

CHAPTER 4 - RESULTS AND DISCUSSIONS

A strategic choice was reached to begin the deployment of a Maintenance Management Portal (MMP) at the FMC Komatsu HD785-7 unit located in Tanjung Enim based on the thorough results of the problem analysis and the cooperative insights gained during the FGD in the previous discussion. The initiation of this MMP deployment took place on July 10, 2023, marking a pivotal step toward addressing and rectifying the identified issues in the maintenance practices. Since its inception, the MMP has been instrumental in revolutionizing the approach to maintenance management, providing a centralized platform for real-time monitoring and data analysis. As we progress toward the early days of November 2023, a comprehensive set of data pertaining to the outcomes of the implemented improvements has been systematically accumulated. This data not only serves as a testament to the ongoing commitment to enhancing operational efficiency but also acts as a valuable resource for evaluating the efficacy of the MMP in optimizing maintenance procedures. The initiative to implement the MMP reflects a forward-thinking approach to proactively address challenges, leveraging technology to bring about positive transformations in the maintenance protocols of the Komatsu HD785-7 unit at Tanjung Enim..

4.1 Initial Evaluation

4.1.1 Problem Identification

A closer look at the data presented in subchapter 3.1 reveals both promising and concerning aspects of the Komatsu HD785-7 unit's performance at UT FMC TJE. While physical availability (PA) exceeds the contractual target set with the customer, a significant gap remains in terms of productivity. The unit underperforms substantially when it comes to running hours, falling well short of the 400 hours per month required for the FMC business in Tanjung Enim to achieve profitability. This critical shortfall underscores the need for a thorough investigation of UT FMC TJE's overall maintenance performance.

To delve deeper into the root cause of this productivity gap, a comprehensive analysis of maintenance effectiveness using the metric of overall equipment effectiveness (OEE) is essential. OEE provides a holistic view of how effectively the unit is utilized, factoring in availability, performance, and quality.

Table 4.1. Overall Equipment Effectiveness (OEE) of Komatsu HD785-7 at UT FMC TJE

Performance Parameter	Target (%)	Advise ment (%)											
		2022						2023					
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Physical Availability	90	90,2	91,5	93,6	89,0	90,8	92,0	91,3	92,5	92,6	90,6	90,4	92,6
PS Leadtime Accuracy	90	83,3	65,4	79,5	79,4	76	85,7	69,7	62,5	91,5	75	87,7	72,7
PS Quality	95	90,5	90,7	73,0	74,8	84,6	76,1	83,9	90,1	88,3	88,9	87,0	91,7
OEE	77	68,0	54,3	54,3	52,9	58,4	60,0	53,4	52,1	74,8	60,4	69,0	61,7

Based on Table 7 above, it can be seen that OEE has never been achieved even in the last 12 months until June 2023, the main problem indicator is the PS Leadtime Accuracy which is only achieved at an average of 77%, besides that PS quality is also not good, as illustrated by its achievement which is only an average of 85%, so even though PA is achieved at an average of 91.5% and is still above the contract target but overall performance is not good and only achieved at an average of 59,9% alone from the target of 77%.

4.1.2 Cause of the Problem

To understand why periodic service time (PS) accuracy is not achieved, we can look through the PS business process itself. Problem analysis of SF business processes can be viewed using the following SIPOC analysis. In examining the causes of periodic service time inaccuracies, we can review each stage in the lifecycle of that service, from start to finish. It is important to ensure that each step in the process is executed efficiently and without obstacles that could affect time accuracy. Nonetheless, these problems can be identified and addressed through the use of comprehensive SIPOC analysis.

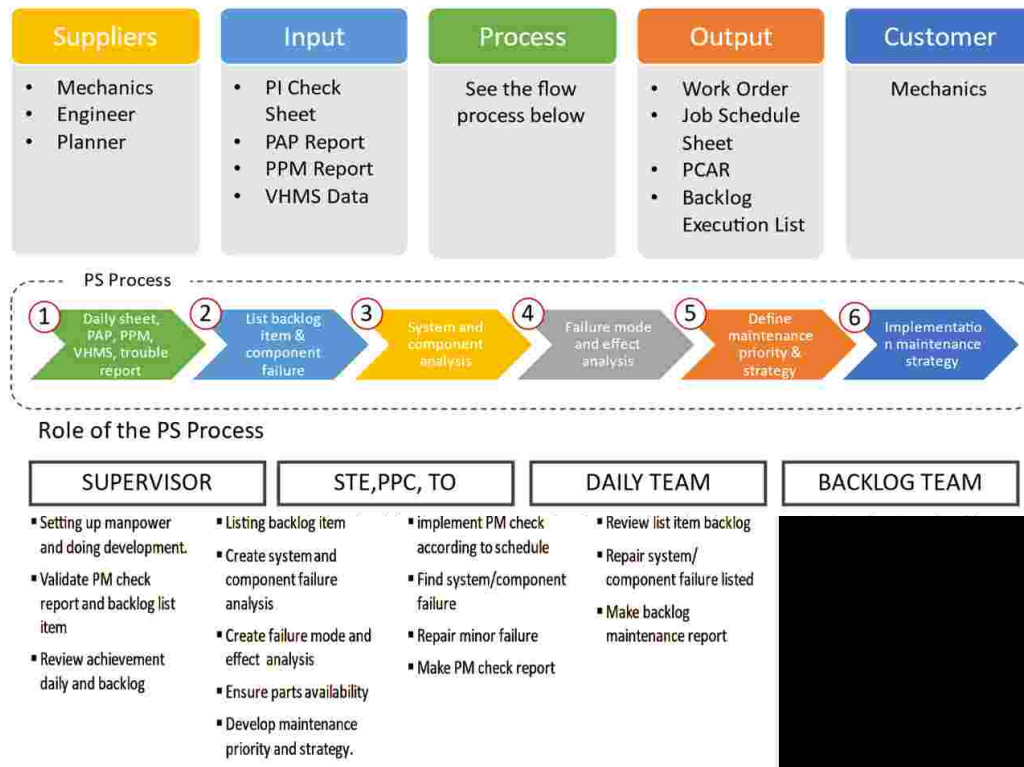


Figure 4.1. SIPOC of PS Process

Furthermore, the maintenance analysis flow process can be described as follows. First of all, the first step in analyzing maintenance is to evaluate the initial condition of the equipment or system to be repaired. This involves collecting data regarding current performance, potential problems, and previous maintenance history. After that, this data is analyzed to identify areas that require special attention or updating. The next stage involves strategic planning to formulate the necessary repair or maintenance actions. Each step in this process is carefully integrated to ensure smooth and effective overall maintenance analysis. Thus, this workflow plays a crucial role in ensuring that maintenance is carried out in a timely manner and with appropriate focus on areas that require special attention.

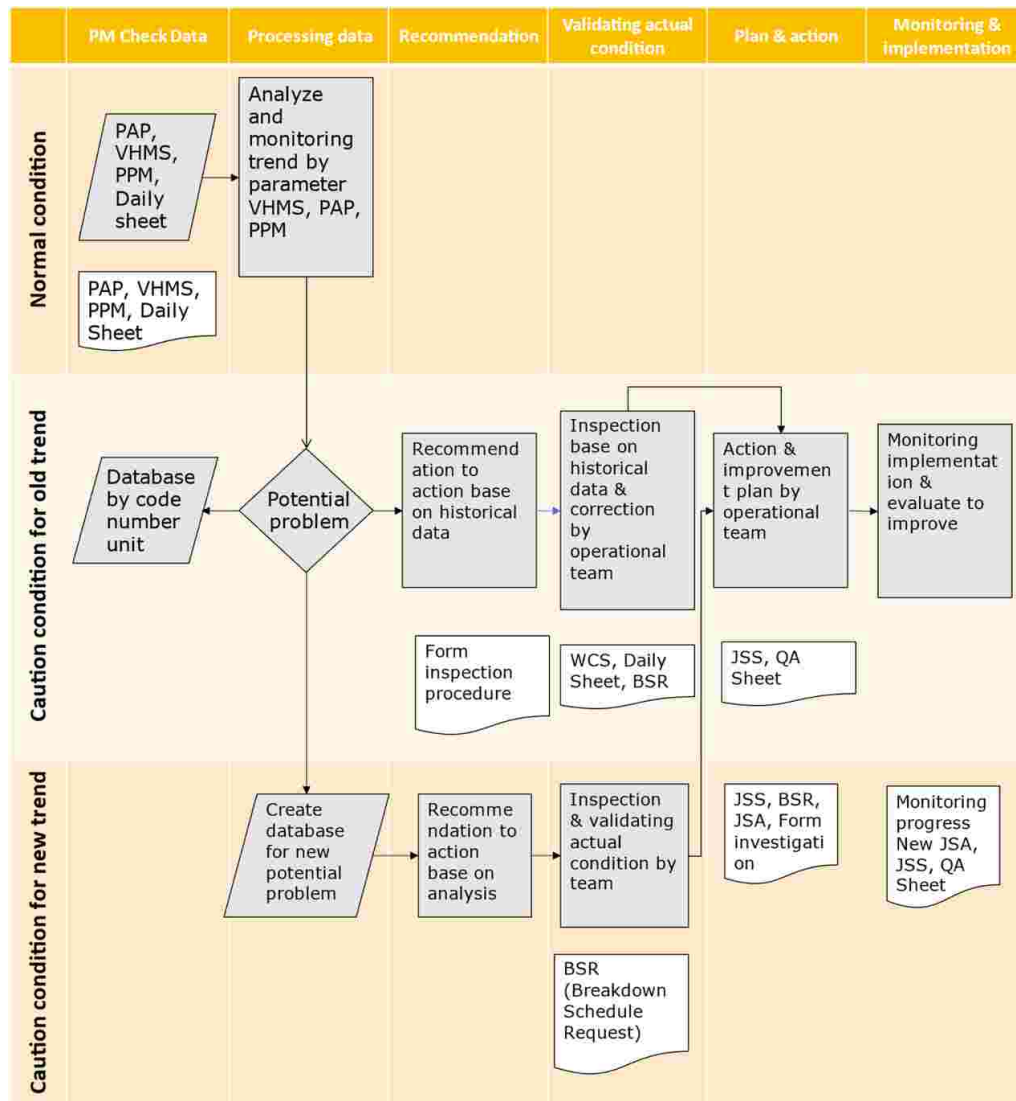


Figure 4.2. Workflow of PS Komatsu HD785-7

The entire maintenance analysis process from input to process, then recommendations for maintenance strategies, is done manually. This results in the emergence of problems, namely data from invalid inputs causing inaccuracies in data processing. These inaccuracies then result in inappropriate maintenance planning, resulting in uncontrolled PS lead times. Manual processes in maintenance analysis leave room for human error, especially when the data entered is invalid or incomplete. In this context, data inaccuracies can stem from typing errors, lack of input validation, or even omissions at the input stage. Therefore, efforts are needed to improve accuracy and efficiency in the maintenance analysis process.

Table 4.2. List of problem found based on FGD

Problem	Source	Impact
PI Check Sheet is not well documented and rarely reviewed	Mechanic, Engineer	Data not available, Inaccurate data, Difficulty identifying problems
Oil analysis (PAP) reports are not well distributed to mechanics and in-depth analysis is not carried out by engineers	Engineer, Mechanic	The mechanic does not know the condition of the machine, the engineer cannot identify potential problems
Machine Inspection Program (PPM) Report is not done well by mechanics	Mechanic	Invalid data, difficulty performing analysis
Vehicle health monitoring system (VHMS) not downloaded regularly	Mechanic, Engineer	Incomplete data, Inaccurate data
Actual Work is not in accordance with JSS, a lot of work is added at the time of PS	Planner, Supervisor	PS jobs become longer, PS Leadtime is inaccurate

From the results of the FGD on the SIPOC model, it was concluded that the cause of the low performance of Komatsu HD785-7 at UT FMC TJE was the low accuracy of PS Leadtime, only 77%. Therefore, the analysis continued using P-M analysis to see the main causes of low PS Leadtime Accuracy, as shown in figure 18 below. This process involves identifying factors that might affect PS Leadtime accuracy, including but not limited to manual processes, inaccuracies in input data, or possible problems with the maintenance system. By understanding these factors more deeply, it is hoped that we can take more targeted corrective actions to improve the accuracy of PS Leadtime.

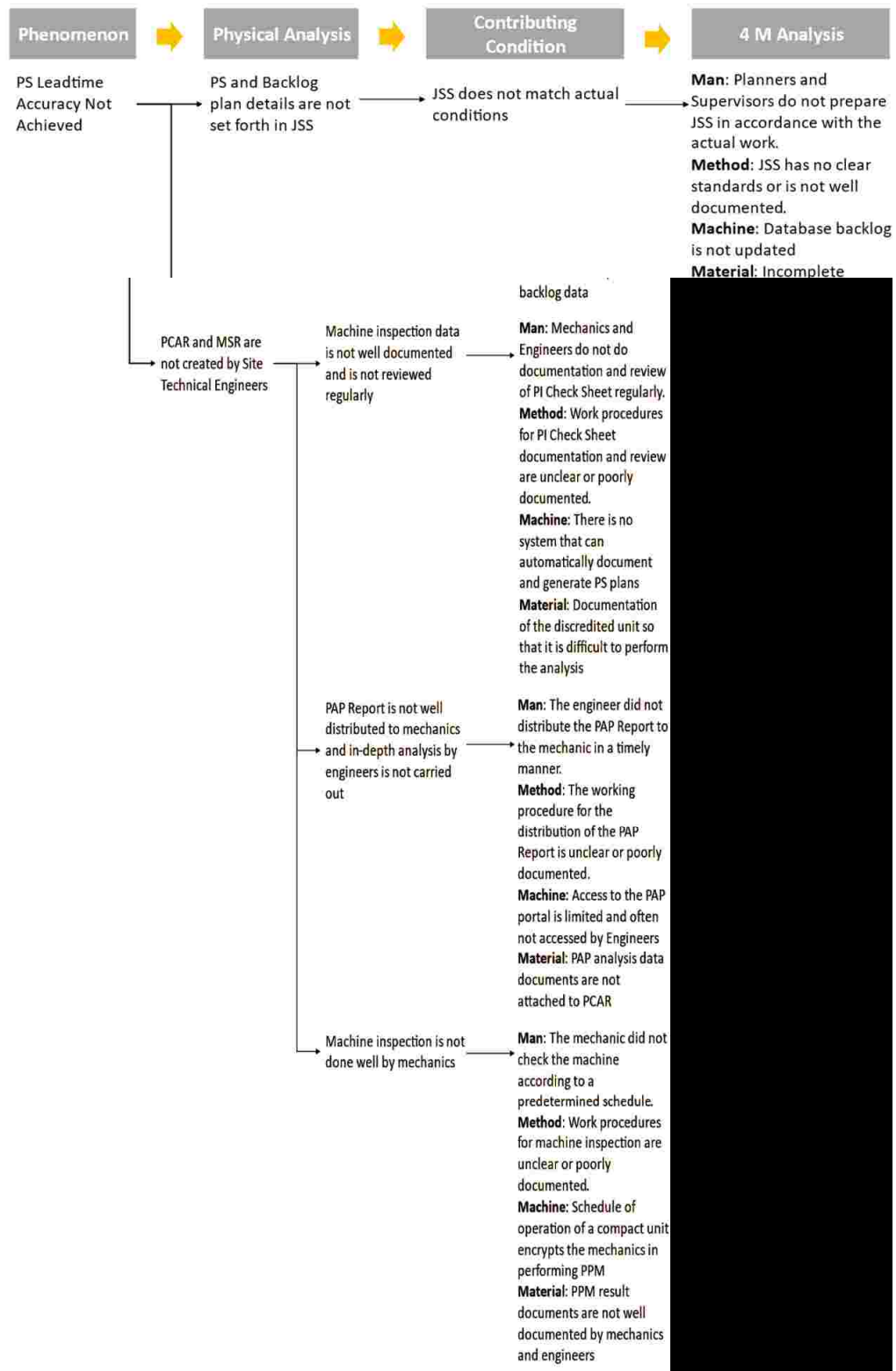


Figure 4.3. P-M Analysis of PS Leadtime Accuracy

From the results of the FGD on the data in figure 18 above, it is concluded that through the following table 29.

Table 4.3. Conclusion of the results of P-M Analysis

Contributing Condition	Source	Principles of Work	Condition	Impact	Solution
Actual Work is not in accordance with JSS	Planner, Supervisor	The unit must be operated in accordance with the specified standards	Additional work at the time of PS	Inaccurate PS Leadtime	JSS preparation must be in accordance with the actual work, avoid additional work outside the schedule
PI Check Sheet is not well documented and rarely reviewed	Mechanic, Engineer	Unit inspection data must be well documented and reviewed regularly	Data not available, inaccurate data	Difficulty identifying the problem	Document PI Check Sheet, review PI Check Sheet regularly
Oil analysis (PAP) reports are not well distributed to mechanics and in-depth analysis is not carried out by engineers	Engineer, Mechanic	The data from the analysis of lubricating oil must be well distributed to mechanics and carried out in-depth analysis by engineers	The mechanic does not know the condition of the unit, the engineer cannot identify potential problems	Findings from oil analysis results are not followed up	Distribute PAP Report to mechanics, in-depth analysis of PAP Report by engineer
Unit Inspection Program (PPM) Report is not done well by mechanics	Mechanic	Unit inspection shall be carried out according to a predetermined schedule	Incomplete data, inaccurate data	in the unit	Perform an inspection of the appropriate unit PPM Report, training mechanics about PPM Report
Vehicle health monitoring system (VHMS) not downloaded regularly	Mechanic, Engineer	Data from monitoring vehicle condition must be downloaded regularly	Incomplete data, inaccurate data	Difficulty analyzing problems in the unit	Download VHMS data regularly, mechanical training about VHMS

4.2 Suggestion to Improve

To address these challenges and improve the FMC business, UT has implemented the Maintenance Management Portal (MMP) as a predictive maintenance strategy. MMP is a web-based platform that integrates data from various sources, such as sensors, telematics, work orders, and inspections, to monitor the condition and performance of the equipment units in real time. MMP uses advanced analytics and artificial intelligence to detect anomalies, diagnose problems, predict failures, and recommend actions. MMP also provides dashboards and reports that enable UNTR and its customers to track key performance indicators (KPIs), such as availability, utilization, productivity, fuel consumption, and maintenance costs. By using MMP, UNTR can optimize its maintenance planning and scheduling, reduce unplanned downtime and component replacements, increase equipment lifespan and resale value, and enhance customer satisfaction and loyalty.

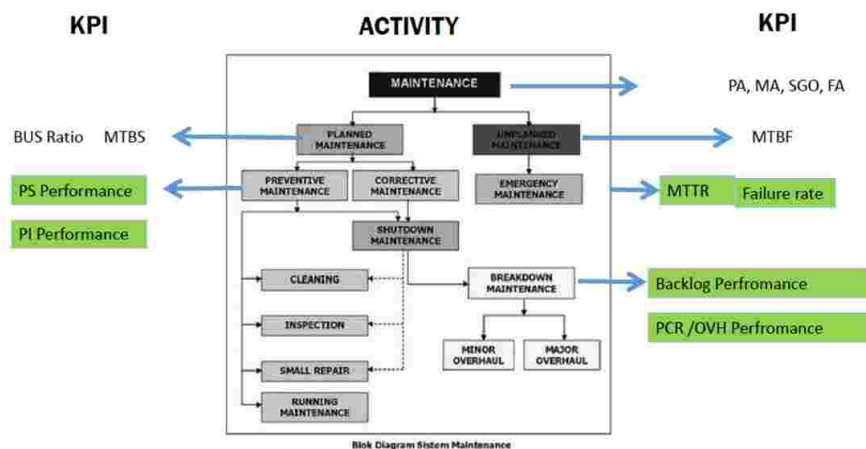


Figure 4.4. KPI Maintenance Management

The MMP is designed to monitor the health condition of heavy equipment units in real-time, leveraging IoT and machine learning technologies. This real-time monitoring enables the implementation of predictive maintenance programs, which can detect potential catastrophic failures that represent considerable maintenance and downtime costs. By using the MMP, UT aims to optimize the life span of heavy equipment components and improve machine performance to achieve higher Comprehensive Cost Effectiveness (CCE).

1) Maintenance Strategy Reference (MSR)

A strong maintenance strategy serves as the cornerstone of efficient and sustainable operations. It includes a systematic framework that outlines how equipment, machines and assets will be managed, maintained and optimized throughout their life cycle. A well-defined maintenance strategy addresses various aspects of maintenance, including preventive, corrective, predictive and even proactive actions to ensure that equipment functions reliably, downtime is minimized and operational efficiency is maximized. This strategy is intricately woven into the overall objectives of the organization, aligning maintenance activities with business objectives such as reducing costs, increasing productivity and enhancing safety. An effective maintenance strategy involves a wise blend of data-driven decision-making, advanced technology and well-defined processes that collectively contribute to extended equipment life, reduced maintenance costs and sustainable value creation. Along with industrial developments, the importance of a comprehensive maintenance strategy remains important in maintaining competitiveness, optimizing resource utilization, and ensuring the smooth functioning of important assets.

In MMP, Monitoring and Service Requests (MSR) form the central element that connects status and action steps, such as Adjustment, Cleaning, Finishing, Installation, and Replacement. These data come from real-time reports sent to the MMP portal, then analyzed using algorithms to provide the best advice in the maintenance process. The MSR menu in MMP displays the following information:

- MSR Resolution Rate: indicates the number of MSRs completed in each time.
- MSR Validation Rate: indicates how many MSRs are validated and must be completed within a given time.
- MSR No Action Rate: reflects the amount of MSR that requires no action in a given time range.
- Historical Login 14 Days: shows how many users logged in each day over the last 14 days. This information provides an overview of user activity and how often they access the MMP portal.

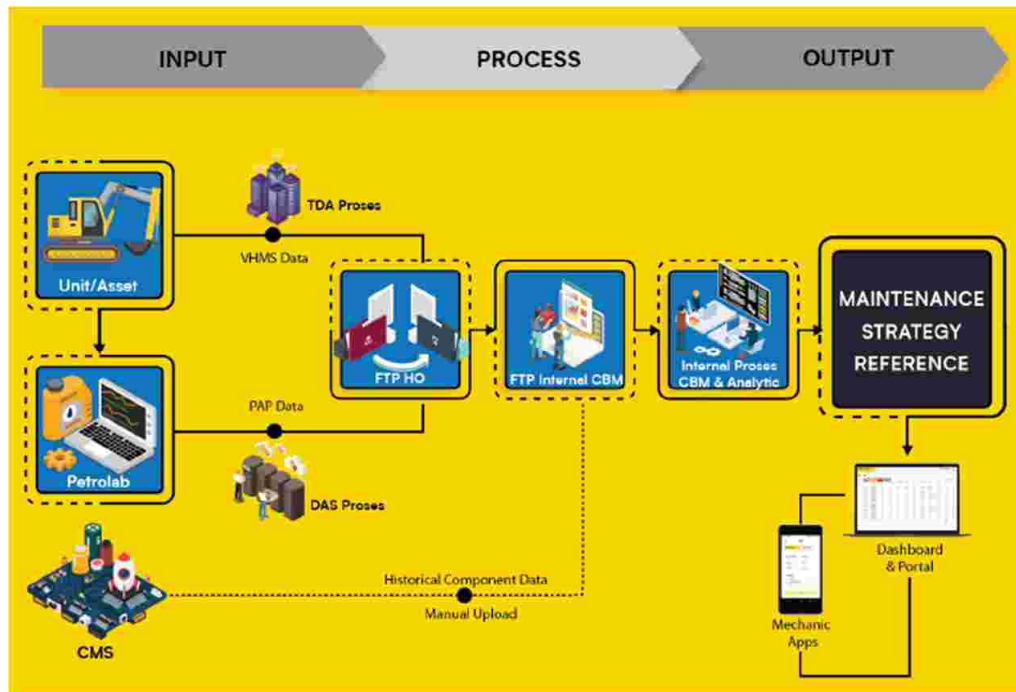


Figure 4.5. Flow Process MSR

Through this MSR menu, portal users can easily track and monitor various aspects of performance and maintenance actions applied. By combining real-time data, analytical algorithms, and graphical visualization, MMP provides powerful tools to optimize equipment maintenance and ensure efficient and reliable operations.

2) Preventive, Corrective Action Request (PCAR)

Preventive and Corrective Action Requests (PCARs) stand as a vital mechanism for enforcing quality, correcting deviations, and driving continuous improvement. PCAR includes both proactive preventive actions and reactive corrective actions, forming a comprehensive approach to addressing problems at various stages. Preventive Action Requests (PAR) focus on identifying potential risks and vulnerabilities before they materialize, mitigating their impact through preventative solutions. This proactive attitude helps prevent potential disruptions and improves overall operational resilience. On the other hand, Corrective Action Requests (CAR) address existing discrepancies by exploring root causes, fixing problems and building sustainable solutions. CAR is indispensable in maintaining quality standards, identifying the source of problems, and preventing recurrence of these problems. Together, PCAR creates a dynamic

framework that not only ensures prompt resolution of problems, but also instils a culture of continuous assessment and improvement.

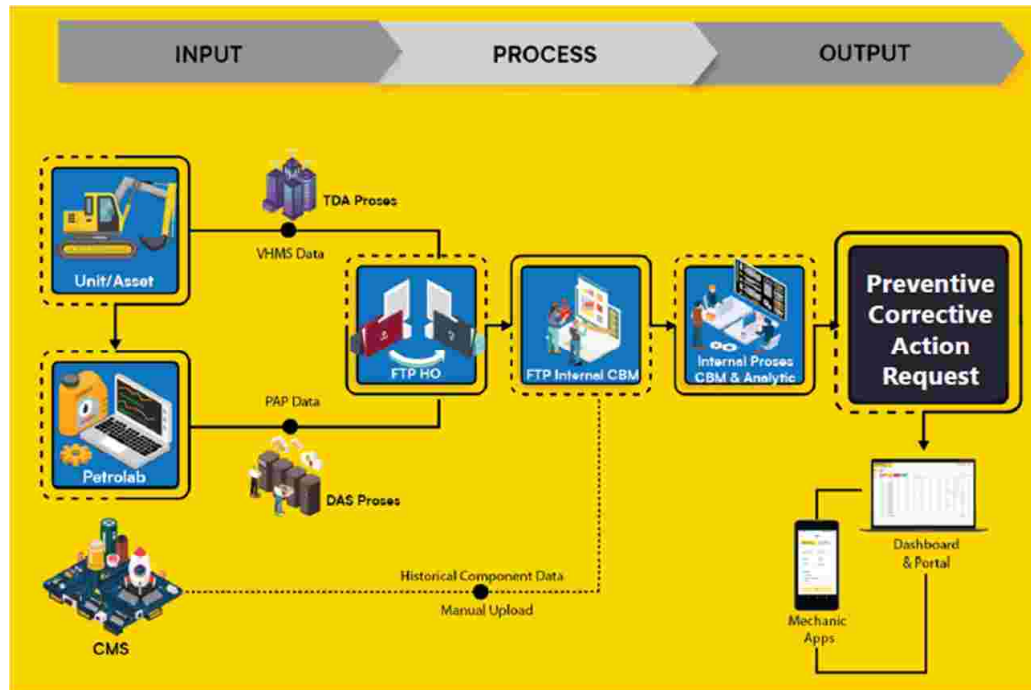


Figure 4.6. Flowchart PCAR

Similar to MSR, PCAR has a menu that will serve as a KPI for the efficiency of the maintenance procedure using this MMP. The following details are displayed in MMP's PCAR menu:

- **PCAR Resolution Rate:** indicates the number of PCAR completed in each time.
- **PCAR Validation Rate:** indicates how many PCAR are validated and must be completed within a given time.
- **PCAR No Action Rate:** reflects the amount of MSR that requires no action in each time range.
- **Historical Login 14 Days:** shows how many users logged in each day over the last 14 days. This information provides an overview of user activity and how often they access the MMP portal.

Observing the performance of the Komatsu HD785-7 FMC unit across various sites, as illustrated in figure 14, the findings from the FGD led to the conclusion that attempting

improvements at the current site is imperative. Consequently, the decision was made to implement the Maintenance Management Portal (MMP) as a strategic initiative. The MMP has proven to be instrumental in addressing obstacles identified through the P-M Analysis, indicating its potential significance in enhancing maintenance practices. The collaborative insights gained from the FGD not only shed light on the need for improvements but also served as a catalyst for innovative solutions, such as the integration of the MMP. This step forward aligns with a proactive approach to streamline maintenance processes and enhance overall operational efficiency. As illustrated in the broader context of figure 14, a comparative analysis across different sites provides valuable insights that can be leveraged to tailor improvements specifically to the unique challenges faced at the current site. As a result, the MMP's adoption is seen as a strategic initiative able to accept certain obstacles found in the FGD and P-M Analysis, helps to maximize the performance of the Komatsu HD785-7 FMC unit

4.3 Implementation of Recommendation

Incorporating the insightful recommendations derived from the extensive analysis presented in Chapter 3, coupled with the collaborative findings from the conducted FGD, a strategic initiative has been undertaken to enhance the effectiveness and efficiency of maintenance management. The overarching goal is to ensure that the PS leadtime attains the targeted accuracy. As a proactive measure, the decision was made to implement the Maintenance Management Portal (MMP). This technologically advanced solution aims to streamline and optimize the entire maintenance process, addressing identified challenges and fostering a more precise approach to achieving the desired PS leadtime accuracy. The momentous initiation of the MMP deployment took place on July 10, 2023, signifying a pivotal milestone in the ongoing efforts to revolutionize maintenance practices. This implementation is expected to yield tangible improvements, not only in terms of accuracy but also in the overall management and efficiency of the maintenance protocols. By leveraging the capabilities of the MMP, the organization is poised to navigate towards a more data-driven and responsive maintenance strategy, aligning with contemporary best practices for achieving operational excellence.



Figure 4.7. Roll out Maintenance Management Portal

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a. Setup Role dan Authorization of User

To ensure maintenance management runs effectively and efficiently, an important step is to set roles and grant user permissions. In this setting, it is determined who can access the system and what can be done by those in the system. This process ensures that each person or team has the level of access and responsibility appropriate for their role. In this way, users only get access to certain functions and data relevant to their work, creating a more structured and secure operational environment. The user consent process involves further details regarding permissions and restrictions, according to the

needs of each user. By implementing a robust framework for setting user roles and permissions, organizations can manage access more proactively, reduce security risks, and create an environment where maintenance management is not only effective and efficient, but also suited to the diverse needs of the workforce.

Table 4.4. Set Up Role dan Authorization of User

Role	Responsibility	Access
Supervisor	Supervise the entire MMP Process so that it runs as intended	All system features and functions
Planner	Create a work plan for maintenance work	All system features and functions necessary for planning
Site Technical Engineer	Make MSR and PCAR analysis and validation	All system features and functions required for maintenance and repair including MSR and PCAR
Mechanic	Implement all MSR and PCAR recommendations	All system features and functions required for maintenance and repair

The Maintenance Management Portal (MMP) is designed to be accessible in two versatile formats: desktop and Android app. Desktop access is universally granted to all users, except for mechanics. In contrast, mechanics exclusively receive access through the Android application. This intentional differentiation is aimed at facilitating mechanics in receiving real-time tasks and seamlessly generating reports. The utilization of the Android app is strategically aligned to cater to the dynamic nature of their work, enabling swift task management and report generation even when on the field. This targeted approach is implemented to enhance the overall efficiency and effectiveness of the mechanics' tasks, ensuring that they have the tools they need at their fingertips to streamline their workflow and contribute to the optimal functioning of the maintenance processes.

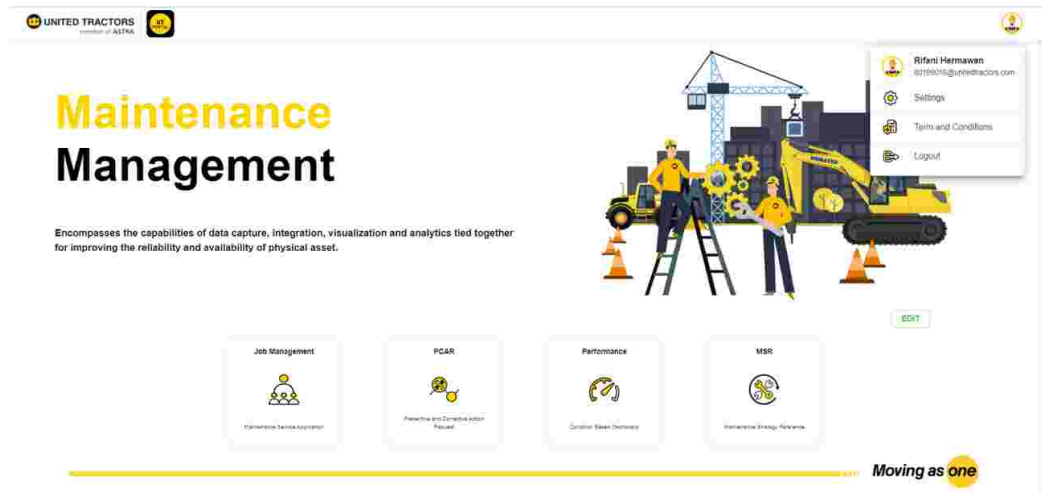


Figure 4.8. Maintenance Management Portal Desktop Version

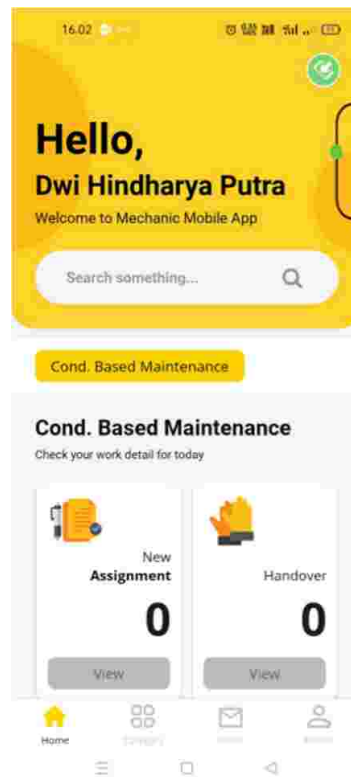


Figure 4.9. Maintenance Management Portal Android Application Version

The exclusive allocation of Android app access to mechanics is rooted in the specific role mechanics play within the system. Mechanics are primarily tasked with receiving assignments and generating reports on tasks delegated by supervisors. These tasks encompass a range of responsibilities, spanning from routine maintenance to more

intricate repair tasks. By limiting Android app access to mechanics, a targeted and streamlined approach is established, aligning precisely with their functional requirements. The app serves as a dedicated platform for mechanics to seamlessly interact with and execute their assigned tasks. This focused accessibility not only ensures that mechanics have a user-friendly tool for real-time task management but also underscores the efficiency of their workflow, ultimately contributing to the overall success of the maintenance and repair processes.

b. Training Program

Ensuring the effective and efficient utilization of the Maintenance Management Portal (MMP) requires a comprehensive training program. The primary objective of this training is to equip users with the knowledge and skills necessary for proficient use of the MMP, enabling them to maximize its functionalities. The training encompasses various aspects, beginning with an introductory module that familiarizes users with the MMP. Subsequent modules delve into the specifics of MMP usage, providing hands-on guidance on tasks such as maintenance planning and execution through the portal.

The MMP training materials are thoughtfully curated to cover key areas, including an overview of the MMP, step-by-step guidance on its utilization, and the development of essential skills for effective maintenance planning and execution within the MMP framework. These training materials serve as valuable resources to empower users with the know-how needed to navigate the MMP seamlessly.



Figure 4.10. In class training, on field practice and user testing

To ensure a holistic learning experience, the training is conducted through in-class sessions, fostering a conducive environment for theoretical understanding. However, recognizing the importance of practical application, the training extends beyond the classroom setting. Field practice and user testing are integral components of the training program, providing users with the opportunity to apply their newfound knowledge in real-world scenarios. This multifaceted approach aims to solidify user proficiency, ensuring that each individual can confidently and effectively employ the MMP in their respective roles.

Some of the features of MMP that have been successfully implemented are as follows:

1) Implementation of Condition Based Monitoring (CBM) Dashboard

The implementation of CBM Dashboard is carried out with the aim of replacing the old CBM dashboard which still relies on manual processes. By migrating to the new CBM Dashboard, organizations can leverage MMP technology to increase efficiency in unit health monitoring and analysis. This not only helps reduce delays and potential errors associated with manual approaches, but also provides quick and accurate access to up-to-date data, enabling more timely decision-making and more comprehensive information regarding unit operational conditions.

CBM SIX PARAMETER

Intelligence Availability HD785-7 & GD825-2

UNIT INFORMATION				VHMS				PAP ENGINE		PAP TRANS				PAP AXLE		PAP HYDRAULIC		PAP CIRCLE	
Equip No	SN Unit	HM Unit	Last Download	Blowby Press Max	E.Oil P.Hi_Min	Cool Temp Max	TM Oil Temp.Max	Boost Press Max	Kondisi	Remark	Kondisi	Remark	Kondisi	Remark	Kondisi	Remark	Kondisi	Remark	Kondisi
HD279	J30533	5222,8	14-May-23	Normal	Normal	Normal	Normal	1135,1	Normal		Normal		Normal		Urgent	Iso Code			
HD280	J30534	5347	14-May-23	Normal	Normal	Normal	Normal	1115,1	Normal		Normal		Normal		Normal				
HD281	J30535	4968,5	14-May-23	Normal	Normal	Normal	Normal	1142,6	Normal		Normal		Normal		Normal				
HD282	J30536	5169,4	14-May-23	Normal	Normal	Normal	Normal	1145,1	Normal		Normal		Normal		Urgent	Iso Code			
HD283	J30537	5001	14-May-23	Normal	Normal	Normal	Normal	1047,6	Normal		Normal		Normal		Normal				
HD284	J30538	5036	14-May-23	Normal	Normal	Normal	Normal	1115,1	Normal		Normal		Normal		normal				
HD285	J30539	4992	14-May-23	Normal	Normal	Normal	Normal	1110,1	Normal		Normal		Normal		normal				
HD286	J30540	4937,1	14-May-23	Normal	Normal	Normal	Normal	1107,6	Normal		Normal		Normal		normal				
HD287	J30541	4827	14-May-23	Normal	Normal	Normal	Normal	Normal	Normal		Normal		Normal		normal				
HD288	J30542	4996	14-May-23	Normal	Normal	Normal	Normal	1120,1	Normal		Normal		Normal		normal				
HD289	J30543	4935,5	14-May-23	Normal	Normal	Normal	Normal	1105,1	Normal		Normal		Normal		normal				
HD290	J30548	4796,5	14-May-23	Normal	Normal	Normal	Normal	1132,6	Normal		Normal		Normal		normal				
HD291	J30549	4704,8	14-May-23	Normal	Normal	Normal	Normal	1090,1	Normal		Normal		Normal		normal				
HD292	J30550	4772,1	14-May-23	Normal	Normal	Normal	Normal	1117,6	Normal		Normal		Normal		normal				
HD293	J30551	4765,7	14-May-23	Normal	Normal	Normal	Normal	1120,1	Normal		Normal		Normal		normal				
HD294	J30552	4905,2	14-May-23	Normal	Normal	Normal	Normal	1125,1	Normal		Normal		Normal		normal				
GD828	13398	8041	14-May-23	Normal	Normal	Normal	Normal	Normal	Normal		Normal		Normal		Normal		normal		
GD829	13405	7612	14-May-23	Normal	Normal	Normal	Normal	Normal	Normal		Normal		Normal		Caution	Si	normal		

- Unit HD Boost pressure (Caution) = Continue Check Jalur Air Cleaner – Turbo – After Cooler – Compression chamber during service maintenance. Plan trial additive EON 708
- HD279 & HD282 (Urgent) PAP Hyd = Flushing & resample
- GD828 (Caution) PAP Hyd = Flushing & resample

Figure 4.11. Previous CBM Dashboard

The dashboard was then replaced with a new dashboard provided by MMP as its superior feature.

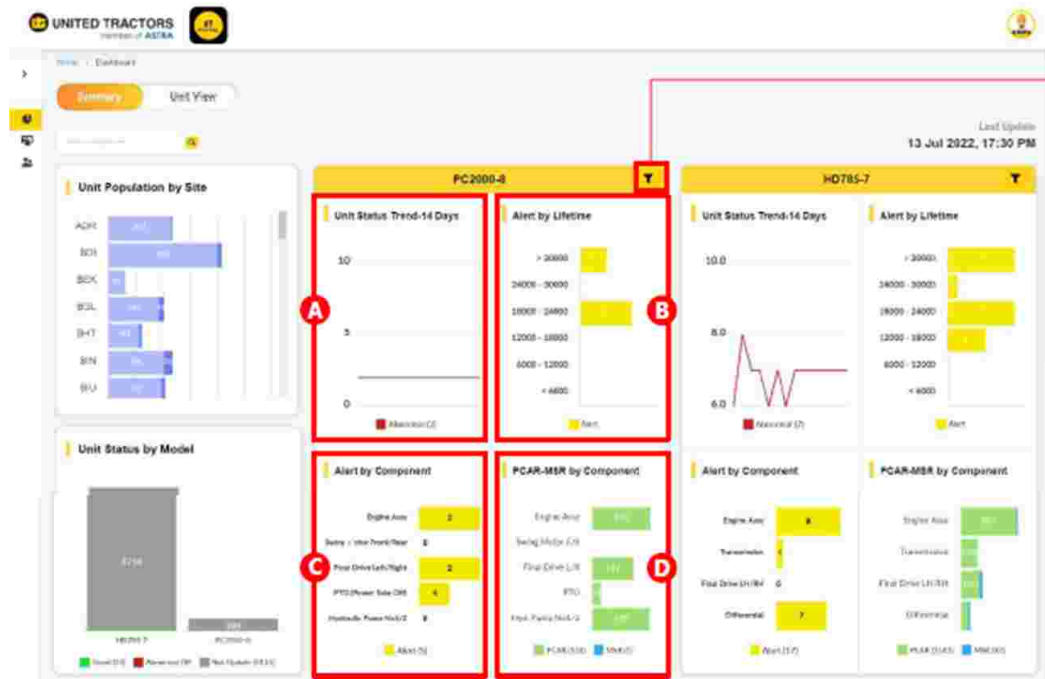


Figure 4.12. New CBM Dashboard

The dashboard provides important information related to the condition of the HD 785-7 unit at UT FMC Tanjung Enim, the information in the dashboard is divided into 4 section.

1. **Unit View:** Displays general information about units belonging to UT FMC Tanjung Enim. Includes the total number of units, the model type of the units, and the location of those units. Then, filters are provided to display information based on the model of the unit, facilitating specific monitoring.
2. **Unit Population by Site:** Displays the number of units owned by UT FMC Tanjung Enim by location, providing an overview of the geographical distribution of units.
3. **Unit Status Trend-14 Days:** Displays the status trend of UT FMC Tanjung Enim units for the last 14 days. This feature is useful for monitoring the development and condition of units over a period of time.

4. Alert by Component (Peringatan oleh Komponen): Menampilkan daftar komponen yang mengalami masalah atau gangguan pada unit-unit UT FMC Tanjung Enim. Informasi ini memungkinkan untuk mengambil tindakan perbaikan dengan cepat guna menjaga kinerja optimal.

Overall, this CBM dashboard provides comprehensive information to UT FMC Tanjung Enim to monitor the condition of the unit.

2) Preventive and Corrective Action Report (PCAR) dan Maintenance Strategy Reference (MSR)

The PCAR & MSR dashboard provides a status-based summary for each selected Site/Unit. This information provides an overall picture of the condition of Preventive and Corrective Action Requests (PCAR) and MSR (Maintenance Strategy Reference), enabling effective monitoring of each relevant unit or location. With status-based views, users can quickly evaluate performance and maintenance needs to improve overall operational efficiency.

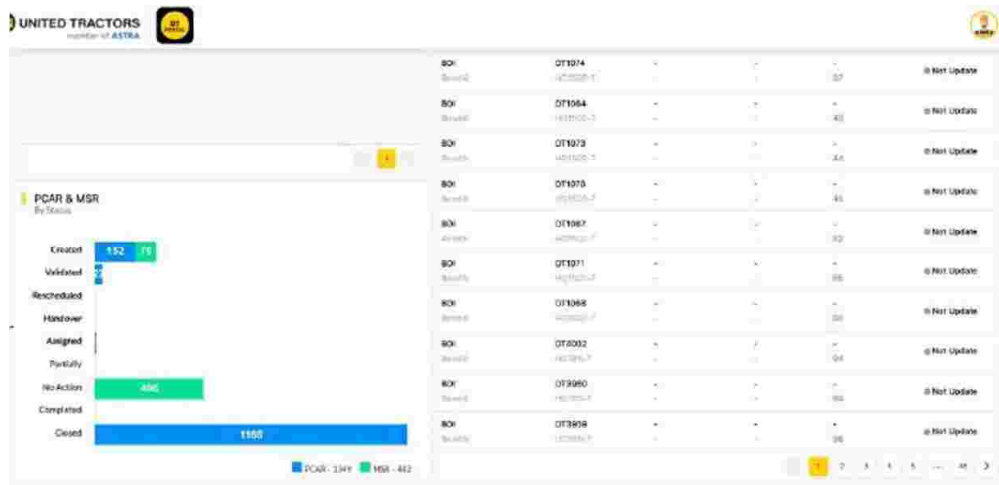


Figure 4.13. PCAR and MSR Dashboard

On the PCAR and MSR dashboard after selecting one of the Units, the display on the Unit Condition summary provides a deep understanding of the condition of the unit.

- Engine Health Score is presented by showing Health Score trends in periods of 1, 3, 6 months, and 1 year, providing a holistic view of engine health.
- The 'Alert' feature provides details about any alert conditions or abnormalities that occur, providing an in-depth understanding of potential issues.
- The 'Oil Analysis Report' feature provides detailed conditions of the last oil sample by component.
- The 'Overview' feature provides detailed information about the Unit and recent data updates.
- The 'Parameters' feature displays Parameter condition trends within the same time range, providing further insight into unit performance.
- The 'Payload' feature provides detailed Payload summaries in periods of 1, 3, 6 months, and 1 year, providing critical information regarding the unit's capacity and workload.

With the availability of this information, monitoring and analysis of unit conditions becomes more comprehensive, providing deep insights into the health and performance of each unit. The accurate and detailed data presented by the system allows decision makers to have a solid foundation in planning maintenance strategies and operational management. Thus, decisions taken can be more effective and timelier, helping organizations maximize efficiency, reduce downtime, and ensure optimal performance of all fleets.

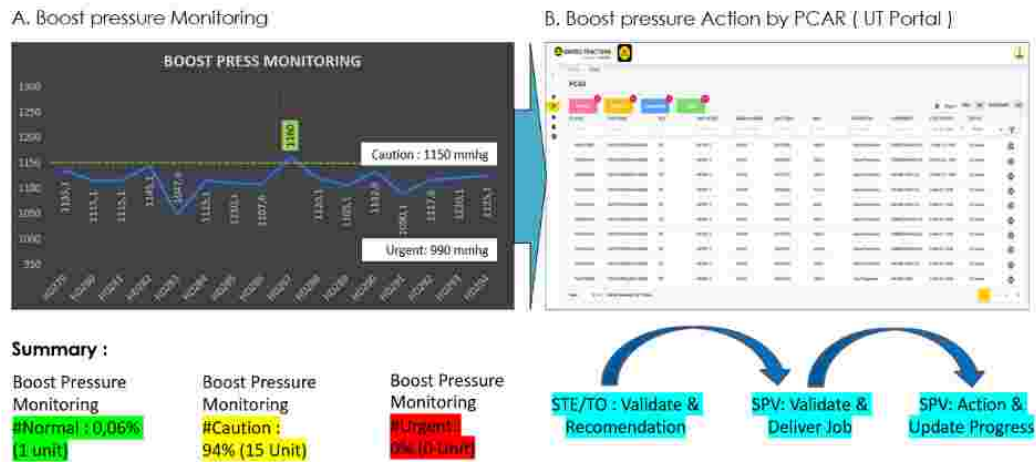


Figure 4.14. Study case of monitoring boost pressure using MMP at UT FMC Tanjung Enim

This case study is a process of monitoring the condition of boost pressure in 15 units of HD785-7, where the condition shows a status of 'caution'. In this monitoring and follow-up, an engineer is responsible for validating the finding data and providing improvement recommendations to the supervisor through the PCAR and MSR features on the MMP. After the engineer submits the PCAR to the supervisor, the supervisor validates the PCAR and MSR and designs a repair strategy, which is then conveyed to the mechanic. Mechanics will receive repair tasks through their HP devices, then execute corrective actions based on recommendations from PCAR and MSR when performing PS (Scheduled Maintenance). Next, the mechanic will compile a report on the repairs that have been made.

Illustrated in the case study above, MMP ultimately creates a structured workflow and involves various levels of responsibility in maintaining the optimal condition of HD785-7 units at FMC Tanjung Enim.

c. Implementation Review

From the initial MMP setup in the first month, several problems were identified and resolved. Here are some of these problems and improvements that have been successfully carried out and have a positive impact on the effectiveness of MMP implementation.

Table 4.5. PICA of Implementation

Problem Identification	Corrective Action	PIC	Due Date
Mechanic cannot login to Mechanics Mobile Apps	Check user role in the system database	Supervisor	17/07/23
Population does not update in MMP	Update population database	Planner	17/07/23
Very Low Speed Internet in Field	Improving network infrastructure	IT Team	20/10/23
No notification for PCAR validation on STE	Making improvements to the program's algorithm	Program Developer	21/07/23
Invalid auto upload because there is double data	Program improvements to only be able to upload recent data	Program Developer	03/08/23

In general, most of the problems encountered in the implementation of the Maintenance Management Portal (MMP) at UT FMC Tanjung Enim have been successfully overcome, allowing MMP to operate smoothly. However, it should be noted that obstacles related to internet speed in the field are still obstacles that require further handling. The importance of solving this problem is urgent, because the successful implementation of MMP greatly affects the effectiveness in maintenance management of the Komatsu HD785-7 unit. By overcoming these obstacles, it is hoped that MMP implementation can run more optimally, contributing more effectively to sustainable maintenance management efforts at UT FMC Tanjung Enim.

4.4 Data Analysis

4.4.1 Technology Acceptance Model (TAM)

The data that forms the basis of this analysis comes from questionnaires given to respondents who have actively used the Maintenance Management Portal (MMP) application. The entire dataset consisted of responses collected from 18 respondents who assessed two important dimensions, namely Perceived Ease of Use (PEU) and Perceived Ease of Understanding (PEOU) from MMP applications.

Each respondent was asked to rate their experience using the Likert scale, which ranged from 1 (strongly disagree) to 5 (strongly agree). This scale is used to measure the extent to which respondents feel comfortable and easy using MMP applications in the context of managing maintenance. The data from this questionnaire forms the basis of a

comprehensive evaluation to understand user perceptions of MMP applications and provides valuable insights for potential improvements and subsequent development.

4.4.1.1 Analysis of Perceived Usefulness (PEU)

Perceived Ease of Use (PEU) is a parameter that measures how users perceive the benefits of the Maintenance Management Portal (MMP) application in improving maintenance performance.

Table 4.6. Descriptive Statistics of Perceived Usefulness (PEU)

<i>Perceived Usefulness (PEU)</i>	
Mean	49,77777778
Standard Error	1,796066063
Median	48
Mode	60
Standard Deviation	7,620062958
Sample Variance	58,06535948
Kurtosis	0,502600303
Skewness	0,088800568
Range	24
Minimum	36
Maximum	60
Sum	896
Count	18
Largest(1)	60
Confidence Level(95,0%)	3,789368159

The average value of Perceived Usefulness (PEU) was 49.78, with a standard deviation of 7.62. This average score indicates that respondents overall strongly agree that the maintenance management portal (MMP) application is beneficial for improving maintenance performance.

The minimum value of Perceived Usefulness (PEU) is 36 and the maximum value is 60. This minimum value indicates that there is one respondent who agrees that the maintenance management portal (MMP) application is useful for improving maintenance performance.

A high average Perceived Usefulness (PEU) score indicates that respondents overall have a positive perception of the maintenance management portal (MMP) application. This can be seen from the following statements:

- MMP applications are useful for improving maintenance efficiency and effectiveness.
- MMP applications can help users to make more informed decisions in maintenance.
- MMP applications can help users to reduce maintenance costs.

A low minimum Perceived Usefulness (PEU) value indicates that there is one respondent who still has a less positive perception of the maintenance management portal (MMP) application. This can be caused by several factors, including:

- Respondents did not fully understand the benefits of MMP applications.
- Respondents had never used an MMP app before.
- Respondents had poor experience using similar apps.

Conclusion:

Based on the data analysis conducted, it can be concluded that respondents as a whole have a positive perception of the maintenance management portal (MMP) application. This shows that the application has the potential to be accepted by users.

Recommendations:

To increase the overall acceptance of the maintenance management portal (MMP) application, several things need to be done, including:

- Conduct more intensive socialization and training on the use of the maintenance management portal (MMP) application.
- Improving and developing the maintenance management portal (MMP) application to better suit user needs.

By doing these things, it is expected that the value of Perceived Usefulness (PEU) can increase so that the maintenance management portal (MMP) application can be utilized more optimally.

4.4.1.2 Analysis of Perceived Ease of Use (PEOU)

Perceived Ease of Use (PEOU) is an indicator that measures the extent to which users perceive the ease of use of the Maintenance Management Portal (MMP) application.

Table 4.7. Descriptive Statistics of Perceived Ease of Use (PEOU)

<i>Perceived Ease of Use (PEOU)</i>	
Mean	16,33333333
Standard Error	0,736534901
Median	16
Mode	16
Standard Deviation	3,124852938
Sample Variance	9,764705882
Kurtosis	1,819868631
Skewness	-1,19427307
Range	12
Minimum	8
Maximum	20
Sum	294
Count	18
Largest(1)	20
Confidence Level(95,0%)	1,553952807

Based on the data provided, an average Perceived Ease of Use (PEOU) value of 16 was obtained, with a standard deviation of 3.13. This average score indicates that respondents overall strongly agree that the maintenance management portal (MMP) application is easy to use.

The minimum value of Perceived Ease of Use (PEOU) is 8 and the maximum value is 20. This threshold indicates that there is one respondent who agrees that the maintenance management portal (MMP) application is easy to use.

A high average Perceived Ease of Use (PEOU) score indicates that respondents overall have a positive perception of the maintenance management portal (MMP) application. This can be seen from the following statements:

- The MMP app has an easy-to-understand interface.
- The MMP application has an easy-to-use way to learn.
- MMP applications do not take much time to learn.

A low minimum Perceived Ease of Use (PEOU) value indicates that there is one respondent who still has a less positive perception of the maintenance management portal (MMP) application. This can be caused by several factors, including:

- Respondents had poor experience using similar apps.
- Respondents had a low level of education.
- Respondents had difficulty in understanding the language used in the MMP application.

A high average Perceived Ease of Use (PEOU) score indicates that respondents overall have a positive perception of the maintenance management portal (MMP) application. This can be seen from the following statements:

- The MMP app has an easy-to-understand interface.
- The MMP application has an easy-to-use way to learn.
- MMP applications do not take much time to learn.

A low minimum Perceived Ease of Use (PEOU) value indicates that there is one respondent who still has a less positive perception of the maintenance management portal (MMP) application. This can be caused by several factors, including:

- Respondents had poor experience using similar apps.
- Respondents had a low level of education.
- Respondents had difficulty in understanding the language used in the MMP application.

Conclusion

Based on the data analysis conducted, it can be concluded that respondents as a whole have a positive perception of the maintenance management portal (MMP) application. This shows that the application has the potential to be accepted by users.

Recommendations

Based on the data analysis carried out, the following can be recommended:

- Conduct more intensive socialization and training on the use of the maintenance management portal (MMP) application, especially for respondents who have a less positive perception of Perceived Ease of Use (PEOU).
- Improving and developing the maintenance management portal (MMP) application to better suit user needs, especially for users with low education levels or have difficulty understanding the language used in the MMP application.

By doing these things, it is expected that the overall acceptance of maintenance management portal (MMP) applications can increase.

Through the application of quantitative descriptive statistical analysis using the Technology Acceptance Model (TAM), it can be concluded that overall, respondents show a level of approval of the benefits and ease of use of the Maintenance Management Portal (MMP) application in improving maintenance performance. The results of this analysis provide a positive picture of the acceptance of the technology, confirming that MMP is considered useful and easy to use by users. This conclusion indicates that MMP has the potential to continue to be adopted and applied in supporting maintenance activities within FMC Tanjung Enim. Thus, the data from TAM analysis provide strong empirical support for the continued use of MMP as an integral part of maintenance management strategy.

4.4.2 Physical Availability

After two months of implementation of the Maintenance Performance Program (MPP) in July 2023, there is an encouraging upward trend in Physical Availability (PA), demonstrating the positive impact of MPP. This increase has been stable since the June 2023 baseline and peaked in September, indicating that MPP not only provides momentary improvements, but also serves as a driver of continuous performance improvement.

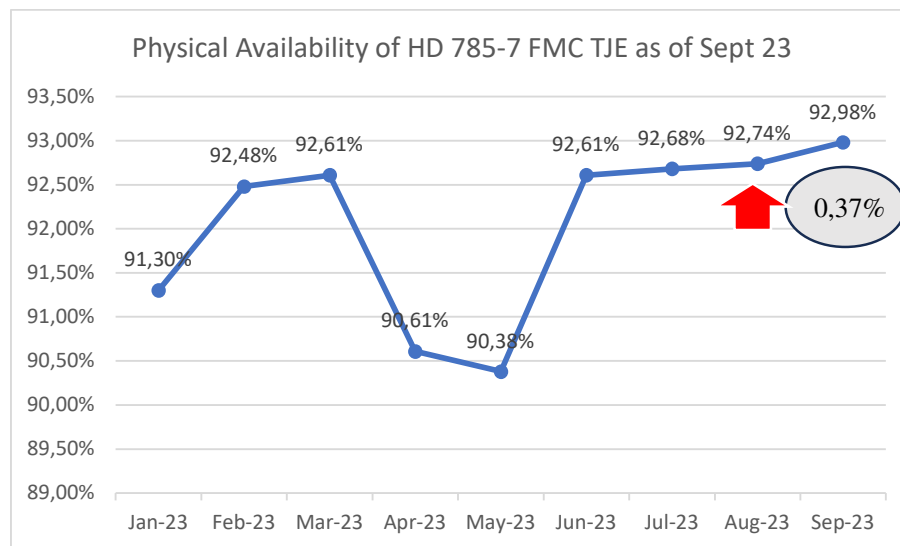


Figure 4.15. Physical Availability of HD 785-7 FMC TJE as of September 2023

Since the initial stage of implementation in July 2023, PA has continued to increase, culminating in an increase of 0.37% in September 2023 with an average increase of 0.12% each month. This continuous improvement shows that MPP not only provides temporary improvements but makes itself a driver of consistent performance improvement. Although still in its early stages, this upward trend provides a clear picture that MPP has a positive and long-term impact on maintenance effectiveness.

4.4.3 PS Leadtime Accuracy

From six performance parameters two months after the implementation of the Maintenance Management Portal (MMP), there was an increase in the percentage in PS

Leadtime accuracy and PS quality. This increased achievement reflects the positive impact of MMP implementation at UT FMC Tanjung Enim.

Table 4.8. Six Performance Parameter as of September 2023

Performance	Target (%)	Achievement (%)								
		Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23
PS Achievement	90	100	100	100	97,1	100	100	100	100	100
PS Accuracy ($\pm$ 50h)	90	100	100	100	100	97,1	88,2	100	100	100
PS Unit Accuracy	90	100	88,2	100	75	100	100	100	100	100
PS Leadtime Accuracy	90	69,7	62,5	91,5	75	87,7	72,7	87,7	96,2	94,3
PS Start Time Accuracy	90	100	100	100	97,6	100	100	100	100	100
PS Quality	90	83,9	90,1	88,3	88,9	87	91,7	92,3	100	100
Before Implementation								After Implementation		

Based on the table, it can be seen that the achievement of HD785-7 maintenance performance at UT FMC TJE has increased from month to month. This shows that the performance of these treatments continues to improve. For PS lead time accuracy has increased significantly in August 2023 form average 71,19% before the implementation of MMP to 96,2% and has successfully achieved the set target. The increase in the percentage of achievement of PS Leadtime accuracy and PS Quality shows that MPP has succeeded in increasing the efficiency and effectiveness of preventive maintenance implementation.

4.4.4 Overall Equipment Effectiveness (OEE)

A fairly good increase in six performance parameters and PA also affects the increase in OEE Maintenance of Komatsu HD785-7 FMC TJE.

Table 4.9. Overall Equipment Effectiveness (OEE) of Komatsu HD785-7 at UT FMC TJE as of September 2023

Performance Parameter	Target (%)	Achievement (%)								
		Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23
PS Leadtime Accuracy	90	69,7	62,5	91,5	75	87,7	72,7	87,7	96,2	94,3

PS Quality	95	83,9	90,1	88,3	88,9	87	91,7	92,3	100	100
Physical Availability	90	91,3	92,48	92,61	90,61	90,38	92,61	92,68	92,74	92,98
OEE	77,0	53,4	52,1	74,8	60,4	69,0	61,7	75,0	89,2	87,7
Before Implementation								After Implementation		

From the table, it can be concluded that OEE has achieved its target at 89.2% in the second month after the implementation of MPP. This shows that MPP can improve overall maintenance performance.

In the overall data analysis, it can be concluded that the implementation of the Maintenance Management Portal (MMP) has succeeded in having a positive impact on maintenance performance. The success of MPP can be seen from the significant improvement in PS Leadtime accuracy through various features related to maintenance planning and maintenance strategies that have been implemented. This improvement ultimately contributes to an increase in Overall Equipment Effectiveness (OEE) which reflects the effectiveness of maintenance at UT FMC Tanjung Enim. Thus, MPP implementation not only provides measurable benefits, but also has the potential to continuously improve the efficiency and effectiveness of maintenance practices throughout the organization.

4.5 Control

Untuk menjaga keseluruhan proses perawatan menggunakan maintenance management portal (MMP) dapat berjalan dengan baik beberapa aktifitas yang telah dilakukan diantaranya.

4.5.1 Pembuatan Guidebook for Using the Maintenance Management Portal (MMP)

Guidebook for Using the Maintenance Management Portal (MMP ini memuat informasi mengenai:

- Akses dan Login: Cara mengakses dan masuk ke MMP.

- Tata Letak dan Navigasi: Penjelasan mengenai tata letak dan cara navigasi di MMP.
- Manajemen Peralatan: Cara mengelola peralatan di MMP.
- Manajemen Perintah Kerja: Cara mengelola perintah kerja di MMP.
- Perawatan Pencegahan: Penjelasan mengenai perawatan pencegahan dan cara menjadwalkannya di MMP.
- Strategi Pemeliharaan: Penjelasan mengenai strategi pemeliharaan yang tersedia di MMP.
- Manajemen Suku Cadang: Cara mengelola suku cadang di MMP.

4.5.2 Monitoring Plan for the use of Maintenance Management Portal (MMP)

Monitoring Plan for the use of Maintenance Management Portal (MMP) involves a comprehensive strategy to oversee and assess the effective utilization of the portal within an organizational context. The plan encompasses various key components, beginning with the establishment of clear performance metrics and benchmarks. These metrics may include user engagement, frequency of portal access, task completion rates, and overall user satisfaction. Regular data collection will be conducted to track these metrics over time, allowing for the identification of trends, patterns, and potential areas for improvement.

Table 4.10. Monitoring Plan for the use of Maintenance Management Portal (MMP)

Aspect	Monitoring Method	Frequency	Reporting Frequency	PIC	Escalation Criteria
System Availability and Performance	System Monitoring Tools	Continuously	Real-time alerts for critical issues, Daily summary reports	Adm Service	Major outage, Performance degradation exceeding 2%
Data Integrity and Accuracy	Data Validation Checks	Daily validation checks	Weekly audits	STE	Data discrepancy exceeding 10%, Validation failures exceeding 10%

User Activity and Adoption	User Activity Reports	Daily logins, Monthly feature usage reports	Monthly reports with quarterly deep dives	IT Officer	Significant drop in user logins, Underutilized features exceeding 10%
Maintenance Operations	Maintenance Performance Reports	Weekly	Weekly reports with monthly performance reviews, work order completion rates, schedule adherence, resource allocation	PPC, Supervisor	Work order completion rate below 90%, Schedule non-adherence exceeding 10%
System Security	Security Logs and Alerts	Continuously, bi-weekly	Alerts for critical events	IT Officer	Unauthorized access attempts, Suspicious activity, System vulnerabilities

4.6 Verification

Some of the factors contributing to MMP's positive impact on lead time accuracy include:

- Improved data integrity: MMP ensures data accuracy through digital record-keeping and standardized processes, eliminating errors and inconsistencies in manual entry.
- Real-time communication: MMP facilitates efficient communication between maintenance personnel, enabling timely response and problem resolution, thus preventing delays.
- Improve Planning and scheduling accuracy: MMP enables advanced planning and resource allocation, optimizes maintenance schedules, and prevents scheduling conflicts.
- Automated task management: MMP automates task assignment and tracking, ensuring efficient workflows and minimizing human error.

The impact of the improvements can be observed through the enhanced performance of the maintenance unit for the Komatsu HD785-7, particularly in the increased accuracy of Preventive Maintenance (PS) tasks. Several specific details regarding the implementation's impact are evident in the improvements related to physical availability, PS Leadtime accuracy, and Overall Equipment Effectiveness (OEE). These improvements signify a positive shift in the operational efficiency of the Komatsu HD785-7, as reflected in the increased uptime due to improved physical availability. Furthermore, the heightened accuracy in PS Leadtime contributes to more precise planning and execution of maintenance tasks, reducing downtime and enhancing overall maintenance effectiveness. The Overall Equipment Effectiveness metric serves as a holistic measure, encapsulating the positive effects of the implemented improvements on various aspects of the maintenance process for the Komatsu HD785-7.

4.6.1 Physical Availability

After implementation until the 5th month, quite encouraging results were obtained, where there was stability in the PA data as shown in the following graph

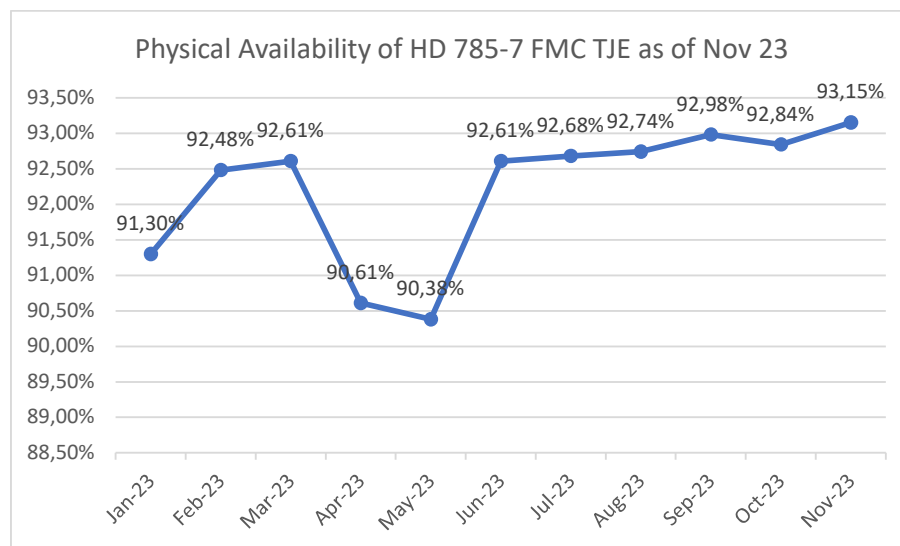


Figure 4.16. Physical Availability after 5 Month Implementation

Until the fifth month, the implementation of the PA graph continues to increase and recorded in November 2023 has reached 93.15%. This is a significant growth rate when compared to data before implementation which only averaged 91.43%.

4.6.2 PS Leadtime accuracy

PS leadtime accuracy data is also quite stable after implementation until the 5th month and obtained quite encouraging results.

Table 4.11. Six Performance Parameter as of November 2023

Performance	Target (%)	Achievement (%)										
		Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23
PS Achievement	90	100	100	100	97,1	100	100	100	100	100	100	100
PS Accuracy ($\pm 50h$)	90	100	100	100	100	97,1	88,2	100	100	100	100	100
PS Unit Accuracy	90	100	88,2	100	75	100	100	100	100	100	100	100
PS Leadtime Accuracy	90	69,7	62,5	91,5	75	87,7	72,7	87,7	96,2	94,3	95,6	100
PS Start Time Accuracy	90	100	100	100	97,6	100	100	100	100	100	100	100
PS Quality	90	83,9	90,1	88,3	88,9	87	91,7	92,3	100	100	100	100

Before Implementation

After Implementation

From the table, it can be seen that the implementation of MMP has had a significant impact on PS Leadtime Accuracy. The realization of PS Leadtime Accuracy increased from 77% to 96.2%, exceeding the set target.

The increase in PS Leadtime Accuracy is caused by several factors, including:

- Improved data accuracy: MMP uses a digital system to record data, so that data becomes more accurate and there are no errors due to manual input.
- Improved communication: MMP facilitates communication between maintenance teams, thus preventing delays in PM implementation.
- Improved planning: MMP allows maintenance teams to plan PM more accurately and efficiently.
- Increased automation: MMP can perform certain tasks automatically, thereby reducing human error.

This increase in achievement has shown that MMP has proven effective in improving the performance of PS leadtime accuracy.

4.6.3 Overall Equipment Effectiveness (OEE)

Dengan meningkatnya peforma dari 2 parameter di atas, tentu akan berdampak secara positif pula pada pencapaian Overall Equipment Effectiveness (OEE).

Table 4.12. Overall Equipment Effectiveness (OEE) of Komatsu HD785-7 at UT FMC TJE as of November 2023

Performance Parameter	Target (%)	Achievement (%)										
		Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23
PS Leadtime Accuracy	90	69,7	62,5	91,5	75	87,7	72,7	87,7	96,2	94,3	95,6	100
PS Quality	95	83,9	90,1	88,3	88,9	87	91,7	92,3	100	100	100	100
Physical Availability	90	91,3	92,48	92,61	90,61	90,38	92,61	92,68	92,74	92,98	92,84	93,15
OEE	77,0	53,4	52,1	74,8	60,4	69,0	61,7	75,0	89,2	87,7	88,8	93,2
Before Implementation							After Implementation					

The data from the table clearly indicates that the implementation of MMP has yielded a substantial impact on Overall Equipment Effectiveness (OEE). The OEE realization witnessed a remarkable surge, escalating from 53.4% to an impressive 89.2%, surpassing the established target. This notable enhancement in OEE can be attributed to several contributing factors. Firstly, the improved accuracy in PS Leadtime has resulted in prolonged equipment operation, thereby positively influencing OEE. Additionally, the quality improvement in PS contributes to more efficient equipment operation, further bolstering OEE. Moreover, the increased availability of equipment has extended operational durations, contributing significantly to the overall improvement in OEE. The multifaceted improvements brought about by the MMP implementation highlight its effectiveness in optimizing equipment performance and operational efficiency.