

## CHAPTER 4 - RESULTS AND DISCUSSION

### 4.1. Problem Discussion

The main problem identified is the gap between the plan and actual sales of major reman components, especially in 2020, 2021, and 2024. Although there is an overall increasing trend, revenue realization is still fluctuating and unstable, with the highest gap occurring in 2020 (only reaching 44.9% of the target), and decreasing again in 2024 (realization of only 92.5%).

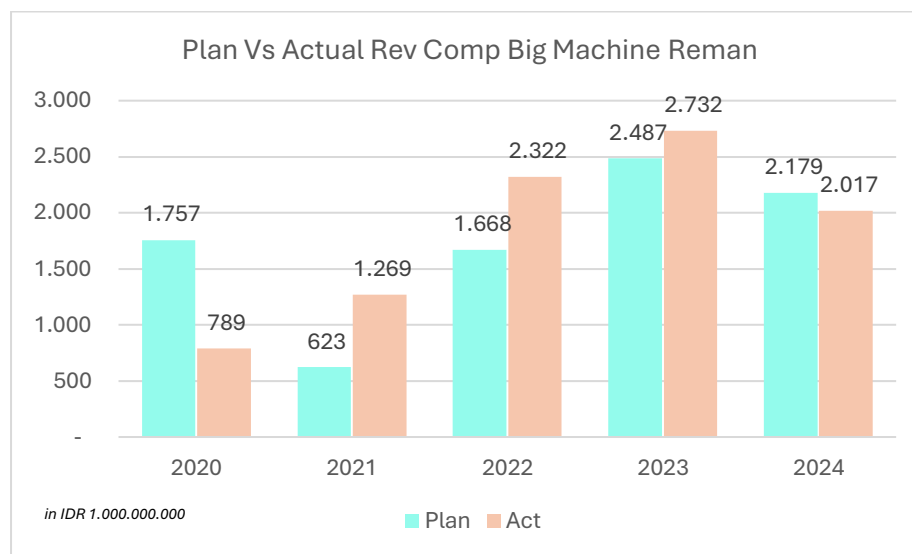


Figure 4. 1 Performance Sales Remanufacturing Big Machine

### 4.2. Problem Analysis

To understand the failure to achieve sales targets for remanufactured heavy equipment components, the systematic approach Fishbone Diagram as a method of RCA (Root Cause Analysis). This approach is effective in identifying the underlying causes of performance deviations from targets (plan), especially in business processes involving many functions such as sales activity, market condition supply chain and transaction.

#### 4.2.1. Fishbone Diagram

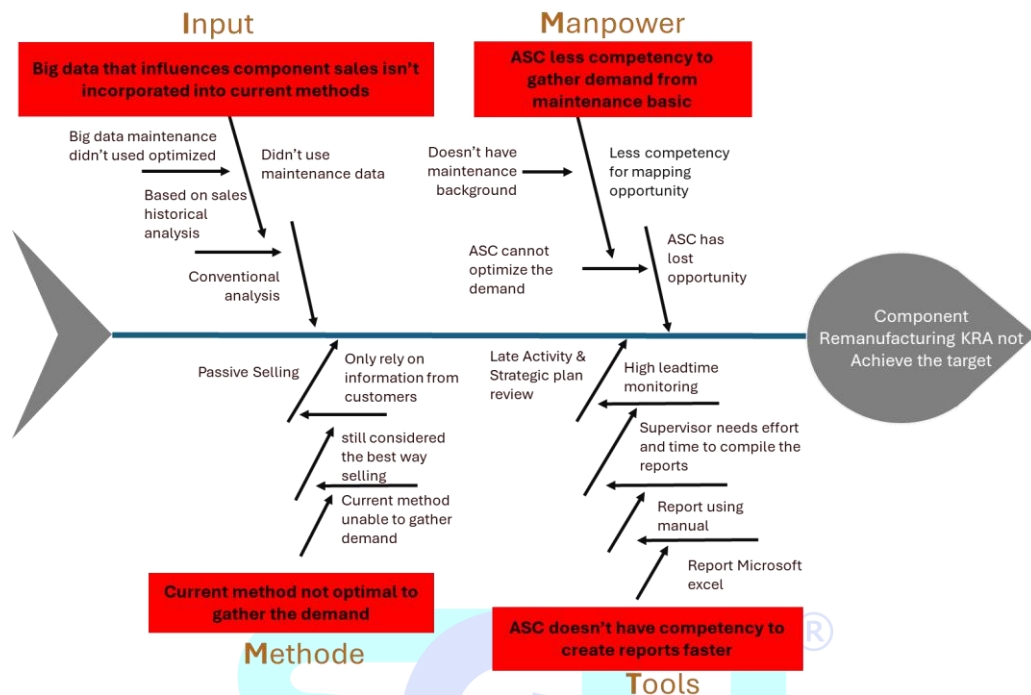


Figure 4. 2 Fishbone Diagram Analysis

Using fishbone analysis, the root of the problem lies in the failure to achieve sales revenue targets in the component remanufacturing big machine (KRA) business. The analysis is divided into several categories relevant to operational issues, including input, manpower, methods, and tools.

##### 1. Input

Conventional analysis approaches, which means most approaches are still reactive, relying on historical sales data and not considering big data maintenance or technical failure indicators such as oil, fault codes, or engine health sensors from VHMS. Even though big data can help in providing input that can help sales strategies.

##### 2. Manpower

The human resources aspect is also a significant contributor to the problem of why sales revenue isn't achieved. It happens because there is a lost opportunity

or lost demand. Lack of ASC (After Sales Consultant) competence in identifying component needs based on maintenance data.

### 3. Method

Passive method (passive selling) describes that ASC only relies on request information from customers without a proactive approach. This has been happening for a long time, relying on the relationship side with customers without realizing that lost demand and opportunities can happen at any time.

### 4. Tools

Limitations in tools and reporting systems also slow down the decision-making process. Because report is the key for activity plan in sales when something happens such as needs from customer, or schedule payment. ASC still use manual tools such as Microsoft excel as their reports to their supervisor or manager at Head Office Jakarta.

#### 4.2.2. SQCD



Table 4. 1 SQCD

| Root Cause                                                                       | No | Idea                                                    | S | Q | C | D | Point | Decision |
|----------------------------------------------------------------------------------|----|---------------------------------------------------------|---|---|---|---|-------|----------|
| Current Method not optimal to gather the demand                                  | 1  | Using advanced method for forecasting customer demand   | 4 | 5 | 4 | 3 | 16    | OK       |
|                                                                                  | 2  | Hire consultant to predict big machine component demand | 4 | 5 | 1 | 4 | 14    | NO       |
|                                                                                  | 3  | Collect unit maintenance customer data                  | 3 | 3 | 5 | 5 | 16    | OK       |
| Big data that influences component sales isn't incorporated into current methods | 4  | Utilize component big data                              | 5 | 4 | 5 | 5 | 19    | OK       |
|                                                                                  | 5  | Hire consultant to do big data analysis                 | 4 | 5 | 1 | 4 | 14    | OK       |
|                                                                                  | 6  | Utilize external big data                               | 4 | 4 | 5 | 5 | 18    | OK       |
| ASC doesn't have competency to create reports faster                             | 7  | Build new tools for component dedicated monitoring      | 4 | 3 | 1 | 2 | 10    | NO       |
|                                                                                  | 8  | Hire admin staff to monitor each ASC selling progress   | 4 | 2 | 1 | 2 | 9     | NO       |

|                                                             |    |                                                                                                                                                    |   |   |   |   |    |    |
|-------------------------------------------------------------|----|----------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|---|----|----|
|                                                             | 9  | Optimizing Sales Force as a monitoring tool                                                                                                        | 4 | 4 | 5 | 4 | 17 | OK |
| ASC less competency to gather demand from maintenance basic | 10 | Training manpower ASC about unit maintenance and big machine component needs                                                                       | 5 | 3 | 2 | 4 | 14 | NO |
|                                                             | 11 | Hire consultant to do process digitalization and automation in case for helping ASC in understand unit maintenance and big machine component needs | 4 | 5 | 1 | 4 | 14 | NO |
|                                                             | 12 | Develop digital tool to help ASC understand maintenance basic                                                                                      | 4 | 5 | 4 | 3 | 16 | OK |

Using SQCD as shown in table 4.1, the author's summary of the ideas that received the highest points are:

#### Idea 1

Using advanced methods for forecasting customer demand (16 points, OK) while point criteria is shown in table 4.2. This recommendation is considered strong because it can improve prediction accuracy and accelerate supply planning.

#### Idea 2

Hire a consultant to predict large machine component demand (14 points, NO). Although this idea is quite strong, its cost and implementation time are the main reasons for rejection.

#### Ide 3

Collect unit maintenance customer data (13 points, OK). This idea emphasizes the importance of accumulating actual field data to support more realistic projections.

Table 4. 2 Evaluation Criteria

| Aspect       | Evaluation criteria |             |           |           |                | Decision |    |
|--------------|---------------------|-------------|-----------|-----------|----------------|----------|----|
|              | 1                   | 2           | 3         | 4         | 5              |          |    |
| Safety (S)   | High risk           | Medium risk | Low risk  | Zero risk | Very high risk | <15      | NO |
| Quality (Q)  | Low                 | Medium      | High      | Very high | Very low       |          |    |
| Cost (C)     | 250-600 mio         | 100-250 mio | 50-100mio | <50 mio   | >600mio        | >=15     | OK |
| Delivery (D) | Long                | Fairly Long | Fast      | Very Fast | Very Long      |          |    |



Figure 4. 3 Root cause Analysis Conclusion

From idea 1, idea 2 and idea 3, author and teams get the final decision is using advanced method for forecasting demand combine with big data analytics and using tools digitalization as shown in figure 4.3.

### 4.3. Improvement

Based on fishbone diagram analysis, it can be concluded that the failure to achieve sales targets is not caused by weak demand, but rather by the inability of the current system to capture and manage component needs opportunities predictively. To answer this challenge, the author will make an improvement:

1. The platform system as the central tool that will be used by ASC to execute all opportunities generated from machine learning to become selling at the end of transaction. Its concept is shown at figure 4.4.

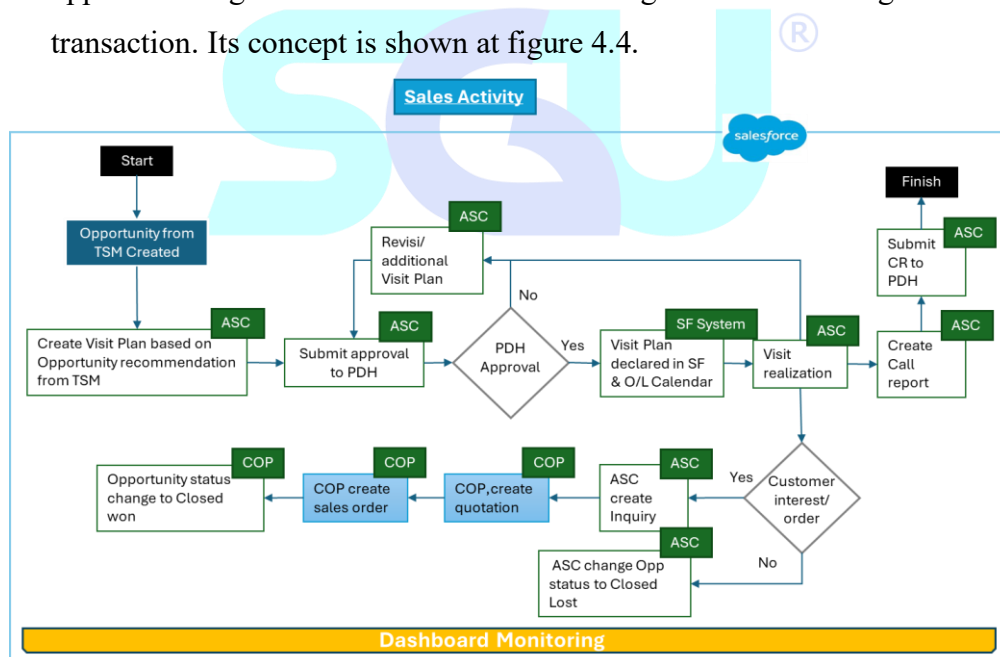


Figure 4. 4 Sales Force Platform Design Architecture

2. Big data utilization using advance analytics.

To solve the main problem, big data utilization with advance analytic using Machine Learning will become the key to building a sales opportunity detection

system (sales opportunity engine). The author will divide it into 3 phases: Input, Proses and Output.

There are several data which will consume as a data input:

- a. VHMS Telemetry & Oil Analysis
- b. Historical Component Replacement
- c. Component Targeted Lifetime
- d. PCAR Threshold
- e. Working Hours
- f. Fault Code
- g. Unit Population
- h. Transaction History

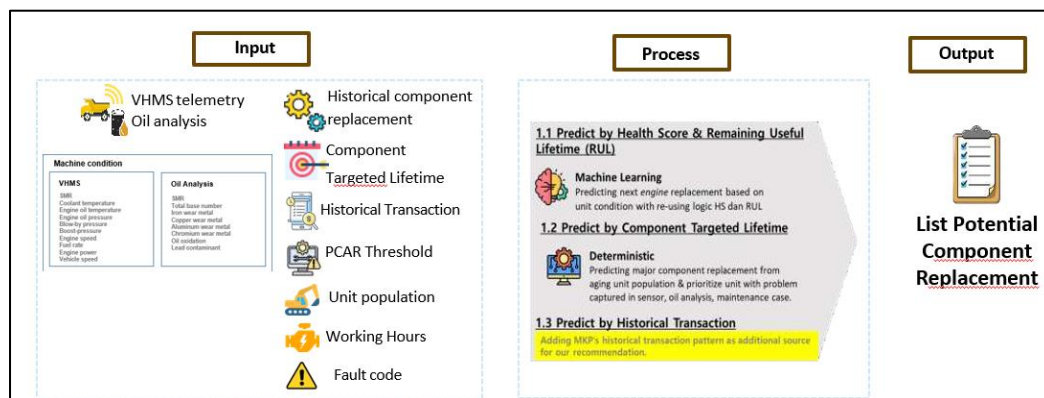


Figure 4. 5 Improvement Design

Fig 4.5 represents the design improvement that is the solution to the root cause analysis. This design is developed based on a data-driven approach and machine learning. This process is divided into three main stages: Input, Process, and Output, which form a systematic flow from technical data acquisition to decision making on what opportunities will be able to help ASC find demand for remanufacturing big machine components.

#### 4.3.1. Input

The initial stage involves integrating various big data sources used as predictor variables in machine learning models:

1. VHMS Telemetry & Oil Analysis

Technical data from heavy equipment sensors such as temperature, pressure, rotational speed, and oil condition analysis results. This data reflects the actual health condition of the component.

2. Historical Component Replacement

Historical data on previous component replacements form a time-to-failure reference and wear trend.

3. Component Targeted Lifetime & PCAR Threshold

Is the standard for component life expectancy and the threshold of the PCAR (Parts Condition Assessment and Recommendation) system.

4. Working Hours & Fault Code

Unit working hours and fault codes as a signal of potential degradation or failure.

5. Unit Population & Transaction History

The number of active units and purchase history from each customer are used to detect purchasing patterns and supply-demand gaps.

#### 4.3.2. Process - Prediction & Analytics Engine

The processing stage consists of three main approaches combined in a hybrid system:

1. Predict by Health Score & Remaining Useful Lifetime (RUL) – Machine Learning

- a. Machine learning models are used to predict the remaining time before a component needs to be replaced (Remaining Useful Lifetime).
- b. Model input includes real-time unit condition data and historical oil analysis.
- c. Algorithms: Random Forest, Gradient Boosting (XGBoost), or Neural Networks for failure time regression.

2. Predict by Component Targeted Lifetime – Deterministic

- a. Rule-based approach based on the technical age of components according to the OEM catalog.

- b. Components with an age >80% of the target lifetime and a history of problems will be prioritized. Algorithms: Random Forest, Gradient Boosting (XGBoost), or Neural Networks for failure time regression.
3. Predict by Historical Transaction – Opportunity Scoring
  - a. Involves analyzing customer buying patterns (repeat rate, time lag, frequency).
  - b. Allow the system to surface offer opportunities based on historical buying behavior, including customers who tend to repeat orders in certain cycles.

#### **4.4.3. Output - List Potential Component Replacement**

The result of this prediction system is the “List of Potential Component Replacements”, namely:

1. A list of components that are predictively likely to be needed in the near future.
2. Equipped with customer priority information, potential transaction value, RFU status, and probability of need score.
3. This output is used by the sales (ASC) team as a guide for a proactive approach to customers, before an explicit request occurs.

#### **4.4.4. Steps for Developing a Predictive System Based on Machine Learning**

##### **1. Business Understanding**

Before building a Machine Learning model, the main thing to do is to understand the business objective, which is to increase sales revenue from remanufactured components. The focus includes:

- a. Identify target variables: potential remanufacturing component big machine transactions.
- b. Identify key factors: working hours, last transaction, lifetime component prediction, customer segmentation, etc.
- c. Define KPIs: conversion rate opportunity, additional revenue

##### **2. Data Collecting**

Data collection is a crucial stage that includes various data sources:

a. VHMS (Vehicle Health Monitoring System):

Data from the Vehicle Health Monitoring System (VHMS) which is shown at table 4.3 and table 4.4 plays a fundamental role in detecting component degradation in real-time and historically. The VHMS dataset shown contains technical data from heavy equipment sensors during operation specially HD785-7 unit model. This data not only describes the condition of the machine at a certain point in time but also serves as an early signal for predicting component remanufacturing needs, especially major components such as the engine, hydraulic system, and cooling system. Each parameter is measured continuously, providing a technical degradation trace that is very useful in identifying machine failure patterns early.

Table 4. 3 VHMS trend HD785-7

(Internal Company Data, 2025)

|    | A       | B       | C         | D      | E      | F     | G      | H      | I      | J      | K     | L       | M       | N       | O       | P      | Q      | R      | S      | T      | U      | V      | W     |
|----|---------|---------|-----------|--------|--------|-------|--------|--------|--------|--------|-------|---------|---------|---------|---------|--------|--------|--------|--------|--------|--------|--------|-------|
| 1  | UNIT_SI | SMR     | TIMEST    | ENG_SF | ENG_SF | BLOWB | LF_EXH | LR_EXH | RF_EXH | RR_EXH | BOOST | E_OIL_R | E_OIL_R | E_OIL_R | ENG_OIL | FUEL_R | COOL_1 | COOL_1 | TM_OIL | AMBIEN | AMBIEN | AMBIEN | ATOMO |
| 2  | 30028   | 58281.8 | 2024-01-0 | 2499   | 1441   | 3.44  | 704    | 710    | 697    | 727    | 165   | 0.59    | 0.1     | 0.34    | 94      | 84.8   | 79     | 29     | 79     | 39     | 30     | 26     | 980   |
| 3  | 30028   | 58301.9 | 2024-01-0 | 2487   | 1416   | 3.38  | 694    | 699    | 684    | 744    | 165   | 0.52    | 0.1     | 0.35    | 91      | 79.9   | 77     | 53     | 78     | 38     | 30     | 26     | 980   |
| 4  | 30028   | 58322.1 | 2024-01-0 | 2448   | 1423   | 3.28  | 705    | 707    | 692    | 791    | 165   | 0.57    | 0.11    | 0.35    | 89      | 80.7   | 76     | 36     | 75     | 37     | 29     | 26     | 980   |
| 5  | 30028   | 58342.3 | 2024-01-0 | 2434   | 1432   | 3.34  | 699    | 700    | 685    | 814    | 165   | 0.51    | 0.1     | 0.35    | 90      | 83.6   | 79     | 53     | 79     | 36     | 29     | 26     | 980   |
| 6  | 30028   | 58362.4 | 2024-01-0 | 2628   | 1443   | 3.36  | 696    | 701    | 686    | 809    | 165   | 0.57    | 0.09    | 0.34    | 95      | 84.5   | 79     | 42     | 83     | 37     | 29     | 26     | 980   |
| 7  | 30028   | 58382.7 | 2024-01-0 | 2414   | 1390   | 3.53  | 690    | 694    | 676    | 807    | 163   | 0.58    | 0.1     | 0.35    | 92      | 78.2   | 79     | 40     | 77     | 38     | 29     | 25     | 980   |
| 8  | 30028   | 58402.8 | 2024-01-1 | 2767   | 1388   | 3.53  | 684    | 691    | 675    | 875    | 161   | 0.59    | 0.11    | 0.34    | 89      | 73.9   | 77     | 30     | 75     | 42     | 30     | 25     | 980   |
| 9  | 30028   | 58422.9 | 2024-01-1 | 2499   | 1392   | 3.57  | 693    | 685    | 667    | 885    | 161   | 0.53    | 0.1     | 0.36    | 89      | 69.8   | 76     | 52     | 77     | 39     | 30     | 26     | 980   |
| 10 | 30028   | 58443.1 | 2024-01-1 | 2703   | 1396   | 3.48  | 678    | 671    | 656    | 874    | 164   | 0.56    | 0.11    | 0.37    | 85      | 71.8   | 73     | 34     | 73     | 39     | 29     | 25     | 980   |
| 11 | 30028   | 58463.4 | 2024-01-1 | 2392   | 1298   | 3.48  | 664    | 659    | 646    | 883    | 158   | 0.55    | 0.11    | 0.37    | 85      | 66.7   | 74     | 34     | 72     | 37     | 30     | 25     | 980   |
| 12 | 30028   | 58483.7 | 2024-01-1 | 2552   | 1326   | 4.8   | 666    | 662    | 647    | 905    | 165   | 0.59    | 0.11    | 0.37    | 85      | 64.9   | 72     | 40     | 71     | 38     | 27     | 25     | 980   |
| 13 | 30028   | 58503.8 | 2024-01-1 | 2473   | 1393   | 3.63  | 683    | 680    | 667    | 906    | 165   | 0.52    | 0.1     | 0.35    | 91      | 74.2   | 76     | 49     | 80     | 37     | 29     | 25     | 980   |
| 14 | 30028   | 58524.1 | 2024-01-1 | 2580   | 1361   | 3.77  | 684    | 678    | 664    | 850    | 162   | 0.59    | 0.1     | 0.36    | 88      | 70.2   | 75     | 31     | 77     | 39     | 29     | 25     | 980   |
| 15 | 30028   | 58544.2 | 2024-01-2 | 2411   | 1383   | 3.76  | 676    | 670    | 656    | 926    | 163   | 0.59    | 0.11    | 0.36    | 85      | 75.2   | 75     | 33     | 71     | 38     | 29     | 25     | 980   |
| 16 | 30028   | 58564.5 | 2024-01-2 | 2497   | 1347   | 3.48  | 688    | 683    | 670    | 891    | 160   | 0.58    | 0.1     | 0.36    | 86      | 67.8   | 75     | 36     | 78     | 42     | 29     | 25     | 980   |
| 17 | 30028   | 58584.7 | 2024-01-2 | 2526   | 1338   | 3.6   | 682    | 675    | 663    | 960    | 163   | 0.62    | 0.11    | 0.37    | 86      | 73.2   | 74     | 28     | 74     | 40     | 30     | 24     | 980   |
| 18 | 30028   | 58604.8 | 2024-01-2 | 2638   | 1364   | 3.64  | 681    | 673    | 662    | 888    | 158   | 0.5     | 0.11    | 0.35    | 87      | 73.2   | 74     | 55     | 76     | 38     | 30     | 26     | 980   |
| 19 | 30028   | 58624.9 | 2024-01-2 | 2573   | 1322   | 3.62  | 683    | 678    | 665    | 840    | 159   | 0.52    | 0.11    | 0.37    | 85      | 68.6   | 72     | 53     | 76     | 40     | 30     | 27     | 980   |
| 20 | 30028   | 58645.1 | 2024-01-2 | 2499   | 1332   | 3.48  | 677    | 674    | 660    | 866    | 161   | 0.6     | 0.11    | 0.36    | 84      | 67.4   | 72     | 30     | 70     | 37     | 29     | 25     | 980   |
| 21 | 30028   | 58665.2 | 2024-01-3 | 2463   | 1309   | 3.51  | 673    | 666    | 656    | 847    | 158   | 0.52    | 0.11    | 0.36    | 87      | 68     | 74     | 52     | 73     | 38     | 30     | 25     | 980   |
| 22 | 30028   | 58685.4 | 2024-02-0 | 2433   | 1355   | 3.6   | 695    | 692    | 679    | 899    | 162   | 0.57    | 0.11    | 0.36    | 85      | 74.1   | 73     | 41     | 74     | 39     | 30     | 26     | 980   |
| 23 | 30028   | 58705.6 | 2024-02-0 | 2378   | 1395   | 3.36  | 711    | 706    | 694    | 959    | 162   | 0.58    | 0.1     | 0.35    | 90      | 81.6   | 80     | 35     | 81     | 40     | 30     | 25     | 980   |
| 24 | 30028   | 58726   | 2024-02-0 | 2479   | 1379   | 4.63  | 710    | 700    | 688    | 968    | 163   | 0.62    | 0.09    | 0.35    | 100     | 76.7   | 87     | 27     | 86     | 39     | 29     | 24     | 980   |
| 25 | 30028   | 58746.1 | 2024-02-0 | 2530   | 1382   | 4.32  | 699    | 690    | 667    | 919    | 166   | 0.53    | 0.08    | 0.33    | 108     | 80.7   | 82     | 53     | 86     | 40     | 30     | 26     | 980   |

Table 4. 4 VHMS trend PC2000-8

(Internal Company Data, 2025)

|    | A       | B       | C         | D      | E      | F     | G       | H       | I       | J       | K      | L       | M       | N       | O      | P     | Q     | R      | S       | T       | U       | V      | W     | X     |
|----|---------|---------|-----------|--------|--------|-------|---------|---------|---------|---------|--------|---------|---------|---------|--------|-------|-------|--------|---------|---------|---------|--------|-------|-------|
|    | UNIT_SI | SMR     | TIMEST    | ENGSP1 | ENGSP2 | BLOWB | LBF_EX1 | LBR_EX1 | RBF_EX1 | RBR_EX1 | BOOST1 | EOIL_P1 | EOIL_P2 | EOIL_P3 | ENGOL1 | COOL1 | COOL2 | FUEL_R | AMBIEN1 | AMBIEN2 | AMBIEN3 | ATOMO1 | PUMP1 | PUMP2 |
| 1  | 20052   | 76340.4 | 2024-01-0 | 1994   | 1749   | 2.46  | 621     | 968     | 904     | 611     | 106    | 0.39    | 0.13    | 0.25    | 103    | 92    | 75    | 138.4  | 42      | 34      | 30      | 980    | 34.35 |       |
| 2  | 20052   | 76360.7 | 2024-01-0 | 1994   | 1735   | 2.4   | 617     | 644     | 904     | 611     | 107    | 0.55    | 0.12    | 0.2     | 102    | 92    | 51    | 131.4  | 42      | 33      | 28      | 980    | 32.4  | 34    |
| 3  | 20052   | 76380.9 | 2024-01-0 | 1997   | 1686   | 2.51  | 648     | 657     | 906     | 610     | 106    | 0.49    | 0.14    | 0.2     | 99     | 91    | 61    | 125.2  | 44      | 32      | 27      | 980    | 31.9  | 32    |
| 4  | 20052   | 76401.1 | 2024-01-0 | 1991   | 1710   | 2.18  | 652     | 684     | 906     | 607     | 107    | 0.53    | 0.14    | 0.27    | 99     | 90    | 56    | 131.3  | 39      | 32      | 27      | 980    | 33.1  | 36    |
| 5  | 20052   | 76421.3 | 2024-01-0 | 1992   | 1693   | 2.18  | 658     | 679     | 910     | 623     | 111    | 0.44    | 0.12    | 0.27    | 98     | 88    | 69    | 127.6  | 38      | 32      | 28      | 980    | 32.1  | 34    |
| 6  | 20052   | 76441.4 | 2024-01-0 | 1989   | 1727   | 2.1   | 641     | 663     | 910     | 616     | 110    | 0.42    | 0.13    | 0.27    | 100    | 89    | 69    | 134.8  | 40      | 33      | 30      | 980    | 31.9  | 34    |
| 7  | 20052   | 76461.7 | 2024-01-2 | 1993   | 1642   | 2.16  | 625     | 644     | 890     | 605     | 108    | 0.62    | 0.13    | 0.27    | 100    | 88    | 26    | 117.9  | 39      | 30      | 25      | 980    | 31.7  | 35    |
| 8  | 20052   | 76481.8 | 2024-01-2 | 1990   | 1728   | 2.07  | 631     | 666     | -32768  | 605     | 105    | 0.5     | 0.13    | 0.27    | 103    | 93    | 63    | 131.2  | 39      | 32      | 28      | 980    | 32.2  | 34    |
| 9  | 20052   | 76501.9 | 2024-01-2 | 1988   | 1715   | 2.14  | 621     | 677     | 969     | 604     | 107    | 0.49    | 0.13    | 0.2     | 104    | 92    | 62    | 129    | 39      | 32      | 28      | 980    | 31.7  |       |
| 10 | 20052   | 76522.1 | 2024-01-2 | 1991   | 1696   | 2.04  | 630     | 672     | 914     | 605     | 106    | 0.61    | 0.13    | 0.23    | 101    | 90    | 36    | 127.8  | 38      | 30      | 23      | 980    | 32.4  | 35    |
| 11 | 20052   | 76542.3 | 2024-01-2 | 1993   | 1701   | 2.16  | 669     | 687     | 969     | 647     | 107    | 0.43    | 0.13    | 0.22    | 104    | 92    | 64    | 129.2  | 40      | 33      | 29      | 990    | 33.1  | 33    |
| 12 | 20052   | 76562.5 | 2024-01-2 | 1992   | 1579   | 2.03  | 609     | 684     | 969     | 597     | 107    | 0.63    | 0.13    | 0.26    | 104    | 91    | 30    | 103.9  | 36      | 30      | 25      | 990    | 33.4  | 33    |
| 13 | 20052   | 76617.2 | 2024-01-3 | 1991   | 1663   | 2.1   | 623     | 682     | 969     | 601     | 106    | 0.56    | 0.13    | 0.22    | 100    | 89    | 46    | 120.2  | 39      | 34      | 28      | 990    | 32.8  | 35    |
| 14 | 20052   | 76637.4 | 2024-02-0 | 1998   | 1690   | 2.02  | 638     | 712     | 969     | 614     | 107    | 0.42    | 0.13    | 0.2     | 104    | 92    | 69    | 125.8  | 41      | 34      | 30      | 990    | 32.3  | 33    |
| 15 | 20052   | 76657.4 | 2024-02-0 | 1988   | 1680   | 1.89  | 625     | 648     | 969     | 607     | 105    | 0.44    | 0.13    | 0.27    | 105    | 93    | 68    | 127.7  | 40      | 33      | 30      | 990    | 32.3  | 34    |
| 16 | 20052   | 76677.5 | 2024-02-0 | 1989   | 1731   | 1.92  | 636     | 634     | 969     | 603     | 105    | 0.4     | 0.13    | 0.2     | 101    | 89    | 71    | 135.8  | 40      | 33      | 29      | 990    | 32.4  | 35    |
| 17 | 20052   | 76697.6 | 2024-02-0 | 1996   | 1680   | 1.99  | 646     | 669     | 969     | 610     | 106    | 0.57    | 0.13    | 0.27    | 104    | 91    | 46    | 126.9  | 41      | 34      | 26      | 990    | 32.6  |       |
| 18 | 20052   | 76717.8 | 2024-02-0 | 1990   | 1648   | 1.88  | 601     | 678     | 969     | 593     | 105    | 0.53    | 0.13    | 0.28    | 102    | 91    | 39    | 123.8  | 36      | 31      | 26      | 990    | 32.2  | 33    |
| 19 | 20052   | 76738   | 2024-02-0 | 1990   | 1673   | 1.88  | 627     | 686     | 969     | 581     | 95     | 0.46    | 0.13    | 0.28    | 100    | 94    | 64    | 129.8  | 41      | 33      | 29      | 990    | 33.8  | 34    |
| 20 | 20052   | 76758.2 | 2024-02-0 | 1991   | 1712   | 1.92  | 737     | 673     | 969     | 594     | 101    | 0.45    | 0.13    | 0.23    | 99     | 92    | 68    | 135.3  | 36      | 31      | 27      | 990    | 32.7  | 35    |
| 21 | 20052   | 76778.2 | 2024-02-0 | 1986   | 1647   | 1.71  | 610     | 692     | 914     | 597     | 99     | 0.47    | 0.12    | 0.26    | 99     | 89    | 63    | 130.4  | 41      | 31      | 28      | 990    | 32.2  | 35    |
| 22 | 20052   | 76798.4 | 2024-02-1 | 1994   | 1676   | 1.88  | 615     | 679     | 835     | 595     | 102    | 0.44    | 0.09    | 0.24    | 99     | 94    | 66    | 126.3  | 38      | 31      | 27      | 990    | 32.4  |       |
| 23 | 20052   | 76818.6 | 2024-02-1 | 1988   | 1676   | 1.9   | 598     | 734     | 784     | 592     | 106    | 0.48    | 0.13    | 0.28    | 101    | 92    | 61    | 124.6  | 37      | 31      | 28      | 990    | 32.7  | 35    |
| 24 | 20052   | 76838.9 | 2024-02-1 | 1990   | 1686   | 2.01  | 603     | 671     | 634     | 587     | 105    | 0.59    | 0.13    | 0.25    | 100    | 90    | 46    | 125.9  | 41      | 29      | 26      | 990    | 33.3  | 34    |

### b. Oil Analysis:

In order to build a machine learning-based predictive model to detect opportunities for remanufactured component needs, this study utilizes a dataset of oil analysis results from various heavy equipment units in the field. This data is taken from the engine condition monitoring system that is run periodically by the aftersales team through the fluid analysis program. The dataset used includes more than 10,000 entries of oil test results on the main components (engine, transmission, final drive, and brake), from various types of big machine heavy equipment models such as D375A, PC1250, WA900. Table 4.5 shows i

This asset is used to build a classification model and detect opportunities for remanufacturing component needs, by:

1. Transforming technical data into predictive variables, such as oil status, wear rate based on working hours, and lubricant change history.
2. Providing a probability score that a particular unit will need remanufacturing component replacement soon (30–90 days).
3. Improving sales targeting accuracy with a machine learning-based approach to the most prospective customer units.

This data is utilized in a classification model using algorithms such as Random Forest or XGBoost, with the aim of:

1. Identifying feature combinations (Status, Hour Meter, Oil Change, etc.) that are significant to component replacement needs.

2. Building an opportunity scoring engine system that can be used by the sales team to prioritize prospects in real-time.
3. Reducing the lead time of the bidding process and increasing the utilization of Ready-for-Use (RFU) components.

Table 4. 5 Oil Analysis (PAP) Data  
(Internal Company Data, 2025)

| UnitMode | Compoi | latNumt | LabNumber  | Customer | CustomerName                   | Branch          | ComponentMat | OilMatrix          | Status    | SamplingDa | ReceivedDa | ReportDa   | HRS_KH | OilChar |
|----------|--------|---------|------------|----------|--------------------------------|-----------------|--------------|--------------------|-----------|------------|------------|------------|--------|---------|
| D375A-6R | BRAKE  | 66346   | B25044404  | 500922   | PT. KARUNIA ARMADA INDONESIA   | MUARA LAWA      | DT30         | GEN DSO 30         | NORMAL    | 17/02/2025 | 21/02/2025 | 24/02/2025 |        | Yes     |
| D375A-6R | ENGINE | 65835   | M24012151  | 4671     | MANDALA KARYA PRIMA PT.        | TARAKAN         | DE40         | GEN DSO 15W-40     | NORMAL    | 09/07/2024 | 10/07/2024 | 10/07/2024 |        | Yes     |
| D375A-6R | ENGINE | 65931   | M22007072  | 4671     | MANDALA KARYA PRIMA PT.        | NFMIC TARAKAN   | 2108636      | GEN DSO 15W-40     | ATTENTION | 27/06/2022 | 29/06/2022 | 30/06/2022 |        | Yes     |
| D375A-6R | ENGINE | 65665   | M22013567  | 4671     | MANDALA KARYA PRIMA PT.        | NFMIC TARAKAN   | 2003733      | GEN DSO 15W-40     | ATTENTION | 29/10/2022 | 01/11/2022 | 02/11/2022 |        | Yes     |
| D375A-6R | ENGINE | 65548   | B250506062 | 573      | PT. JHONLIN BARATAMA           | BATULICIN       | DE40         | GEN DSO 15W-40     | NORMAL    | 03/03/2025 | 10/03/2025 | 12/03/2025 |        | Yes     |
| D375A-6R | ENGINE | 65171   | E24001999  | 202866   | PT. KALIMANTAN PRIMA PERSADA   | TANJUNG ENIM    | DE40         | MED. SX 15W40, TIE | NORMAL    | 18/01/2024 | 05/02/2024 | 06/02/2024 |        | Yes     |
| D375A-6R | ENGINE | 65904   | R23018227  | 4908     | PT. KALIMANTAN PRIMA PERSADA   | LOREH           | DE40         | GEN DSO 15W-40     | NORMAL    | 08/05/2023 | 12/05/2023 | 13/05/2023 |        | Yes     |
| D375A-6R | ENGINE | 66034   | B23087831  | 30       | PT. KALIM PRIMA COAL           | SANGATTA        | DE40         | GEN DSO 15W-40     | NORMAL    | 11/05/2023 | 30/05/2023 | 31/05/2023 |        | Yes     |
| D375A-6R | ENGINE | 65779   | B22017083  | 501373   | BERKAT ANUGRAH SEJAHTERA - BBE | NFMIC SAMARINDA | 2026475      | GEN DSO 15W-40     | NORMAL    | 12/02/2022 | 17/02/2022 | 18/02/2022 |        | Yes     |
| D375A-6R | ENGINE | BD54    | B23014337  | 501628   | PT. BERKAT ANUGRAH SEJAHTERA   | NFMIC RANTAU    | 2144007      | GEN DSO 15W-40     | NORMAL    | 18/01/2023 | 24/01/2023 | 26/01/2023 |        | Yes     |
| D375A-6R | ENGINE | 66067   | B23087832  | 30       | PT. KALIM PRIMA COAL           | SANGATTA        | DE40         | GEN DSO 15W-40     | NORMAL    | 11/05/2023 | 30/05/2023 | 31/05/2023 |        | No      |
| D375A-6R | ENGINE | 65786   | T524024695 | 1768     | PT. SAPTA INDIRA SEJATI        | SIS             | D375A-6R ENG | MEDITRAN SX 15W-40 | CAUTION   | 11/07/2024 | 13/07/2024 | 15/07/2024 | 5197   | Yes     |
| D375A-6R | ENGINE | 65957   | T524020979 | 1768     | PT. SAPTA INDIRA SEJATI        | SIS             | D375A-6R ENG | MEDITRAN SX 15W-40 | CAUTION   | 01/07/2024 | 03/07/2024 | 04/07/2024 | 11343  | No      |
| D375A-6R | ENGINE | 65858   | R21008318  | 4671     | MANDALA KARYA PRIMA PT.        | TARAKAN         | 2073776      | GEN DSO 15W-40     | NORMAL    | 25/05/2021 | 02/06/2021 | 03/06/2021 |        | Yes     |
| D375A-6R | ENGINE | 65831   | T524017305 | 1768     | PT. SAPTA INDIRA SEJATI        | SIS             | D375A-6R ENG | MEDITRAN SX 15W-40 | CAUTION   | 20/06/2024 | 22/06/2024 | 24/06/2024 | 15820  | Yes     |
| D375A-6R | ENGINE | 65901   | M24016385  | 4682     | PT. RIUNG MITRA LESTARI - RMP  | TARAKAN         | DE40         | GEN DSO 15W-40     | NORMAL    | 05/09/2024 | 07/09/2024 | 08/09/2024 |        | Yes     |
| D375A-6R | ENGINE | 66067   | B24038586  | 30       | PT. KALIM PRIMA COAL           | SANGATTA        | DE40         | GEN DSO 15W-40     | NORMAL    | 27/02/2024 | 05/03/2024 | 06/03/2024 |        | No      |
| D375A-6R | ENGINE | 66062   | B24131139  | 30       | PT. KALIM PRIMA COAL           | SANGATTA        | DE40         | GEN DSO 15W-40     | CAUTION   | 14/07/2024 | 19/07/2024 | 20/07/2024 |        | Yes     |
| D375A-6R | ENGINE | 65450   | R23027699  | 501129   | PT. FAJAR ANUGRAH DINAMIKA     | TANJUNG REDEB   | DE40         | GEN DSO 15W-40     | NORMAL    | 03/07/2023 | 06/07/2023 | 07/07/2023 |        | Yes     |
| D375A-6R | ENGINE | 65884   | B25070299  | 501792   | PT. HASNUR RIUNG SINERGI       | RANTAU          | DE40         | GEN DSO 15W-40     | NORMAL    | 22/03/2025 | 27/03/2025 | 28/03/2025 |        | Yes     |
| D375A-6R | ENGINE | 65890   | M25003827  | 4682     | PT. RIUNG MITRA LESTARI - RMP  | TARAKAN         | DE40         | GEN DSO 15W-40     | CAUTION   | 23/02/2025 | 26/02/2025 | 27/02/2025 |        | Yes     |
| D375A-6R | ENGINE | 65762   | B21097866  | 54       | PT. RENTAL PERDANA PUTRATAMA   | NFMIC LOAJANAN  | 2025550      | GEN DSO 15W-40     | ATTENTION | 01/11/2021 | 09/11/2021 | 10/11/2021 |        | Yes     |
| D375A-6R | ENGINE | 65353   | B23045570  | 501805   | PT. BAYAN RESOURCES, TBK       | MUARA LAWA      | DE40         | GEN DSO 15W-40     | NORMAL    | 11/03/2023 | 18/03/2023 | 21/03/2023 |        | Yes     |
| D375A-6R | ENGINE | 65762   | B20048386  | 54       | PT. RENTAL PERDANA PUTRATAMA   | LOAJANAN        | DE40         | GEN DSO 15W-40     | NORMAL    | 13/05/2020 | 20/05/2020 | 22/05/2020 | 9049   | Yes     |

### c. Historical Component Replacement

The historical data of heavy equipment component replacement available in this table plays an important role in understanding the maintenance and component replacement trends that occur during the use of heavy equipment in daily operations. This data provides an overview of the frequency of failure of certain components, the duration of each component's life, and the types of components that often experience failure. In general, this data shows recurring component replacement patterns, which can be used to build machine learning-based predictive models to improve operational efficiency.

In this table, we can see several components that are frequently replaced, including engine components, hydraulic systems, and electronic parts, each of which has a different failure rate based on the operating hours of the heavy equipment. This data shows how the frequency of component replacement is affected by various factors, such as the intensity of equipment use, component quality, and unstable operational conditions.

### Table 4. 6 Historical Component Replacement Data

| ANN T SUMBARA      |            |           |        |                        |                       |              |       |       |       |                        |                 |                  |
|--------------------|------------|-----------|--------|------------------------|-----------------------|--------------|-------|-------|-------|------------------------|-----------------|------------------|
| LAST UPDATE: 06-05 |            |           |        |                        |                       |              |       |       |       |                        |                 |                  |
| POL UPDATE: 000    |            |           |        |                        |                       |              |       |       |       |                        |                 |                  |
| PROJECT            | MODEL UNIT | CODE UNIT | STATUS | GROUP                  | COMPONENT             | PART NUMBER  | QTY   | PLAN  | PLAN  | JOB DESCRIPTION        | UPDATE QTY TIME | LAST REPLACEMENT |
|                    |            |           |        |                        |                       |              |       |       |       |                        |                 | NO. OF LIFESPAN  |
|                    |            |           |        |                        |                       |              |       |       |       |                        |                 | I STATUS         |
|                    |            |           |        |                        |                       |              |       |       |       |                        |                 | NO. WORK ORDER   |
|                    |            |           |        |                        |                       |              |       |       |       |                        |                 | LF               |
| ANN T-7            | HTF-7      | 3306      | 3306   | ENGINE & RELATED PARTS | TERMINAL HOSES        | ALL          | 20000 | 60000 | 60000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | ENGINE & RELATED PARTS | INTAKE HOSES          | ALL          | 20000 | 60000 | 60000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | ELECTRICAL SYSTEM      | BATTERY NO.1          | N600         | 1     | 6000  | 6000  | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | ELECTRICAL SYSTEM      | BATTERY NO.2          | N600         | 1     | 6000  | 6000  | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | ELECTRICAL SYSTEM      | BATTERY NO.3          | N600         | 1     | 6000  | 6000  | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | ELECTRICAL SYSTEM      | BATTERY NO.4          | N600         | 1     | 6000  | 6000  | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | FORWARD A/C SYSTEMS   | N600         | 1     | 6000  | 6000  | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | PUMP REAR A/C COOLING | 700-52-42726 | 1     | 30000 | 30000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | FORWARD A/C COOLING   | 700-52-42726 | 1     | 30000 | 30000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | PUMP REAR A/C COOLING | 700-52-42726 | 1     | 30000 | 30000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | PUMP REAR A/C COOLING | 700-52-42726 | 1     | 30000 | 30000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | PUMP REAR A/C COOLING | 700-52-42726 | 1     | 30000 | 30000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | PUMP REAR A/C COOLING | 700-52-42726 | 1     | 30000 | 30000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | PUMP REAR A/C COOLING | 700-52-42726 | 1     | 30000 | 30000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | PUMP REAR A/C COOLING | 700-52-42726 | 1     | 30000 | 30000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | PUMP REAR A/C COOLING | 700-52-42726 | 1     | 30000 | 30000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | PUMP REAR A/C COOLING | 700-52-42726 | 1     | 30000 | 30000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | PUMP REAR A/C COOLING | 700-52-42726 | 1     | 30000 | 30000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | PUMP REAR A/C COOLING | 700-52-42726 | 1     | 30000 | 30000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | PUMP REAR A/C COOLING | 700-52-42726 | 1     | 30000 | 30000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | PUMP REAR A/C COOLING | 700-52-42726 | 1     | 30000 | 30000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | PUMP REAR A/C COOLING | 700-52-42726 | 1     | 30000 | 30000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | PUMP REAR A/C COOLING | 700-52-42726 | 1     | 30000 | 30000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | PUMP REAR A/C COOLING | 700-52-42726 | 1     | 30000 | 30000 | Replace Component Assy | 2000            | 2000             |
| ANN T-7            | HTF-7      | 3306      | 3306   | FORWARD A/C SYSTEMS    | PUMP REAR A/C COOLING | 700-52-42726 | 1     | 30000 | 30000 | Replace                |                 |                  |

The data provides information on the target lifetime of the components used in heavy equipment. This data includes an estimate of the life of each component based on operational conditions and previous

maintenance. Determining the target lifetime for each component is essential for planning maintenance and component replacement more effectively, reducing downtime, and ensuring optimal performance of heavy equipment in the long term.

In this data, the target lifetime of each component is determined based on historical analysis and applicable industry standards from principal. This target lifetime serves as a reference for knowing when a component should be replaced or undergo intensive maintenance. In this case, components with a shorter target lifetime may require more frequent replacement, while components with a longer target lifetime can be replaced less frequently but must still be monitored carefully to prevent sudden failure.

The application of machine learning in analyzing this target lifetime data allows us to identify patterns that can predict component life more accurately. Algorithms such as regression analysis, decision trees, and random forests can be used to predict when a component will reach the end of its useful life based on historical data on the use and operational conditions of the heavy equipment.

Table 4. 7 Component Targeted Lifetime Data

(Internal Company Data, 2025)

| No | Model Unit | Component              | Part Number    | Part Number 2 | Lifetime1 | Lifetime2 | Lifetime3 |
|----|------------|------------------------|----------------|---------------|-----------|-----------|-----------|
| 1  | HD785-7    | ENGINE ASSY            | RM6219-B0-0041 | 6219-B0-0041  | 30000     | 48000     | 66000     |
| 2  | HD785-7    | ENGINE ASSY            | RM6219-B0-0040 | 6219-B0-0040  | 30000     | 48000     | 66000     |
| 3  | HD785-7    | TRANSMISSION           | RM561-13-70001 | 561-13-70001  | 30000     | 48000     | 66000     |
| 4  | HD785-7    | REAR AXLE INSTALLATION | RM561-22-70003 | 561-22-70003  | 30000     | 48000     | 66000     |
| 5  | HD785-7    | FRONT AXLE LH          | RM561-27-8B204 | 561-27-8B204  | 30000     | 48000     | 66000     |
| 6  | HD785-7    | DIFFERENTIAL           | RM561-22-71003 | 561-22-71003  | 30000     | 48000     | 66000     |
| 7  | HD785-7    | FINAL DRIVE LH         | RM561-88-70201 | 561-88-70201  | 30000     | 48000     | 66000     |
| 8  | HD785-7    | FINAL DRIVE RH         | RM561-88-70301 | 561-88-70301  | 30000     | 48000     | 66000     |
| 9  | HD785-7    | FRONT AXLE RH          | RM561-27-8B204 | 561-27-8B204  | 30000     | 48000     | 66000     |
| 10 | PC2000-8   | FINAL DRIVE LH         | RM21T-27-00300 | 21T-27-00300  | 20000     | 38000     | 56000     |
| 11 | PC2000-8   | FINAL DRIVE RH         | RM21T-27-00310 | 21T-27-00310  | 20000     | 38000     | 56000     |
| 12 | PC2000-8   | TRAVEL MOTOR           | RM706-7L-01110 | 706-7L-01110  | 20000     | 38000     | 56000     |
| 13 | PC2000-8   | ENGINE ASSY            | RM6219-C0-0030 | 6219-C0-0030  | 20000     | 38000     | 56000     |
| 14 | PC2000-8   | MAIN PUMP 1            | RM708-2K-00120 | 708-2K-00120  | 30000     | 45000     | 60000     |
| 15 | PC2000-8   | MAIN PUMP 2            | RM708-2K-00120 | 708-2K-00120  | 30000     | 45000     | 60000     |
| 16 | PC2000-8   | PTO (POWER TAKE OFF)   | RM21T-38-00160 | 21T-38-00160  | 20000     | 38000     | 56000     |
| 17 | PC2000-8   | Swing Machinery FRONT  | RM21T-26-00300 | 21T-26-00300  | 20000     | 38000     | 56000     |
| 18 | PC2000-8   | Swing Machinery REAR   | RM21T-26-00300 | 21T-26-00300  | 20000     | 38000     | 56000     |
| 19 | PC2000-8   | Swing Motor FRONT      | RM706-7K-01120 | 706-7K-01120  | 20000     | 38000     | 56000     |
| 20 | PC2000-8   | Swing Motor REAR       | RM706-7K-01120 | 706-7K-01120  | 20000     | 38000     | 56000     |

e. Fault code

Fault code data recorded by the VHMS system plays an important role as an early indicator of component failure and a signal for the need for replacement. This dataset comes from automatic monitoring of heavy equipment units that record every error event, the duration of the disruption, and the frequency of occurrence of specific fault codes. For example, a fault code such as 2201LH may refer to a low oil pressure sensor or overheating of a particular component. Repeated occurrences of this code may be an indicator that the component is nearing the end of its useful life or has experienced significant degradation.

The Functions of Fault Code Data in Remanufacturing Prediction System are:

1. Early Detection of Potential Component Needs

Repeated VHMS codes with increasing duration are signals of systemic degradation, such as piston ring failure, oil pump failure, or

overheating of the cooling system. All of which are candidates for remanufactured components.

## 2. Input Features for Machine Learning Models

- In predictive models, fault data is used as categorical (encoded) and numeric variables (number of occurrences, total duration).
- The combination of fault codes, working hours, and oil history becomes a comprehensive signal in predicting Remaining Useful Life (RUL).

## 3. Improving Opportunity Scoring Accuracy

Units that experience critical or repeated fault codes will receive a high probability score to be categorized as remanufactured component sales prospects.

Table 4. 8 Fault Code Data  
(Internal Company Data, 2025)

| Unit Model | MCHN_SRL_NUM | CODE   | FROM_DATE  | TO_DATE    | COUNT_EVENT | TOTAL_DURATION_MINUTES |
|------------|--------------|--------|------------|------------|-------------|------------------------|
| D375A-6R   | 65843        | 2201LH | 22/02/2024 | 22/02/2024 | 1           | 0                      |
| D375A-6R   | 65843        | 2201LH | 05/03/2024 | 05/03/2024 | 1           | 1                      |
| D375A-6R   | 65843        | 2201LH | 19/04/2024 | 19/04/2024 | 1           | 2                      |
| D375A-6R   | 65843        | 2201LH | 24/05/2024 | 24/05/2024 | 1           | 1                      |
| D375A-6R   | 65843        | 2201LH | 25/05/2024 | 25/05/2024 | 1           | 2                      |
| D375A-6R   | 65843        | 2201LH | 22/04/2025 | 22/04/2025 | 1           | 7                      |
| D375A-6R   | 65843        | 2301LH | 01/12/2024 | 02/12/2024 | 2           | 1191                   |
| D375A-6R   | 65843        | 2301LH | 11/12/2024 | 12/12/2024 | 1           | 1345                   |
| D375A-6R   | 65843        | 2301LH | 11/01/2025 | 11/01/2025 | 1           | 1                      |
| D375A-6R   | 65843        | 2301LH | 16/01/2025 | 16/01/2025 | 2           | 4                      |
| D375A-6R   | 65843        | 2301LH | 20/01/2025 | 20/01/2025 | 1           | 8                      |
| D375A-6R   | 65843        | 2301LH | 30/01/2025 | 30/01/2025 | 1           | 1                      |
| D375A-6R   | 65843        | 2301LH | 24/02/2025 | 24/02/2025 | 1           | 4                      |
| D375A-6R   | 65843        | 2301LH | 06/03/2025 | 06/03/2025 | 1           | 1                      |
| D375A-6R   | 65843        | 2301LH | 11/03/2025 | 11/03/2025 | 3           | 2                      |
| D375A-6R   | 65843        | 2301LH | 14/03/2025 | 14/03/2025 | 2           | 2                      |
| D375A-6R   | 65843        | 2301LH | 15/03/2025 | 15/03/2025 | 1           | 0                      |
| D375A-6R   | 65843        | 2301LH | 02/04/2025 | 02/04/2025 | 1           | 0                      |
| D375A-6R   | 65843        | 2301LH | 06/04/2025 | 06/04/2025 | 1           | 1                      |
| D375A-6R   | 65843        | 2301LH | 13/04/2025 | 13/04/2025 | 3           | 4                      |
| D375A-6R   | 65843        | 2301LH | 28/04/2025 | 28/04/2025 | 1           | 0                      |

|          |       |        |            |            |    |      |
|----------|-------|--------|------------|------------|----|------|
| D375A-6R | 65843 | 2301LH | 02/05/2025 | 02/05/2025 | 1  | 0    |
| D375A-6R | 65843 | AA10NX | 20/02/2024 | 20/02/2024 | 5  | 22   |
| D375A-6R | 65843 | AA10NX | 31/07/2024 | 31/07/2024 | 3  | 10   |
| D375A-6R | 65843 | AA10NX | 30/09/2024 | 30/09/2024 | 3  | 29   |
| D375A-6R | 65843 | AA10NX | 03/10/2024 | 03/10/2024 | 3  | 0    |
| D375A-6R | 65843 | AA10NX | 05/10/2024 | 05/10/2024 | 2  | 0    |
| D375A-6R | 65843 | AA10NX | 09/03/2025 | 09/03/2025 | 12 | 50   |
| D375A-6R | 65843 | AA10NX | 17/04/2025 | 17/04/2025 | 8  | 65   |
| D375A-6R | 65843 | AA10NX | 18/04/2025 | 18/04/2025 | 36 | 581  |
| D375A-6R | 65843 | AA10NX | 19/04/2025 | 19/04/2025 | 40 | 184  |
| D375A-6R | 65843 | AA10NX | 20/04/2025 | 20/04/2025 | 11 | 67   |
| D375A-6R | 65843 | B@BCNS | 25/08/2024 | 25/08/2024 | 1  | 10   |
| D375A-6R | 65843 | B@BCNS | 22/04/2025 | 22/04/2025 | 6  | 3    |
| D375A-6R | 65843 | B@BCNS | 23/04/2025 | 23/04/2025 | 2  | 1    |
| D375A-6R | 65843 | B@BCZK | 12/06/2024 | 19/06/2024 | 1  | 9653 |
| D375A-6R | 65843 | B@BCZK | 16/11/2024 | 17/11/2024 | 2  | 145  |
| D375A-6R | 65843 | B@BCZK | 03/12/2024 | 03/12/2024 | 2  | 90   |
| D375A-6R | 65843 | B@BCZK | 04/12/2024 | 04/12/2024 | 1  | 67   |
| D375A-6R | 65843 | B@BCZK | 09/12/2024 | 09/12/2024 | 2  | 7    |
| D375A-6R | 65843 | B@BCZK | 10/12/2024 | 10/12/2024 | 1  | 7    |
| D375A-6R | 65843 | B@BCZK | 01/01/2025 | 01/01/2025 | 1  | 15   |
| D375A-6R | 65843 | B@BCZK | 02/01/2025 | 02/01/2025 | 1  | 1    |
| D375A-6R | 65843 | B@BCZK | 03/01/2025 | 03/01/2025 | 9  | 151  |
| D375A-6R | 65843 | B@BCZK | 09/01/2025 | 09/01/2025 | 1  | 2    |
| D375A-6R | 65843 | B@BCZK | 10/01/2025 | 10/01/2025 | 1  | 240  |
| D375A-6R | 65843 | B@BCZK | 12/01/2025 | 12/01/2025 | 1  | 359  |
| D375A-6R | 65843 | B@BCZK | 13/01/2025 | 14/01/2025 | 1  | 601  |
| D375A-6R | 65843 | B@BCZK | 14/01/2025 | 14/01/2025 | 2  | 147  |
| D375A-6R | 65843 | B@BCZK | 15/01/2025 | 16/01/2025 | 3  | 380  |
| D375A-6R | 65843 | B@BCZK | 22/01/2025 | 22/01/2025 | 1  | 12   |
| D375A-6R | 65843 | B@BCZK | 23/01/2025 | 23/01/2025 | 1  | 16   |
| D375A-6R | 65843 | B@BCZK | 24/01/2025 | 25/01/2025 | 2  | 195  |
| D375A-6R | 65843 | B@BCZK | 25/01/2025 | 26/01/2025 | 1  | 131  |
| D375A-6R | 65843 | B@BCZK | 27/01/2025 | 27/01/2025 | 4  | 782  |
| D375A-6R | 65843 | B@BCZK | 28/01/2025 | 29/01/2025 | 1  | 78   |
| D375A-6R | 65843 | B@BCZK | 31/01/2025 | 31/01/2025 | 2  | 82   |
| D375A-6R | 65843 | B@BCZK | 01/02/2025 | 01/02/2025 | 2  | 369  |
| D375A-6R | 65843 | B@BCZK | 02/02/2025 | 02/02/2025 | 3  | 473  |

### 3. Data Cleansing

Before training, the data needs to be carefully prepared:

- Cleaning: removing duplicates, handling missing values.

- b. Transformation: normalization (min-max/standardization), categorical encoding (one-hot).
- c. Feature engineering: creating new features, such as last installation, trend of working hours, interval between replacements.
- d. Data split: 70% training and 30% testing, including cross-validation.

#### 4. Model Development (Training & Testing)

This model development (training & testing) stage includes:

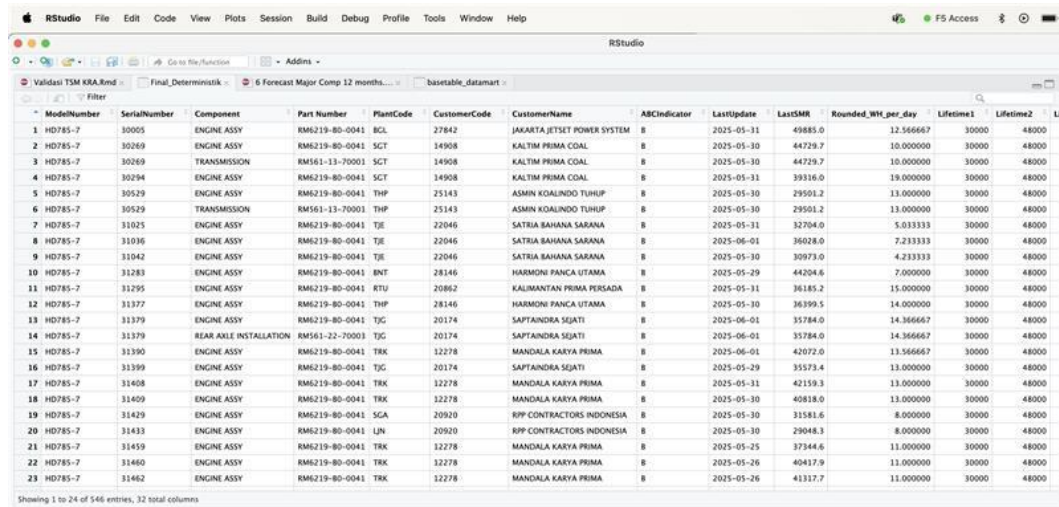
- a. Algorithm selection: XGBoost, Random Forest, Logistic Regression.
- b. Model training: parameter tuning using grid search or Bayesian optimization techniques.
- c. Performance evaluation using metrics: accuracy, precision, recall, F1-score, and ROC-AUC.
- d. Cross-validation: ensuring the model can be generalized on unseen data.

#### 5. Deployment

The best model after further evaluation is deployed to the operational system:

- a. Integration into internal dashboards for sales and ASC teams.
- b. Real-time monitoring: generate scoring opportunities periodically (daily/weekly).
- c. Implement automatic alerts or notifications as follow-up triggers.
- d. Implement MLOps strategies: record pipelines, versioning, and performance monitoring.

#### 6. Deterministic Data



| ModelNumber | SerialNumber | Component              | Part Number    | PlantCode | CustomerCode | CustomerName                | ABCIndicator | LastUpdate | LastSMR | Rounded_Wht_per_day | Lifetime1 | Lifetime2 |
|-------------|--------------|------------------------|----------------|-----------|--------------|-----------------------------|--------------|------------|---------|---------------------|-----------|-----------|
| HD785-7     | 10005        | ENGINE ASSY            | RM6219-B0-0041 | BCL       | 27842        | JAKARTA JETSET POWER SYSTEM | B            | 2025-05-31 | 49885.0 | 12.56667            | 30000     | 48000     |
| HD785-7     | 10269        | ENGINE ASSY            | RM6219-B0-0041 | SCT       | 14908        | KALTIM PRIMA COAL           | B            | 2025-05-30 | 44729.7 | 10.00000            | 30000     | 48000     |
| HD785-7     | 10269        | TRANSMISSION           | RM561-13-70001 | SCT       | 14908        | KALTIM PRIMA COAL           | B            | 2025-05-30 | 44729.7 | 10.00000            | 30000     | 48000     |
| HD785-7     | 10294        | ENGINE ASSY            | RM6219-B0-0041 | SCT       | 14908        | KALTIM PRIMA COAL           | B            | 2025-05-31 | 39316.0 | 19.00000            | 30000     | 48000     |
| HD785-7     | 10529        | ENGINE ASSY            | RM6219-B0-0041 | THP       | 25143        | ASMIN KUALINDO TUPHUP       | B            | 2025-05-30 | 29501.2 | 13.00000            | 30000     | 48000     |
| HD785-7     | 10529        | TRANSMISSION           | RM561-13-70001 | THP       | 25143        | ASMIN KUALINDO TUPHUP       | B            | 2025-05-30 | 29501.2 | 13.00000            | 30000     | 48000     |
| HD785-7     | 11025        | ENGINE ASSY            | RM6219-B0-0041 | TJE       | 22046        | SATRIA BAHANA SARANA        | B            | 2025-05-31 | 32704.0 | 5.013333            | 30000     | 48000     |
| HD785-7     | 11036        | ENGINE ASSY            | RM6219-B0-0041 | TJE       | 22046        | SATRIA BAHANA SARANA        | B            | 2025-06-01 | 36028.0 | 7.213333            | 30000     | 48000     |
| HD785-7     | 11042        | ENGINE ASSY            | RM6219-B0-0041 | TJE       | 22046        | SATRIA BAHANA SARANA        | B            | 2025-05-30 | 30973.0 | 4.213333            | 30000     | 48000     |
| HD785-7     | 11283        | ENGINE ASSY            | RM6219-B0-0041 | BNT       | 28146        | HARMONI PANCA UTAMA         | B            | 2025-05-29 | 44204.6 | 7.00000             | 30000     | 48000     |
| HD785-7     | 11295        | ENGINE ASSY            | RM6219-B0-0041 | RTU       | 20862        | KALIMANTAN PRIMA PERSADA    | B            | 2025-05-31 | 36181.2 | 15.00000            | 30000     | 48000     |
| HD785-7     | 11377        | ENGINE ASSY            | RM6219-B0-0041 | THP       | 28146        | HARMONI PANCA UTAMA         | B            | 2025-05-30 | 36390.5 | 14.00000            | 30000     | 48000     |
| HD785-7     | 11379        | ENGINE ASSY            | RM6219-B0-0041 | TJC       | 20174        | SAPTANDORA SEJATI           | B            | 2025-06-01 | 31784.0 | 14.36667            | 30000     | 48000     |
| HD785-7     | 11379        | REAR AXLE INSTALLATION | RM561-22-70003 | TJC       | 20174        | SAPTANDORA SEJATI           | B            | 2025-06-01 | 31784.0 | 14.36667            | 30000     | 48000     |
| HD785-7     | 11390        | ENGINE ASSY            | RM6219-B0-0041 | TRK       | 12278        | MANDALA KARYA PRIMA         | B            | 2025-06-01 | 41072.0 | 13.56667            | 30000     | 48000     |
| HD785-7     | 11399        | ENGINE ASSY            | RM6219-B0-0041 | TJC       | 20174        | SAPTANDORA SEJATI           | B            | 2025-05-29 | 31573.4 | 13.00000            | 30000     | 48000     |
| HD785-7     | 11408        | ENGINE ASSY            | RM6219-B0-0041 | TRK       | 12278        | MANDALA KARYA PRIMA         | B            | 2025-05-31 | 42159.3 | 13.00000            | 30000     | 48000     |
| HD785-7     | 11409        | ENGINE ASSY            | RM6219-B0-0041 | TRK       | 12278        | MANDALA KARYA PRIMA         | B            | 2025-05-30 | 40818.0 | 13.00000            | 30000     | 48000     |
| HD785-7     | 11429        | ENGINE ASSY            | RM6219-B0-0041 | SCA       | 20920        | RPP CONTRACTORS INDONESIA   | B            | 2025-05-30 | 31581.6 | 8.00000             | 30000     | 48000     |
| HD785-7     | 11433        | ENGINE ASSY            | RM6219-B0-0041 | LNI       | 20920        | RPP CONTRACTORS INDONESIA   | B            | 2025-05-30 | 29048.3 | 8.00000             | 30000     | 48000     |
| HD785-7     | 11459        | ENGINE ASSY            | RM6219-B0-0041 | TRK       | 12278        | MANDALA KARYA PRIMA         | B            | 2025-05-25 | 37344.6 | 11.00000            | 30000     | 48000     |
| HD785-7     | 11460        | ENGINE ASSY            | RM6219-B0-0041 | TRK       | 12278        | MANDALA KARYA PRIMA         | B            | 2025-05-26 | 40417.9 | 11.00000            | 30000     | 48000     |
| HD785-7     | 11462        | ENGINE ASSY            | RM6219-B0-0041 | TRK       | 12278        | MANDALA KARYA PRIMA         | B            | 2025-05-26 | 41317.7 | 11.00000            | 30000     | 48000     |

Figure 4. 6 Deterministic Data  
(Internal Company Data, 2025)

## 7. Final Data List Component Prediction

After all data input and processing, it produces an output as an opportunity which is called List Potential Component Replacement. In operation we called it Targeted Sales Marketing Major Component. This data will be reviewed again based on market conditions, customer financial status, pending damage core customer, and mining business conditions.

Table 4. 9 List Potential Component Replacement

| Model Number | Serial Number | Unit Code | Component                   | Part Number    | Plant Code |
|--------------|---------------|-----------|-----------------------------|----------------|------------|
| HD785-7      | J30159        |           | ENGINE ASSY                 | RM6219-B0-0041 | TRK        |
| HD785-7      | J30160        |           | ENGINE ASSY                 | RM6219-B0-0041 | TRK        |
| HD785-7      | 31804         | 4190      | ENGINE ASSY                 | RM6219-B0-0041 | TRK        |
| PC2000-8     | J10041        | 2104      | ENGINE ASSY                 | RM6219-C0-0030 | TRK        |
| HD785-7      | 31731         | DT90-356  | ENGINE ASSY                 | RM6219-B0-0041 | TJG        |
| HD785-7      | 31409         | 4148      | TRANSMISSION                | RM561-13-70001 | TRK        |
| HD785-7      | 31782         | 4179      | TRANSMISSION                | RM561-13-70001 | TRK        |
| HD785-7      | J30165        |           | REAR AXLE INSTALLATION      | RM561-22-70003 | TRK        |
| HD785-7      | J30238        | DT90-410  | TRANSMISSION                | RM561-13-70001 | TJG        |
| HD785-7      | 31036         | -         | ENGINE ASSY                 | RM6219-B0-0041 | TJE        |
| HD465-7      |               |           | FINAL DRIVE ASR RH HD465-7R | RM569-88-80201 | SMD        |
| HD465-7      |               |           | FINAL DRIVE ASR LH HD465-7R | RM569-88-80301 | SMD        |

|         |  |  |                 |                |     |
|---------|--|--|-----------------|----------------|-----|
| HD465-7 |  |  | ENGINE HD465-7R | RM624E-B0-0012 | SMD |
|---------|--|--|-----------------|----------------|-----|

| Customer Code | Customer Name        | ABCIndicator | LastUpdate | LastSMR |
|---------------|----------------------|--------------|------------|---------|
| 12278         | MANDALA KARYA PRIMA  | B            | 30/03/2025 | 38077,6 |
| 12278         | MANDALA KARYA PRIMA  | B            | 30/03/2025 | 36035,6 |
| 12278         | MANDALA KARYA PRIMA  | B            | 30/03/2025 | 36812,7 |
| 12278         | MANDALA KARYA PRIMA  | B            | 30/03/2025 | 39822,7 |
| 20174         | SAPTAINDRA SEJATI    | B            | 27/03/2025 | 34980,4 |
| 12278         | MANDALA KARYA PRIMA  | B            | 30/03/2025 | 39956   |
| 12278         | MANDALA KARYA PRIMA  | B            | 30/03/2025 | 38689,3 |
| 12278         | MANDALA KARYA PRIMA  | B            | 30/03/2025 | 38157,3 |
| 20174         | SAPTAINDRA SEJATI    | B            | 30/03/2025 | 33876   |
| 22046         | SATRIA BAHANA SARANA | B            | 30/03/2025 | 35575   |
| 25387         | GRAHA PRIMA ENERGY   |              |            |         |
| 25387         | GRAHA PRIMA ENERGY   |              |            |         |
| 25387         | GRAHA PRIMA ENERGY   |              |            |         |

| Rounded_WH_per_day | Lifetime1 | Lifetime2 | Lifetime3 | Last_comp_repl |
|--------------------|-----------|-----------|-----------|----------------|
| 14                 | 30000     | 48000     | 66000     |                |
| 14                 | 30000     | 48000     | 66000     |                |
| 12                 | 30000     | 48000     | 66000     |                |
| 17                 | 20000     | 38000     | 56000     | 22837          |
| 11                 | 30000     | 48000     | 66000     |                |
| 15                 | 30000     | 48000     | 66000     |                |
| 16                 | 30000     | 48000     | 66000     |                |
| 14                 | 30000     | 48000     | 66000     |                |
| 10,0666667         | 30000     | 48000     | 66000     |                |
| 8,26666667         | 30000     | 48000     | 66000     |                |
|                    |           |           |           |                |
|                    |           |           |           |                |
|                    |           |           |           |                |

| SMR_Comp | latest_hs  | rul_final  | next_smr | predicted_replace |
|----------|------------|------------|----------|-------------------|
| 38077,6  | 0,19093595 | 403,19909  | 38077,6  | 30/03/2025        |
| 36035,6  | 0,31202807 | 1987,94732 | 36035,6  | 30/03/2025        |

|         |            |            |         |            |
|---------|------------|------------|---------|------------|
| 36812,7 | 0,2839526  | 2670,38307 | 36812,7 | 30/03/2025 |
| 16985,7 | 0,30999473 | 350,8272   | 20000   | 19/04/2025 |
| 34980,4 | 0,29275075 | 18000      | 34980,4 | 27/03/2025 |
| 39956   |            |            | 39956   | 30/03/2025 |
| 38689,3 |            |            | 38689,3 | 30/03/2025 |
| 38157,3 |            |            | 38157,3 | 30/03/2025 |
| 33876   |            |            | 33876   | 30/03/2025 |
| 35575   | 0,0706804  | 3272,51572 | 35575   | 30/03/2025 |
|         |            |            |         |            |
|         |            |            |         |            |
|         |            |            |         |            |

| prediction_source | urgency | hs_modus_2months | hs_modus_10days |
|-------------------|---------|------------------|-----------------|
| Targeted Lifetime | 1       | 0,1              | 0,2             |
| Targeted Lifetime | 1       | 0,4              | 0,4             |
| Targeted Lifetime | 1       | 0,3              | 0,3             |
| RUL               | 1       | 0,3              | 0,3             |
| Targeted Lifetime | 1       | 0,3              | 0,3             |
| Targeted Lifetime | 1       |                  |                 |
| Targeted Lifetime | 1       |                  |                 |
| Targeted Lifetime | 1       |                  |                 |
| Targeted Lifetime | 1       |                  |                 |
| Targeted Lifetime | 1       | 0,2              | 0               |
|                   |         |                  |                 |
|                   |         |                  |                 |
|                   |         |                  |                 |

| VHMS_Problem                   | PAP_Problem | TRS_BUS_1mo | TRS_BUS_1mo_Count |
|--------------------------------|-------------|-------------|-------------------|
| ExhTemp                        |             |             |                   |
| ExhTemp                        |             |             |                   |
| ExhTemp                        |             |             |                   |
| CoolTempMx                     |             |             |                   |
| BlowbyPress;BoostPress;ExhTemp |             |             |                   |
|                                |             |             |                   |
|                                |             |             |                   |
|                                | Fe          |             |                   |
|                                |             |             |                   |
| ExhTemp                        |             |             |                   |
|                                |             |             |                   |

|  |  |  |  |
|--|--|--|--|
|  |  |  |  |
|  |  |  |  |

| Fault_1mo                                                                                                                                                                                                                         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CA451-Rail Press. Sensor High Error (count: 106) (duration: 1001 minutes);CA553-Rail Press. High Error (count: 17) (duration: 76 minutes);B@BAZK-Drop in Engine Oil Level (count: 6) (duration: 19 minutes)                       |
|                                                                                                                                                                                                                                   |
|                                                                                                                                                                                                                                   |
|                                                                                                                                                                                                                                   |
| F@BBZL-High Blowby Pressure (count: 2118) (duration: 12213 minutes);B@BAZK-Drop in Engine Oil Level (count: 2) (duration: 513 minutes)                                                                                            |
| B@JANS-Steering Oil Overheat (count: 12) (duration: 591 minutes);DGR6KX-Abnormality in Steering Oil Temp. Sensor Circuit (count: 8) (duration: 82 minutes)                                                                        |
| DAQW00-NEUTRAL OVER SPEED CAUTION (count: 77) (duration: 196 minutes);DAQV00-NEUTRAL COAST CAUTION (count: 4) (duration: 2 minutes);15B0NX-T/M Oil Filter Clogged (count: 1) (duration: 6 minutes)                                |
|                                                                                                                                                                                                                                   |
| B@JANS-Steering Oil Overheat (count: 12) (duration: 3634 minutes);DGR6KX-Abnormality in Steering Oil Temp. Sensor Circuit (count: 11) (duration: 1225 minutes);DAQW00-NEUTRAL OVER SPEED CAUTION (count: 1) (duration: 1 minutes) |
|                                                                                                                                                                                                                                   |
|                                                                                                                                                                                                                                   |
|                                                                                                                                                                                                                                   |
|                                                                                                                                                                                                                                   |

| Fault_Count_1mo | Priority_Unit | yymm   | total_amount_kra_6m |
|-----------------|---------------|--------|---------------------|
| 129             | 1             | 202503 | 5,41E+10            |
|                 | 1             | 202503 | 5,41E+10            |
|                 | 1             | 202503 | 5,41E+10            |
|                 | 1             | 202503 | 5,41E+10            |
| 2120            | 1             | 202503 | 6,93E+10            |
| 20              | 1             | 202503 | 5,41E+10            |
| 82              | 1             | 202503 | 5,41E+10            |
|                 | 1             | 202503 | 5,41E+10            |
| 24              | 1             | 202503 | 6,93E+10            |
|                 | 1             | 202503 | 8510328116          |
|                 |               |        |                     |
|                 |               |        |                     |
|                 |               |        |                     |

| rfm_kra_category | INSPIRE   | Industry |
|------------------|-----------|----------|
| Best Champion    | CLUSTER A | MNG      |

|               |           |     |
|---------------|-----------|-----|
| Best Champion | CLUSTER A | MNG |
| Best Champion | CLUSTER A | MNG |
| Best Champion | CLUSTER A | MNG |
| Best Champion | CLUSTER A | MNG |
| Best Champion | CLUSTER A | MNG |
| Best Champion | CLUSTER A | MNG |
| Best Champion | CLUSTER A | MNG |
| Best Champion | CLUSTER A | MNG |
| Champion      | CLUSTER A | MNG |
|               |           |     |
|               |           |     |
|               |           |     |

#### 4.5. Implementation

After the model and platform development phase was completed, author and team make activities before launching and socialization to all plants. The activities are:

##### 1. Update to Board Director

All design plans and activity plans are reported to the board of directors so that top management also supports all activities because it will involve large-scale component remanufacturing transaction business in all plants, especially mining plants, which are the company's main business for generating revenue.

Figure 4.7 below shows the teams update about project plan for the first time.

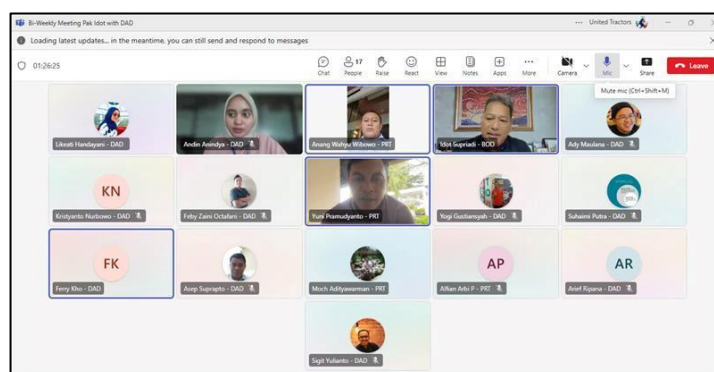


Figure 4. 7 Content update to CSSD Department

##### 2. Update to customer support department.

The author and team present in weekly customer support department review to explain background, design concept, POC, business process improvement and plan activity. Main point for this activity is to communicate analysis results and implementation plans for data analytics and machine learning-based initiatives to supporting departments to improve sales of remanufactured components that previously missed targets. This approach is expected to foster shared understanding, collaborative support, and effective cross-functional integration.

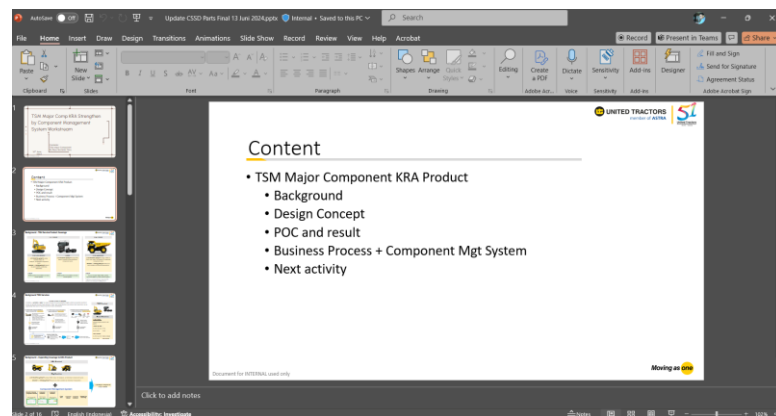


Figure 4. 8 Content update to CSSD Department

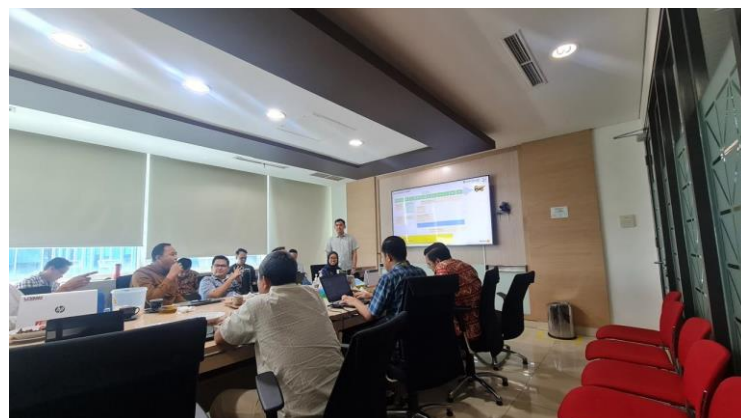


Figure 4. 9 Present on Customer Support Department Weekly Review

### 3. POC at selective plant

The author and team chose 10 pilot customers at various plants as a Proof of Concept (POC). Main point for this activity is to explain background, design concept, POC, business process improvement to improve sales of remanufactured components.

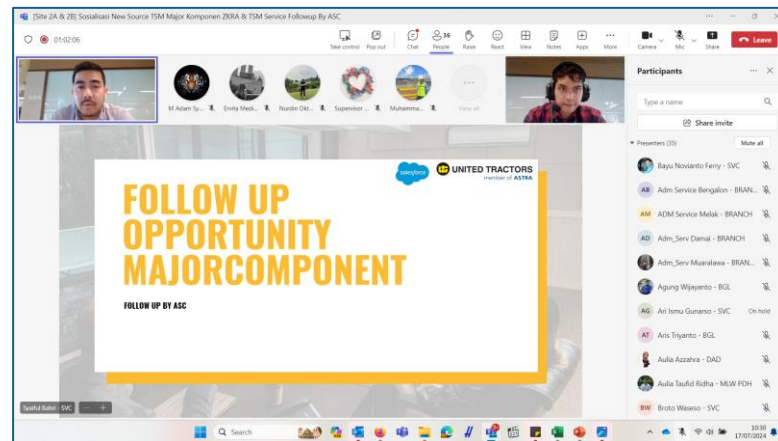


Figure 4. 10 Introduction and POC at plants

#### 4. Release Opportunity

The author and team created an opportunity and then uploaded it to the Sales Force platform and presented it to the ASC team. The main point of this activity is to ensure all opportunities are uploaded and appear on ASC's sales force platform at the appropriate plant. Only plants with opportunities will be listed.

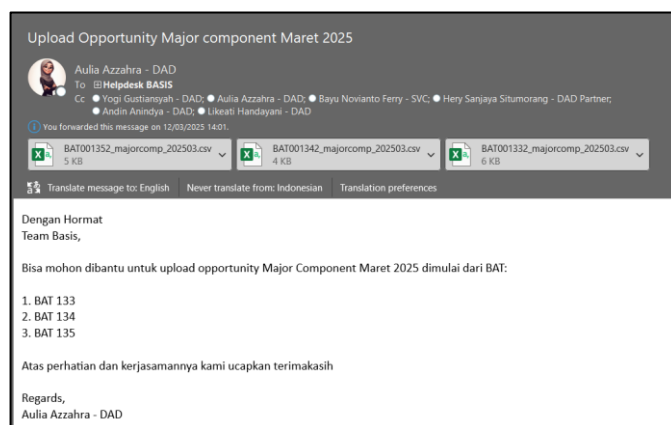


Figure 4. 11 Opportunity Release and Request upload to Sales Force

## 5. Opportunity Display on Platform

**Report Opportunities - Opportunities / Prospects**

**Report Opportunities - Major Component Years to date**

Total Results: 38

Total Sales Amount: IDR 33,366,723,801.00

Total Quotation Amount: IDR 2,175,000,002.00

Total SO Amount: IDR 16,866,429,994.00

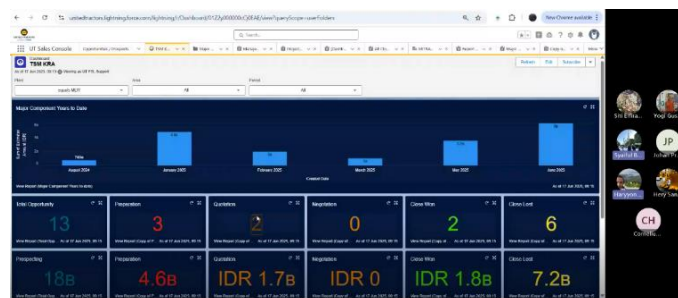
Total Billing Amount: IDR 12,371,953,858.00

| Source                                   | Created Date | Estimated Amount      | Inquiry Amount | Quotation Amount     | SO Amount            | Opportunity Name                         | Account Name                | SAP Inquiry ID | Plant | Opportunity Owner   | Inquiry Created Date | Last Reason    |
|------------------------------------------|--------------|-----------------------|----------------|----------------------|----------------------|------------------------------------------|-----------------------------|----------------|-------|---------------------|----------------------|----------------|
| MAJORCOMPONENT (38)                      | Nov 0 2020   | IDR 33,366,723,801.00 | IDR 0.00       | IDR 0.00             | IDR 0.00             | MAJORCOMPONENT_10781_H1_KH788_C_1486_448 | BANGKALA KARTHA PRIMA       | -              | 786   | BANG PRASETIYO SOLO | -                    | -              |
| MAJORCOMPONENT_10781_H1_KH788_C_1486_448 | Nov 0 2020   | IDR 1,146,687,280.00  | IDR 0.00       | IDR 0.00             | IDR 0.00             | MAJORCOMPONENT_10781_H1_KH788_C_1486_448 | BANGKALA KARTHA PRIMA       | -              | 786   | BANG PRASETIYO SOLO | -                    | -              |
| MAJORCOMPONENT_10781_H1_KH788_C_1486_448 | Nov 0 2020   | IDR 464,586,177.00    | IDR 0.00       | IDR 0.00             | IDR 0.00             | MAJORCOMPONENT_10781_H1_KH788_C_1486_448 | PULITA PERKASA ABADI        | -              | 880   | PANGU KUTU BIKERAN  | -                    | Not as Planned |
| MAJORCOMPONENT_10781_H1_KH788_C_1486_448 | Nov 0 2020   | IDR 1,887,873,763.00  | IDR 0.00       | IDR 0.00             | IDR 0.00             | MAJORCOMPONENT_10781_H1_KH788_C_1486_448 | PULITA PERKASA ABADI        | -              | 880   | PANGU KUTU BIKERAN  | -                    | No Demand      |
| MAJORCOMPONENT_10781_H1_KH788_C_1486_448 | Nov 0 2020   | IDR 0.00              | IDR 0.00       | IDR 0.00             | IDR 98,275,274.00    | MAJORCOMPONENT_10781_H1_KH788_C_1486_448 | SAPTERANA SEATI             | -              | 745   | YUSTONARMA HANNO    | 07082008, 31 10      | -              |
| MAJORCOMPONENT_10781_H1_KH788_C_1486_448 | Nov 0 2020   | IDR 0.00              | IDR 0.00       | IDR 0.00             | IDR 98,275,274.00    | MAJORCOMPONENT_10781_H1_KH788_C_1486_448 | SAPTERANA SEATI             | -              | 745   | YUSTONARMA HANNO    | 07082008, 31 10      | -              |
| MAJORCOMPONENT_10781_H1_KH788_C_1486_448 | Nov 0 2020   | IDR 1,910,000,000.00  | IDR 0.00       | IDR 1,910,000,000.00 | IDR 1,910,000,000.00 | MAJORCOMPONENT_10781_H1_KH788_C_1486_448 | BINA SARANA SUDJES          | -              | 849   | HARYONO             | 07082008, 31 10      | -              |
| MAJORCOMPONENT_10781_H1_KH788_C_1486_448 | Nov 0 2020   | IDR 1,146,687,280.00  | IDR 0.00       | IDR 0.00             | IDR 0.00             | MAJORCOMPONENT_10781_H1_KH788_C_1486_448 | INDONESIA TULUTRI NUSANTARA | -              | 854   | ABIMIO SUDJES       | 07082008, 31 10      | -              |

File Tools | Detail Reports | Subreports | Shared Tools

Figure 4. 12 Opportunity Release and Request upload to Sales Force

## 6. Weekly Monitoring



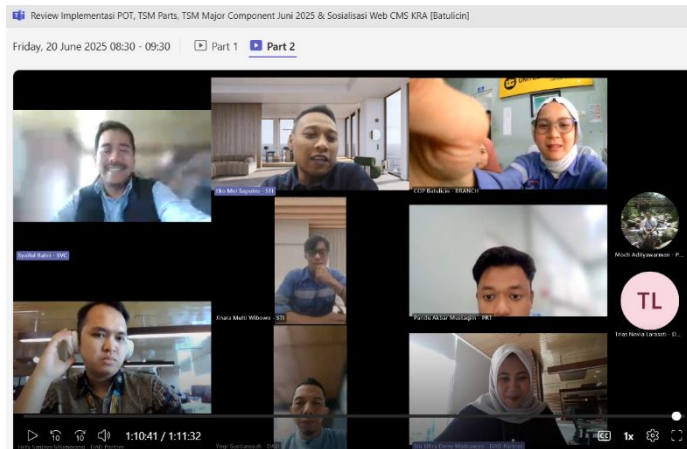


Figure 4. 13 Weekly Review and Monitoring

The figure 4.13 above explains the weekly review and monitoring which has led by “change management” team. They are responsible for conducting weekly reviews and monitoring for all plants that receive opportunities. The review schedule is adjusted to the plant team's schedule, particularly the ASC as sales representative.

Table 4.10 shows the review schedule that is released every 3 months in a year by adjusting the schedule of the plant team so that all plants can understand and collaborate to follow up with customers.

Table 4. 10 Weekly Review and Monitoring Schedule

| No | Area | Nama SDH              | Area              | SDH | PPC | SPV | PDH | PDHM | COP | ASC | PTO | PDC | PDCH | 29-Apr | 03-May | 04-May | 05-May | 29-Jun | 03-Jul | 29-Jul |      |
|----|------|-----------------------|-------------------|-----|-----|-----|-----|------|-----|-----|-----|-----|------|--------|--------|--------|--------|--------|--------|--------|------|
|    |      |                       |                   |     |     |     |     |      |     |     |     |     |      | Pagi   | Sore   | Pagi   | Sore   | Pagi   | Sore   | Pagi   | Sore |
| 1  | TJE  | PKB                   | Aan Kurma Wardyan | PDG | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | Dwi winarto           | FMC PTBA          | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | Giyanto               | NFMC PTBA         | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | BUNYANTO              | JKT               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | GALIH WICKASONO       | PTK               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
| 2  | BIM  | Tri Aji Wijayanto     | PTK               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | IMAM PRAKOSA          | SBY               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | NURDIANSYAH           | BHT               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | FELIX SHOMBING        | THP               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | KRISNAWAN             | V RTU             | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
| 3  | ADR  | Djunarto              | NFMC PPA          | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | Stevianus             | Satuli            | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | DWI PUJI MARGIANTO    | ADR Non FMC       | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | WISNU PRASETYO        | ADR FMC SIS       | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | AGUS HARIYADI         | ADR Non FMC SIS   | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
| 4  | DMI  | AGUS HARIYADI         | ADR TJ Buma       | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | SULAIMAN              | DMI               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | Deni Eko Muksi        | TBG               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | Syamsudin             | MLW               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | Bottor Simanjuntak    | SMD               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
| 5  | SMD  | SIGIT YOGO TRILAKSONO | JBV               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | SUMARYANTO            | LIN               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | ADE SUNARTO           | SPE               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | BIONDANY GUMILANG     | BLP               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | Wagiyono              | TRK               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
| 6  | BKI  | SUTISNO               | Loreh             | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | ANDRY ALANSYAH        | BKI Non FMC       | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | WIDIYANTO             | BKI               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | NICO FEBRI KURNIAWAN  | LTJ               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | MASKURDI SKUNDA-PUTRA | SBT               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
| 7  | TJR  | YEDI                  | BGN               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | SUJONO                | LBN               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | ASEP LUKMAN SUHENDAR  | TJR               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | Rhesa Andika Prasetya | MDO               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | Andik Sugianto        | SRK               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
| 8  | SGT  | ILHAM KURNIADY        | FRP               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | Mochammad Zam         | BGL Non           | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | MUHAMMAD ABUJULLAH    | BGL SKL           | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | WAWAN EBRIANTO        | BGL               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | HERY SUSANTO          | SGT               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
| 9  | ITG  | Ridho Putra Amri      | TDM               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |
|    |      | Rahmat Gunawan, B.C   | ITG               | V   | V   | V   | V   | V    | V   | V   | V   | V   |      |        |        |        |        |        |        |        |      |

## 7. Head Office Review



Figure 4. 14 Review and Monitoring with stakeholders (OBD)

The figure 4.14 above explains the weekly review and monitoring with OBD department as a stakeholder for major component transactions. Review and reporting are carried out every 3rd week of each month to update progress on opportunities followed up by ASC while ensuring that the transaction process remains in accordance with SOP.

## 4.6. Result and Analysis

### 4.6.1. Platform System

The platform created as a tool for implementation is available with various features:

1. Opportunities for plants
2. Follow up staging until billing
3. Progress Realtime update for each ASC

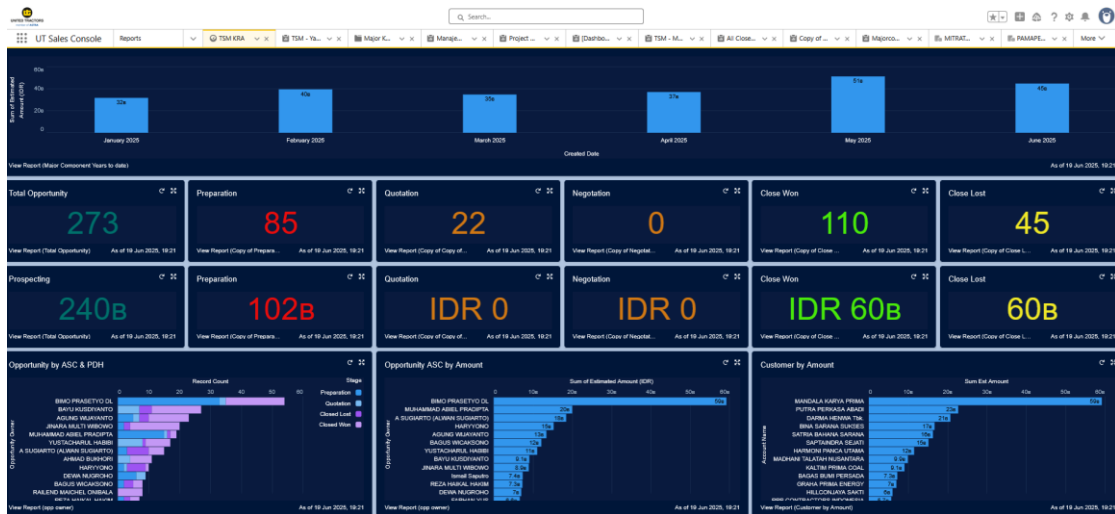


Figure 4. 15 Platform

The figure 4.15 above shows a monitoring dashboard using the sales force platform that makes it easy for all PICs to monitor progress daily, monthly, and annually.

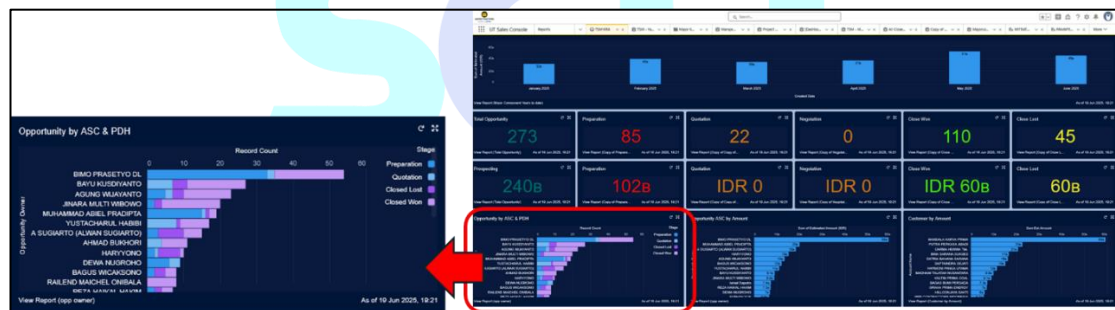


Figure 4. 16 Each ASC progress

The figure 4.16 above shows one of the features of the sales force platform dashboard that illustrates the progress and performance of each sales representative who receives opportunities.

## 4.6.2. Achievement

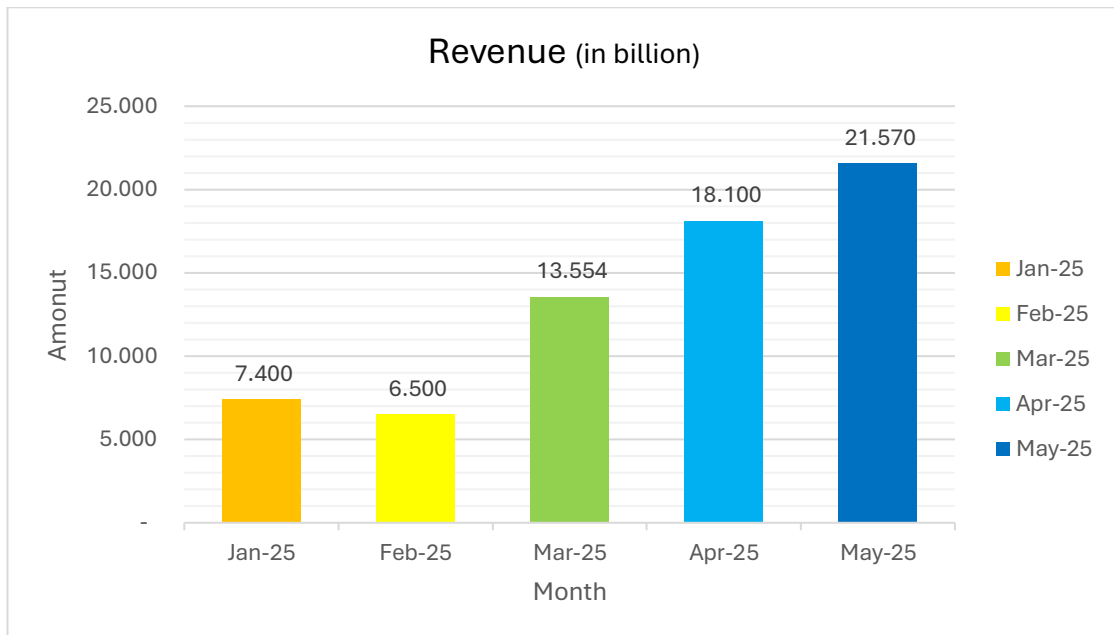


Figure 4. 17 Achievement

The implementation of a Machine Learning based predictive system in the major component remanufacturing business has shown significant achievements, especially in increasing revenue and changing transaction patterns. This study successfully demonstrated that implementing a machine learning-based predictive system resulted in an average monthly revenue increase of approximately 12 billion rupiah as an additional revenue in component remanufacturing business from Januari until May 2025. It contributes exceeds the established minimum target of 5 billion rupiah per month.

This success is supported by a shift in transaction patterns from reactive to proactive. In the old transaction pattern, component requests only arose when a unit was damaged or broke down. Customers would receive additional information from the maintenance team and then forward it to the After Sales Consultant (ASC) to obtain the required components.

With this new system, a list of components predicted by machine learning using big data will be communicated to the ASC for follow-up or validation with the customer. This allows the ASC to educate customers about potential unit failures early and prepare components well before the unit breaks down.

#### 4.6.3. Comparison of An Old and New Transaction Patterns



Figure 4. 18 Old Transaction Pattern

Figure 4.18 shows the old transaction pattern of demand components appears when the unit has broken down. At that time, the customer will get information from the maintenance team regarding the need for components so that the unit can work again. The information on the need for components is conveyed to ASC and ASC gets demand for components according to the needs.



Figure 4. 19 New Transaction Pattern

Figure 4.19 shows with this study, the list of predicted components produced by machine learning from big data utilization will be informed to ASC for follow up or validation to customers. In this way ASC will be able to help provide education or information on which units have the potential to breakdown so that ASC can prepare components well in advance of the unit breakdown. This will provide extraordinary benefits for customers because when the breakdown component unit is ready, the breakdown unit downtime is shorter, which will ultimately help customers to continue running their production plans.

#### 4.6.4. Cost & Benefit Analysis

Table 4. 11 Cost and Benefit Project

| PROJECT BENEFIT                                            |                          |
|------------------------------------------------------------|--------------------------|
| Revenue                                                    | Rp 12.000.000.000        |
| <b>Total Benefit</b>                                       | <b>Rp 12.000.000.000</b> |
| PROJECT COST                                               |                          |
| <b>Man Power</b>                                           |                          |
| 14 manpower                                                | Rp 221.480.000           |
| <b>Infrastructure</b>                                      |                          |
| Platform License (47\$/month) x 1800 users                 | Rp 1.381.941.000         |
| <b>Total Cost</b>                                          | <b>Rp 1.603.421.000</b>  |
| <b>NET QUALITY INCOME (PROJECT BENEFIT - PROJECT COST)</b> |                          |
|                                                            | Rp 10.396.579.000        |
| <b>RASIO NQI (NET QUALITY INCOME) = NQI/PROJECT COST</b>   |                          |
|                                                            | 648%                     |

Table 4.11 shows project benefit and project cost monthly consisting of:

1. 14 manpower are data scientist team, a platform developer team, the CSSD team and an OBD team
2. 1800 users are manpower which using the platform in all areas, head office, branches and sites.

It shows that NQI is very positive. This very positive NQI value indicates that this project generates benefits that far exceed its costs, indicating the success of the study and improvement.