, and will provide an overview of the detailed condition of the goods, whether there are damaged, cracked and so on.

The second stage in the 20 Tons Excavator heavy equipment refurbishment process chain, namely Disassembly. The disassembly stages include Technical Analysis 1 and Technical Analysis 2, Disassembly, Inspection & Measuring, Parts list, Pricing, and Reporting.

To determine the condition of tools or components of heavy equipment, it is necessary to conduct a more detailed examination by conducting inspections in the form of Technical Analysis 1 and Technical Analysis 2. assessment of the entire circumference of the tool. While Technical Analysis 2 is in the form of inspection, checking, and measurement for the work of tools or components using measuring tools.

Furthermore, this release process is called the disassembly process by removing each part of the tool in the form of components and in more detail in the form of spare parts.

After removing the above, we need to inspect the condition of each spare part and component according to the manufacturer's instructions in the form of GRPTS (Guideline Reusable Parts) which is a guideline made by the manufacturer in determining whether the spare parts or components are still suitable for use or not and then we make a list according to the category of spare parts or components. Features that can be used again or not.

Furthermore, spare parts or components that are not suitable for use will be priced, or procurement costs will be made.
At the end of this stage, a report on the condition of the equipment and costs incurred as an offer to the employer is made.

At the Approval stage, the employer will take steps in the form of checking the list of spare parts or components submitted by the workshop in the form of a list of spare parts or components that can still be used and those that cannot be used so that the employer bears the costs.

In addition to spare parts or components that are carried out by the workshop itself, there is a possibility that there are parts of work that are not carried out by the workshop which may be handed over to other workshops outside the workshop which is usually called OWSS (Out Work Side Service) which needs to be known.

After that, the workshop will make an offer to the owner of the heavy equipment, the price for repairs in the form of the need for spare parts in the form of services and working time.

The final step of this stage is the owner will approve the implementation of the work with details of spare parts and costs proposed by the workshop.

As a follow-up to the approval of the offer mentioned above, the workshop will continue the next step in carrying out complementary work by ordering spare parts or components and third parties can work on those given by the workshop. All this will be collected during the workshop.

The next stage is installing and assembling spare parts or components, known as assembly, according

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to the instructions with specifications determined by the manufacturer and of course, doing initial testing on these spare parts, components and tools.

As the final stage of the heavy equipment refurbishment process is Testing. Testing implementation is a crucial stage, so the tool owner accepts the entire series of repair stages. The purpose of testing is to ensure that the tool works according to the specifications specified by the manufacturer. There are three steps in the testing stage: ground test, painting, and Technical Analysis 1 and Technical Analysis 2.

This ground test is crucial to ensure that all repair work and tools meet the manufacturer's specifications and that the tool owner can operate normally and productively.

For the satisfaction of the tool owner or employer, the tool is repainted to make it attractive to look at.

Furthermore, to complete all corrective repairs and ready-to-use tools, it is necessary to carry out final measurements and checks in the form of Technical Analysis 1 and Technical Analysis 2, as explained above.

SIPOC Diagram (*Supplier, Input, Process, Output and Customer*)

This diagram will provide an overview of the influence and process on customer service (employers) and the final result of the SIPOC diagram (Table 2) is a "template" to define the process before we start to map, measure, and improve the process [8].

Table 2. SIPOC Diagram

Supplier	Input	Process	Output	Customer
Pemilik alat	Ticket	RECEIVING	Job Description	Service operation
Service operation	Service order no.	DIS-ASSEMBLE	Parts list/ Quotation	Pemilik alat
Pemilik alat	Parts list / Quotation	APPROVAL	Quotation approval	Service operation
Service operation	Quotation approval	PARTS ORDER/ OWSS	New parts/ Component repair	Serviceman
Serviceman	New parts/ Component repair	ASSEMBLY	Unit ready to test	Serviceman
Servicenan	Unit ready to test	TESTING	Unit ready to delivery	Pemilik alat
INPUT INDICATOR		PROCESS INDICATOR		OUTPUT INDICATOR

In Table 2 above, SIPOC can clearly see the process indicators in the Receiving process, Disassembly process, Approval process, Parts order/OWSS process, Assembly process, and Testing process. Where are the input indicators from and what are the inputs and what are the results (output indicators) and for what purpose.

In the Receiving Process, it comes from the owner of the internal equipment in the form of tickets and the results obtained are in the form of a job description for the service operation section.
The Disassembly stage is sourced from the service operation in the form of a service order number and the results in the form of a list of spare parts and offers for tool owners.

The approval process is sourced from the equipment owner in the form of a list of spare parts; the result is an offer of approval for service operations.
The process of ordering spare parts and OWSS is sourced from the tool's owner in the form of approval of the spare parts list / OWSS and the result is the approval of spare parts for service operations.

The assembly process comes from the serviceman in the form of new spare parts or components that have just been repaired and the result is the readiness of the tool to be tested for its performance by the serviceman.

The last process is testing from the serviceman in the form of a unit ready to be tested for performance and the results of the tool being tested are prepared to be handed over to the device owner.

VOC & VOB

Voice of Customer (VOC) is a customer's needs and desires that are the basis of developing a product. In addition, it is also used as input, feedback, and claims from customers who have purchased

products or services. Voice of Business (VOB) are the needs, wants, expectations, and preferences, whether spoken or not, of the people who make up (run) the business itself (for example, shareholders, officers, or others involved in the governance company) [9].

To be able to meet the targets agreed upon between the employer and the service provider, it is essential to establish a common perception generated (output indicators) that come from the provider/customer in the form of critical requests (Critical Customer Requirements) and critical business requirements (Critical Business Requirements) such as which can be seen in Figure 2.

The first thing that needs to be known is the customer/employer's voice. This needs to be known so that we know what the main problem (Key Customer Issue) is in the customer and the problem with the business itself (Business Issue). These two issues will clarify the appropriate steps to meet this critical demand.

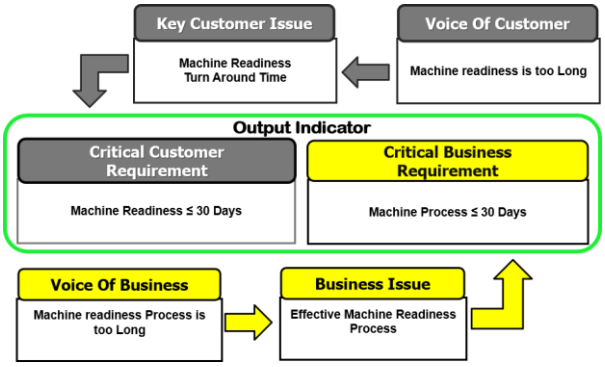

Figure 2. Equalization of perceptions between customer desires and current business issues

For the workshop to provide the best service, it is required to equalize the perception between the employer's request and the workshop so that the results are as expected.

The workshop party must know the true voice or desire of the tool owner as the employer and determine the tool owner's or employer's main wishes. Likewise, the repair shop must know the voice in the same business and see the key to the success of this work.

By knowing the voices of the owner and the business developing at that time, we can determine a common perception so that what the workshop produces is in accordance with what the tool owner or employer wants.

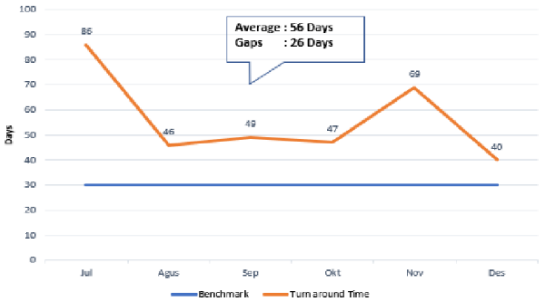

Figure 3. Data on the completion of repair work that has been carried out at the Palembang City Workshop

According to the data graph above (Figure 3), which is the TAT times for the 20 Ton Excavator repair carried out by this workshop, it can be seen that it is very volatile and is influenced by various factors.

3.2. Measure

Below is data from several units carried out in the refurbishment process, to be taken as parts that need to be repaired.

Table 3. Repair work time data

SN Units	Receiving	Dis-assemble	Approval	Order parts /OWSS	Assemble	Testing
XBA10852	1	2	4	19	2	15
YBP00331	1	2	17	8	3	13
LT302154	1	2	8	18	2	6
FT302180	1	2	1	2	1	3
TTT00298	1	1	15	3	12	11
ZBT10776	1	2	9	8	3	1
YBP00156	1	2	27	5	3	11
GAY10086	1	6	2	4	2	2
Average Des 20 (Days)	1	2	10	8	4	13
Expected (Days)	1	5	5	5	7	7
Gaps	0	-3	5	3	-4	6

Based on the records of the refurbishment process for the 20 ton Excavator heavy equipment in Table 3, it was found that for the receiving process 8 out of 8 units met expectations, the disassembly

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process, 7 out of 8 units met expectations, approval process 5 out of 8 units met expectations, 4 out of 8 units met expectations, the spare parts supply process and OWSS met expectations, the assembly process 7 out of 8 units met expectations and the testing process 4 out of 8 units met expectations.

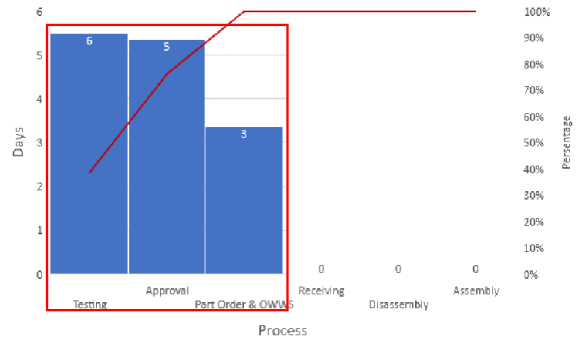


Figure 4. Pareto of gap sub-process TAT

From the data in Figure 4 above, problem statements arise when carrying out heavy equipment rejuvenation that exceeds the target time or delay. There are three problem statements, namely: (1) There is a delay in the testing process for more than six days (Delay process testing). Over six days), (2) There is a delay in the agreement approval process for more than five days (Delay process approval over six days), and (3) There is a delay in the spare parts procurement process and work carried out by other/third parties (OWSS) for more than six days. Then three days (Delay process parts order/OWSS over three days).

3.3. Analyze

After obtaining three problem statements from the measurement stages above, we need to do a root cause analysis using the Ishikawa diagram [10]. The following is the Root Cause Analysis of the three problem statements.

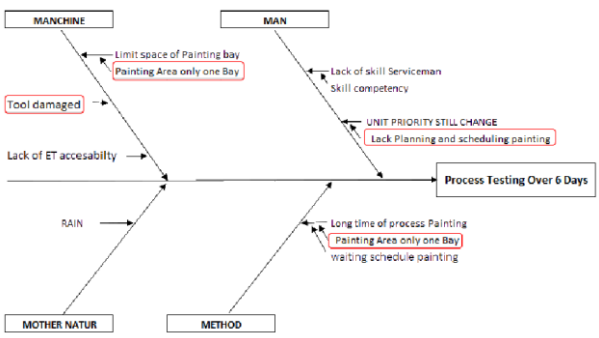


Figure 5. Root cause analysis of Testing process over six days with Ishikawa diagram

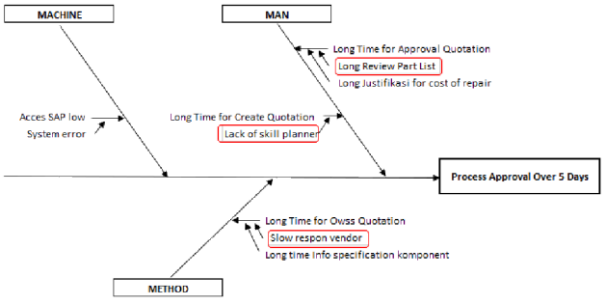


Figure 6. Root cause analysis of Approval process over six days with Ishikawa diagram

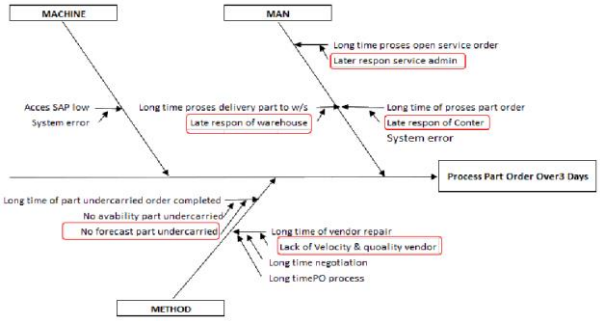


Figure 7. Root cause analysis of Parts order/OWSS process over 6 days with Ishikawa diagram

From the three analyzes above in Figures 5, 6, and 7, it was found ten root problems that significantly affect, namely: Lack of quality and the lack of speed for third parties to complete their work (Lack of velocity and quality of Vendors), slow response from vendors (Slow response) of the vendor), there is no plan to prepare spare parts for the undercarriage of the excavator (no forecast undercarriage parts), There is only one area for painting (painting area only one bay, slow response from parts ordering parts (late response of counterparts), slow response from the service admin (Lare response of service admin), lack of expertise in the planning section (lack of skills of the planner, lack of response from the warehouse section (lack of skills of warehouseman), poor planning and painting work (lack of planning and painting)), there is no priority in work (no priority job). From the ten root problems above, we will analyze using the Cause and effect metric [11], as follows.

Table 4. Data Root cause analysis with Cause and effect Metric

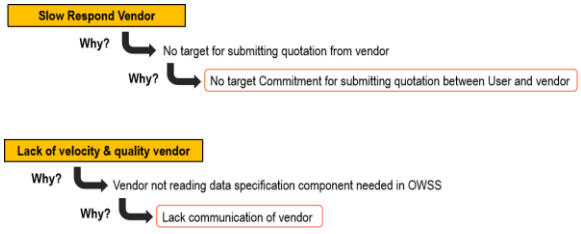
		Process Testing Over 6 Days	Process Oder Parts/OWSS 3 Days	Process Approval Over 5 Days	Problem Statement
		10	10	10	Importance
No	Process Step/Root Cause/Solutions	Rating of Correlation of input to output (0,1,3,9)			Process Step, input, variable priority valve
1	Lack of Velocity & Quality of vendor	0	9	9	180
2	Slow respon of vendor	0	9	9	180
3	No forecast undercarriage parts	0	9	9	180
4	Painting Area only one bay	9	9	0	180
5	Late respons of parts counter	3	9	1	70
6	Late respon of service admin	3	3	1	70
7	Lack of skills planning	1	3	3	70
8	Late respon of warehouse	1	3	1	50
9	Lack of Planning dan scheduling of painting	3	0	0	30
10	No priority units	1	0	3	30

Based on the above analysis (Table 4), we can group based on the priority of the root cause according to the table below.

Table 5. Data Root cause of the problem

Problem statement	No	Root cause of problem	Comments
Approval process	1	Slow response from Vendor	Need further analysis
OWSS spare parts procurement and workmanship	2	Not fast and not good quality of work from the Vendor	Need further analysis
	3	Not pre-preparing the undercarriage tribe	Need futher analysis
The testing process is more than 6 days	4	Only one painting area	The root of the problem remains

From table 5 above, it can be seen that out of the four root problems, three problem statements came from and only one painting area remained as the root of the problem. For that, we have to look for three fixed root causes that we don't know why this happened. Then we use the five why technique. "Why why" analysis is a method to explore the root of the problem to find a solution [12].



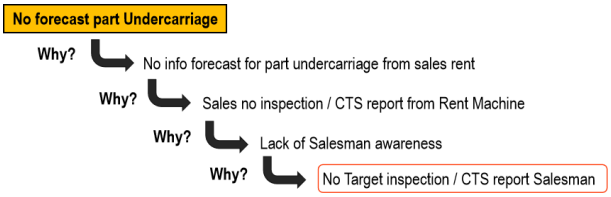


Figure 8. "Why why" analysis instead of three root causes

Using the 5Why Technique or Why why analysis in Figure 8 above, we get a slow response from the vendor because there is no commitment target when the vendor must submit an offer. The lack of speed and the lack of quality of the vendor's work is caused by the lack of good communication between the workshop personnel and the vendor and the absence of preparation for the supply of undercarriage spare parts caused by the absence of inspection targets or reports of workshop officers assigned to inspect, measure and report the undercarriage.

3.4. Improve

This stage takes steps to improve the conditions encountered in the analysis stage. The following actions were taken to resolve the actual root of the problem, namely: the root of the problem of lack of communication with vendors. The steps were to improve the quality and quantity of communication frequency through the WhatsApp group between the workshop team and the vendor.

The root of the problem is that there is no target for bid delivery commitments from vendors, so the solution is to make an agreement between the two parties (workshop-vendor) for the maximum length of time to send offers from vendors to workshops.

For the root of the problem, there is no target for inspection, inspection, and measurement of undercarriage thirst. The steps taken are making a list of visit schedules with accuracy and conducting joint visits regularly. For the limited painting area, steps need to be taken to create a temporary painting area that is controlled every weekly meeting.

3.5. Control

The control stage is a crucial stage of work done regularly and pleases all parties involved with the RACI method.

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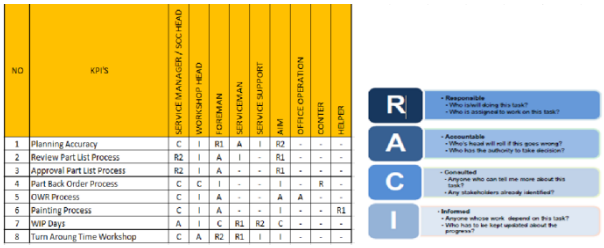
RACI is a method that will make it easier to identify the roles and responsibilities of team members [13]. Therefore, thorough preparation is needed in the manufacturing process, starting from determining who is involved in the various tasks. Here's the RACI we made in Figure 9.



NO	KPI'S	SERVICE MANAGER / SCC HEAD	WORKSHOP HEAD	FOREMAN	SERVICEMAN	SERVICE SUPPORT	AIM	OFFICE OPERATION	CENTER	HELPER
1	Planning Accuracy	C	I	R1	A	I	R2	-	-	-
2	Review Part List Process	R2	I	A	I	-	R1	-	-	-
3	Approval Part List Process	R2	I	A	-	-	R1	-	-	-
4	Part Back Order Process	C	C	I	-	-	I	-	R	-
5	OWR Process	C	I	A	-	-	A	A	-	-
6	Painting Process	C	I	A	-	-	I	-	-	R1
7	WIP Days	A	I	C	R1	R2	C	-	-	-
8	Turn Aroung Time Workshop	C	A	R2	R1	I	I	-	-	-

Figure 9. RACI control management

With this RACI, the team works regularly and pleasantly and successfully meets the expected targets from the start.

4. CONCLUSIONS AND SUGGESTIONS

Based on this research, it can be concluded that to improve Turnaround Time (TAT) in the heavy equipment refurbishment process, namely setting the painting area, preparing for the supply of spare parts, and ensuring the completion of work submitted to other parties (Vendors), so that the completion time of all work can meet the best expectations.

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