

CHAPTER 3 – RESEARCH METHODS

3.1 Scope of study

This research focused on optimizing machine health monitoring, which can affect the reduction of unscheduled downtime duration and improve machine Physical Availability (PA) of Komatsu Dump Truck HD785-7.

3.2 Research Timeline

This research was conducted for around 16 weeks as stated in detail activities in Table 3.1 Time Frame of Research Study

Table 3.1 Time Frame of Research Study

NO	ACTIVITY	WORK SEQUENCES (WEEKS)															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
DEFINE																	
1	Problem Identification																
2	Define Objective																
3	Literature Review																
4	Define Research Methodology																
MEASURE																	
5	Data Collection																
6	Data Validation																
7	Data Variable to PA																
ANALYSIS																	
8	Root Cause Analysis																
9	Solution Determination																
10	Focus Group Discussion																
IMPROVE																	
11	Alternative Design																
12	Implementation																
CONTROL																	
13	Verification																
14	Standardization																

3.3 Research Flow Process

This research has flow process as describe at Figure Research Flow Process, that explain the detail processes, start from background in introduction, problem statement, research objective, literature review, research method, result, conclusion, and recommendation.

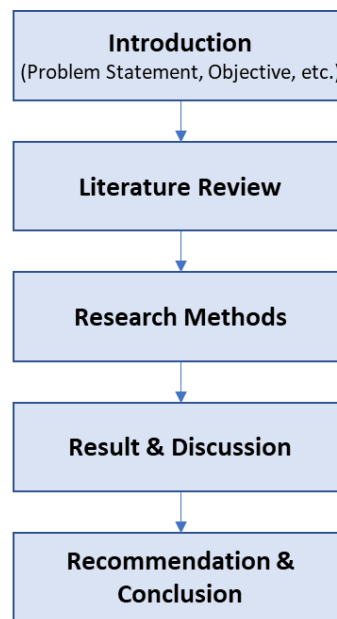


Figure 3.1 Research Flow Process.

3.4 Research Method Framework

Descriptive analysis will be used in this research to gather, compile, and present data. This includes gathering, categorizing, analyzing values and statistics, and making graphs and representations. There are five steps in DMAIC: Define, Measure, Analyze, Improve, and Control. The DMAIC framework's pillars allow us to enhance a business function or a whole organization for efficiency and effectiveness. The data driven DMAIC methodology covers every detail. It delivers extensive business processes or function improvements.

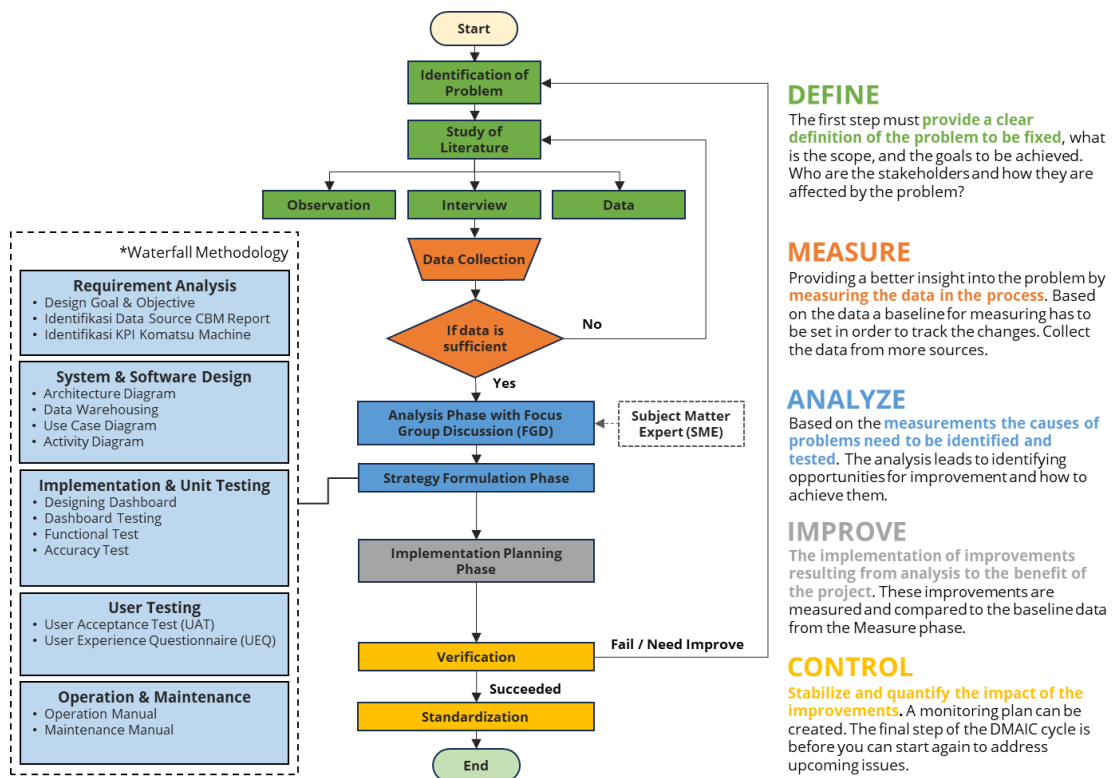


Figure 3.2 Research Method Framework.

3.5 Analytical Method

DMAIC is a structured problem-solving and process improvement methodology commonly used in Six Sigma. The acronym DMAIC stands for Define, Measure, Analyze, Improve, and Control. The Analyze phase is a critical step in the DMAIC process, where the focus is on identifying the root causes of the problems and inefficiencies within a process.

3.5.1. Define

In the DMAIC framework, "Define" is the first phase and serves as the starting point for a structured problem-solving and process improvement approach, commonly associated with Six Sigma. The primary objective of the Define phase is to clearly articulate and understand the problem or opportunity that the improvement project aims to address. This phase involves several key activities:

a. Project Charter

Creation of a project charter, which is a formal document that outlines the project's scope, objectives, goals, team members, stakeholders, and a high-level timeline. The project charter sets the foundation for the entire DMAIC process.

b. Problem Statement

Clearly defining the problem or opportunity that the project aims to solve. The problem statement should be specific, measurable, achievable, relevant, and time-bound (SMART). As described in Chapter 1 section 1.2 Research Problems, the main problem of the research is the Physical Availability (PA) of Komatsu Dump Truck HD785-7 was not achieved from the targeted PA of the company. Average PA of all HD785-7 only 84,04% of target 88,00%.

c. Project Scope

Defining the boundaries and limitations of the project. This helps in focusing efforts on the most critical issues and prevents the project from becoming overly complex or broad in scope. As describe in section 3.1 Scope of Study, this research focused on optimizing machine health monitoring, which can affect the reduction of unscheduled downtime duration and improve machine Physical Availability (PA) of Komatsu Dump Truck HD785-7.

d. Stakeholder Identification

Identifying and involving relevant stakeholders who have an interest in or are affected by the process under investigation. This includes both internal and external stakeholders. The internal stakeholder is the HD785-7 distributor, meanwhile the external stakeholder is PT. XYZ itself.

e. Team Formation

Assembling a cross-functional team with the necessary skills and expertise to address the defined problem. Team members may come from different departments within an organization.

Table 3.2 Project Team

NO	DISTRIBUTOR	QTY	PT. XYZ	QTY
1	Site Manager	1	Plant Manager	1
2	Service Department Head	1	Plant Section Head	1
3	Service Supervisor	2	Plant Group Leader	2
4	Site Technical Engineer	1	Engineer	1
5	Plant Production Control	1	Planner	1
6	Data Analyst	2	Data Analyst	1

f. High-Level Process Map

Developing a high-level process map that outlines the major steps in the process. This map provides a visual representation of the process flow and helps the team understand the context of the problem.

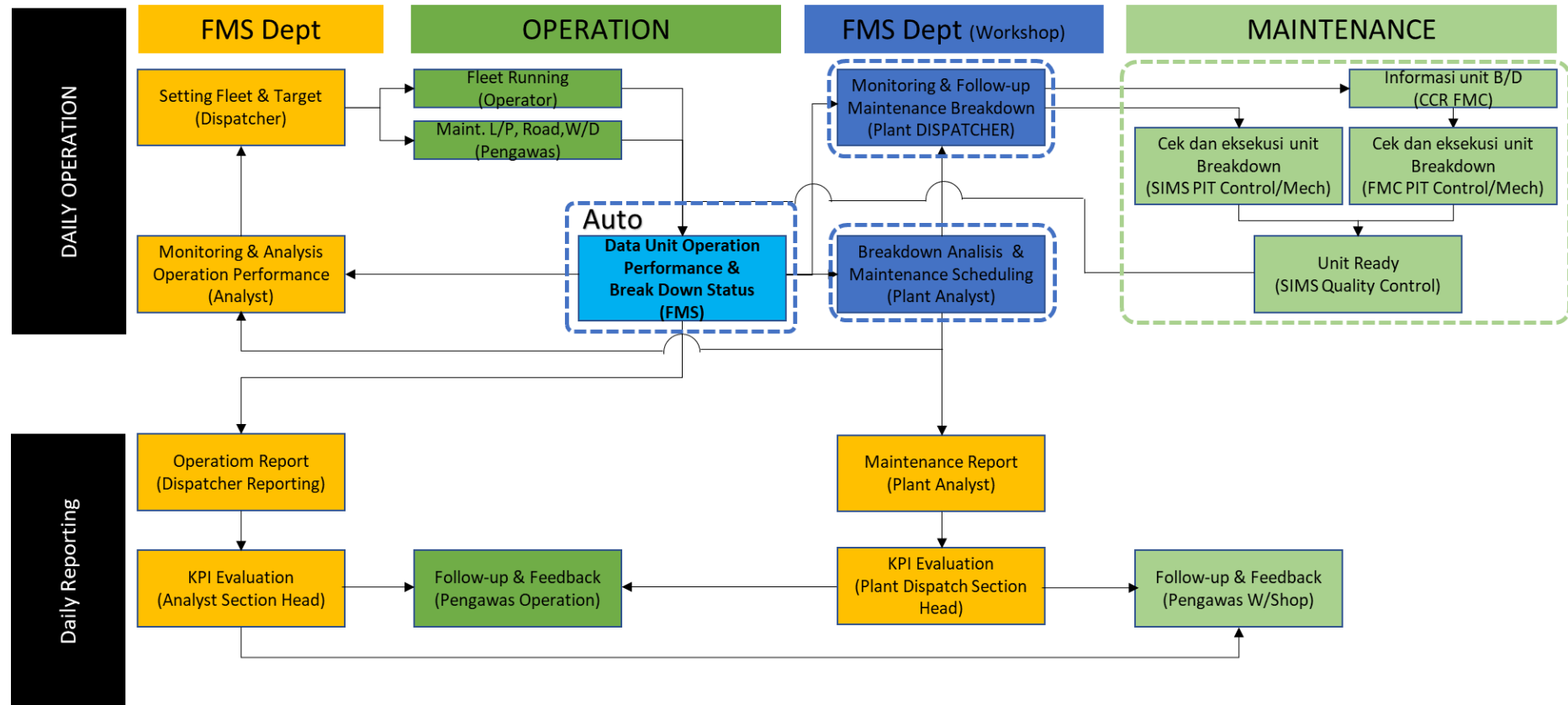


Figure 3.3 Strategy Formulation.

g. Goal Setting

Establishing specific, measurable, and achievable goals for the improvement project. These goals should align with the overall objectives of the organization and the expectations of the stakeholders. As described in Chapter 1 section 1.3 Research Objectives, the goal of the research is to reduce unscheduled downtime for improving the Physical Availability (PA) of Komatsu Dump Truck HD785-7 to the company target.

h. Data Collection Plan

Developing a plan for collecting the data needed to assess the current state of the process. This plan outlines what data will be collected, how it will be collected, and who will be responsible for the data collection.

Table 3.3 Data Collection Plan

NO	TYPES OF DATA	SOURCE/PIC	PERIODE
1	Physical Availability (PA) Summary	Planner	Jul-23
2	Downtime Summary	Planner	Jul-23
3	Periodic Inspection (PI) Summary	Supervisor	Jul-23
4	VHMS Data Summary	Site Technical Engineer	Jul-23
5	Oil Analysis Summary	Site Technical Engineer	Jul-23

The Define phase sets the foundation for the rest of the DMAIC process by providing a clear understanding of the problem, establishing project boundaries, and aligning project goals with organizational objectives. It helps ensure that the improvement efforts are targeted and focused on areas that will have a meaningful impact on the organization's performance. The outputs of the Define phase, such as the project charter and problem statement, guide the team throughout the subsequent phases of Measure, Analyse, Improve, and Control.

3.5.2. Measure

In the DMAIC framework, "Measure" is the second phase, following the Define phase. The Measure phase involves gathering data to assess and quantify the current state of the process. This data-driven approach is essential for establishing a baseline and

understanding the magnitude of the problem. Here are key activities and objectives associated with the Measure phase:

a. Process Mapping and Flowcharting

Further refine the high-level process map developed in the Define phase. Create a detailed process map that outlines each step in the process, including inputs, outputs, and key process metrics.

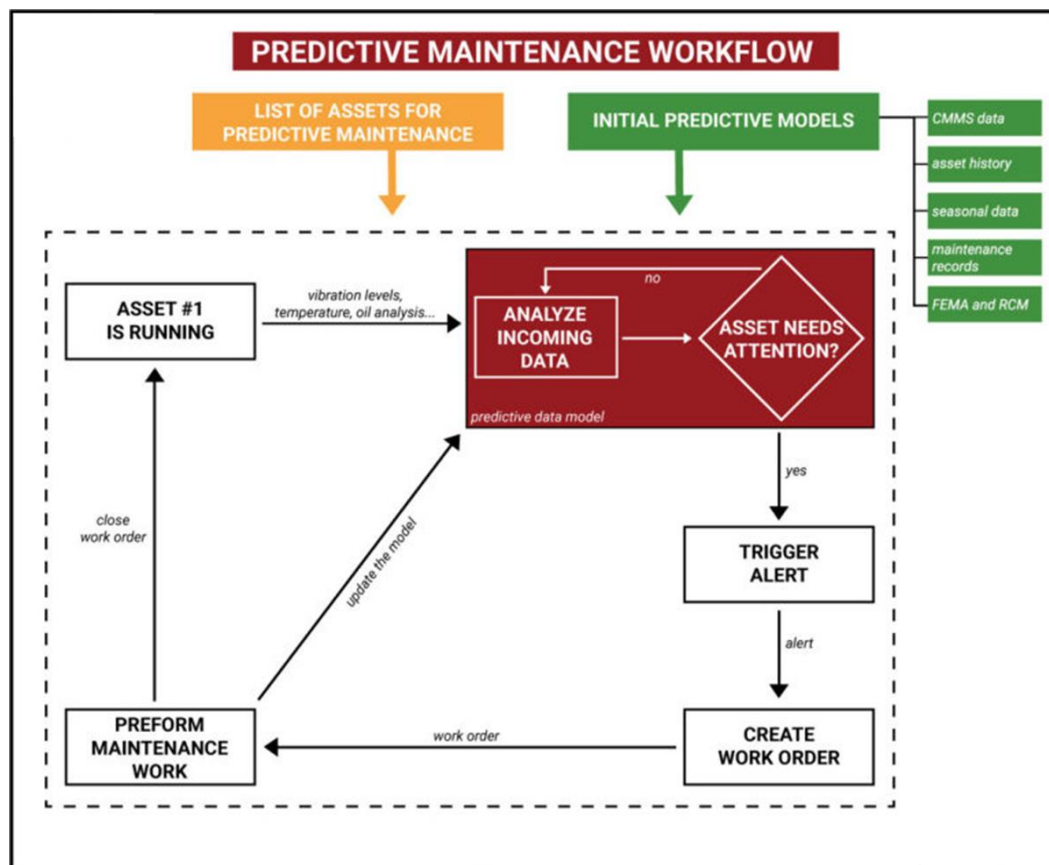


Figure 3.4 Predictive Maintenance Workflow.

b. Identification of Critical Process Characteristics

Determine the critical process characteristics or key variables that significantly impact the performance of the process. These are the factors that need to be measured and controlled for effective improvement.

c. Data Collection

Develop a detailed plan for collecting relevant data based on the critical process characteristics identified. This plan includes specifying what data to collect, how to collect it, and who is responsible for data collection.

d. Measurement System Analysis (MSA)

Assess the reliability and accuracy of the measurement instruments used to collect data. MSA helps ensure that the measurements taken are valid and consistent, reducing the risk of errors in the data.

e. Establishing a Baseline

Collect data from the current process to establish a baseline performance level. This baseline serves as a reference point for measuring improvement throughout the DMAIC process. This research baseline performance level is to set the Physical Availability (PA) to minimum 88%.

f. Data Validation

Verify the accuracy and completeness of the collected data. This involves checking for outliers, missing values, or other issues that may affect the reliability of the data.

g. Data Analysis

Perform basic data analysis to understand the central tendency, variability, and distribution of the collected data. This analysis helps identify trends and patterns in the process performance.

h. Process Capability Analysis

Assess the capability of the current process to meet customer requirements. Process capability indices, such as C_p and C_{pk} , may be calculated to quantify how well the process performs within specification limits.

i. Establishing Measurement Baselines

Set baselines for key performance indicators (KPIs) and other relevant metrics. These baselines provide a reference point for evaluating the impact of improvement efforts. The Measure phase provides a quantitative understanding of the current state of the process, allowing the project team to identify areas of improvement and establish a foundation for comparison in subsequent phases. The outputs of the Measure phase inform the Analyze phase, where the team delves deeper into the data to identify the root causes of process issues.

3.5.3. Analyze

In the DMAIC framework, the "Analyze" phase is the third stage following Define and Measure. The Analyze phase focuses on identifying the root causes of the problems or inefficiencies identified in the earlier stages. The goal is to gain a deeper understanding of the process and its contributing factors. Here are the key activities and objectives associated with the Analyze phase:

a. Data Analysis

Build on the data collected in the Measure phase and perform more in-depth analysis using statistical and analytical tools. This may involve techniques such as regression analysis, hypothesis testing, and other statistical methods to explore relationships and patterns in the data.

b. Root Cause Analysis

Identify and prioritize the root causes of the problems observed in the process. Techniques such as the 5 Whys, Fishbone (Ishikawa) diagrams, and Failure Mode and Effects Analysis (FMEA) may be employed to systematically dig deeper into the factors contributing to issues.

c. Identifying Critical Xs (Independent Variables)

Determine the critical Xs, or independent variables, that have a significant impact on the dependent variable, which is the process output. These are the factors that, when controlled or optimized, can lead to improvements in the process.

d. Statistical Tools and Techniques

Use a variety of statistical tools and techniques to analyze data and relationships within the process. This may include correlation analysis, analysis of variance (ANOVA), and graphical methods like Pareto charts and scatter plots.

e. Data Stratification

Further stratify the data to understand variations within different subgroups. This helps in identifying specific patterns or trends that may not be apparent when looking at the data as a whole.

f. Confirmation Bias Check

Ensure that the analysis is unbiased and based on objective findings. Confirmation bias, where one may unconsciously favor information that confirms preexisting beliefs, should be minimized.

g. Iterative Analysis

The Analyze phase is often iterative. As the team uncovers information, they may need to refine their analysis, gather additional data, or adjust their hypotheses to gain a more accurate understanding of the root causes.

h. Documentation

Document the findings of the analysis, including identified root causes and critical Xs. This documentation serves as a basis for decision-making in the subsequent Improve and Control phases and provides a historical record of the analytical process.

The outputs of the Analyze phase inform the development of solutions in the Improve phase. By understanding the root causes of process issues, the project team can develop targeted and effective strategies for improvement.

3.5.4. Improve

In the DMAIC framework, the "Improve" phase is the fourth stage, following Define, Measure, and Analyze. The primary objective of the Improve phase is to develop and implement solutions that address the root causes identified during the Analyze phase. This phase focuses on making changes to the process to achieve measurable improvements. Here are the key activities and objectives associated with the Improve phase:

a. Generate Solutions

Brainstorm and generate potential solutions to address the identified root causes. The team should consider a range of options and evaluate their feasibility.

b. Evaluation of Solutions

Evaluate and prioritize the potential solutions based on criteria such as effectiveness, feasibility, and impact. This may involve using decision matrices, cost-benefit analysis, or other decision-making tools.

c. Pilot Testing

Implement a small-scale pilot test of the selected solutions to assess their effectiveness in a controlled environment. This allows the team to identify any unforeseen issues before full implementation.

d. Refinement of Solutions

Based on the results of the pilot test, refine, and optimize the selected solutions. This may involve adjusting implementation plans, modifying processes, or fine-tuning specific elements of the proposed changes.

e. Full Implementation

Roll out the refined solutions across the entire process or organization. This often requires careful planning and coordination to ensure a smooth transition from the existing state to the improved state.

f. Monitoring and Control

Establish monitoring mechanisms to track the performance of the implemented solutions. This includes defining key performance indicators (KPIs) and setting up a system to regularly assess and control the process.

g. Continuous Improvement

Foster a culture of continuous improvement by encouraging ongoing feedback, monitoring, and adjustment. Teams should be prepared to iterate on the improvements based on new data and feedback. In this research, researcher and Subject Matter Expert (SME) conduct weekly coordination meeting to review the effectiveness of machine health monitoring system.

h. Change Management

Implement change management strategies to address resistance and ensure that employees are well-prepared for the changes. Effective communication and training are crucial elements of successful change management.

i. Documentation

Document all changes made during the Improve phase, including the rationale, implementation details, and any adjustments made along the way. This documentation is valuable for future reference and analysis.

The outputs of the Improve phase lay the groundwork for the final phase, Control. Successful implementation of improvements leads to a more efficient and effective process. Regular monitoring and feedback mechanisms help ensure that the improvements are sustained over time, contributing to long-term success.

3.5.5. Control

In the DMAIC framework, the "Control" phase is the fifth and final stage. The Control phase focuses on maintaining and sustaining the improvements made during the Improve phase to ensure that the process remains stable and consistently meets the desired performance levels. The key activities and objectives of the Control phase include:

a. Documentation and Standardization

Document all changes made to the process during the DMAIC journey. This includes updated standard operating procedures (SOPs), work instructions, and any other relevant documentation. Standardizing processes helps ensure consistency.

b. Development of Control Plans

Create control plans outlining the key process controls and monitoring mechanisms. Control plans define how the process will be monitored, what metrics will be tracked, and the actions to be taken if there are deviations from the desired performance.

c. Establishing Performance Metrics

Define and establish key performance indicators (KPIs) that reflect the success criteria identified during the Define phase. These metrics serve as benchmarks for ongoing monitoring and control.

d. Training and Skill Development

Provide training to employees involved in the process to ensure that they understand the changes made and are equipped to operate within the updated procedures. This is essential for sustaining improvements over the long term.

e. Implementation of Visual Controls

Use visual management tools and controls to make it easy for operators and stakeholders to quickly assess the state of the process. Visual controls can include dashboards, charts, and other visual aids that highlight key performance metrics.

f. Process Audits

Conduct regular audits to verify that the process is adhering to the standardized procedures and that the implemented improvements are being maintained. Audits help identify any deviations or areas that may require corrective action.

g. Continuous Monitoring

Implement a system for continuous monitoring of the process. This involves regularly collecting and analyzing data to ensure that the process remains within the desired control limits.

h. Response Plans

Develop response plans that outline actions to be taken in the event of deviations or unexpected issues. Having predefined responses helps prevent the recurrence of problems and allows for swift corrective actions.

i. Feedback Mechanisms

Establish feedback mechanisms to capture insights from employees, stakeholders, and customers. This feedback can be valuable for identifying potential areas for improvement and ensuring that the process remains aligned with organizational goals.

j. Closure and Handover

Ensure that the project is formally closed, and responsibilities are handed over to the relevant stakeholders. This includes documenting the final results, lessons learned, and any ongoing responsibilities for maintaining the improvements.

The Control phase is essential for ensuring that the improvements achieved through the DMAIC process are sustained over time. It emphasizes the importance of continuous monitoring, feedback, and proactive management to prevent the reoccurrence of problems and maintain a high level of process performance.