Reduction of over and above cost per check in Aircraft Maintenance

Shaik Mohamed Nagutha G

ROADMAP

OVERVIEW

Background

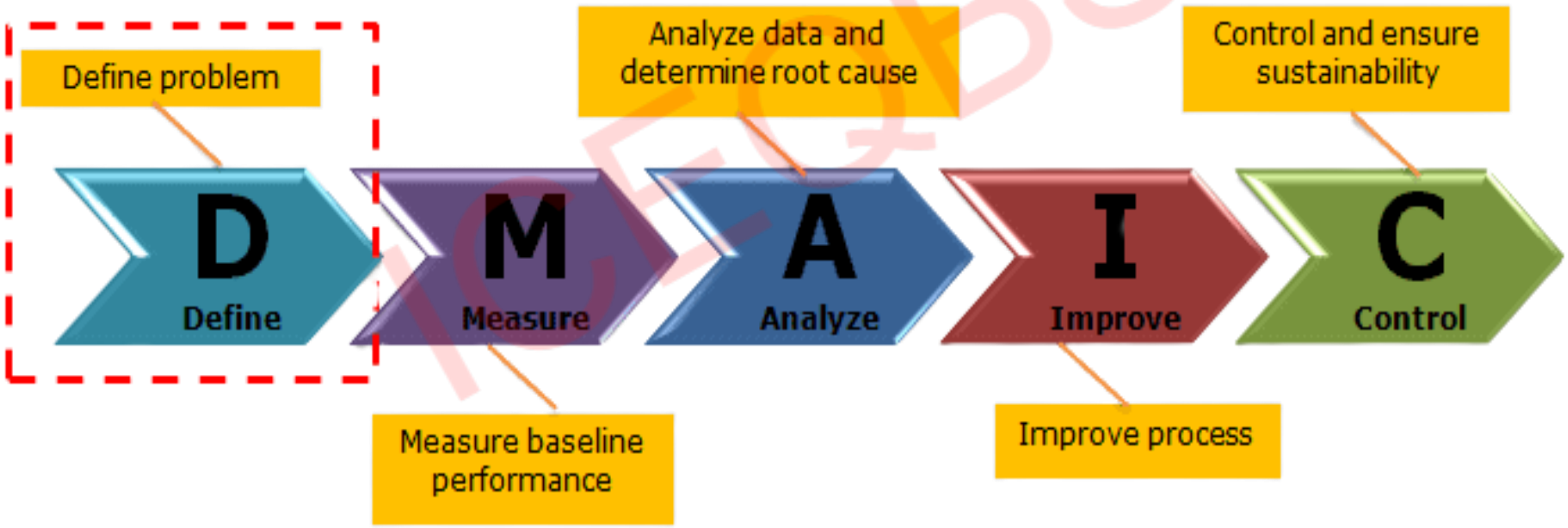
This project, undertaken in the **aviation maintenance and MRO (Maintenance, Repair & Overhaul)**, addresses the high *Over & Above* maintenance costs averaging **USD 51,389 per aircraft check** over the past nine months.

The primary cost drivers include **unplanned component failures, rework, and repair delays** during maintenance checks.

By improving component reliability and strengthening preventive maintenance processes, the project aims to achieve a **20% cost reduction**, targeting an average of **USD 41,000 per check**.

This initiative is expected to generate approximately **USD 100,000 in savings over six months** for 10 aircraft checks while enhancing **operational efficiency, fleet availability, regulatory compliance (EASA/FAA), and customer satisfaction**.

DEFINE PHASE

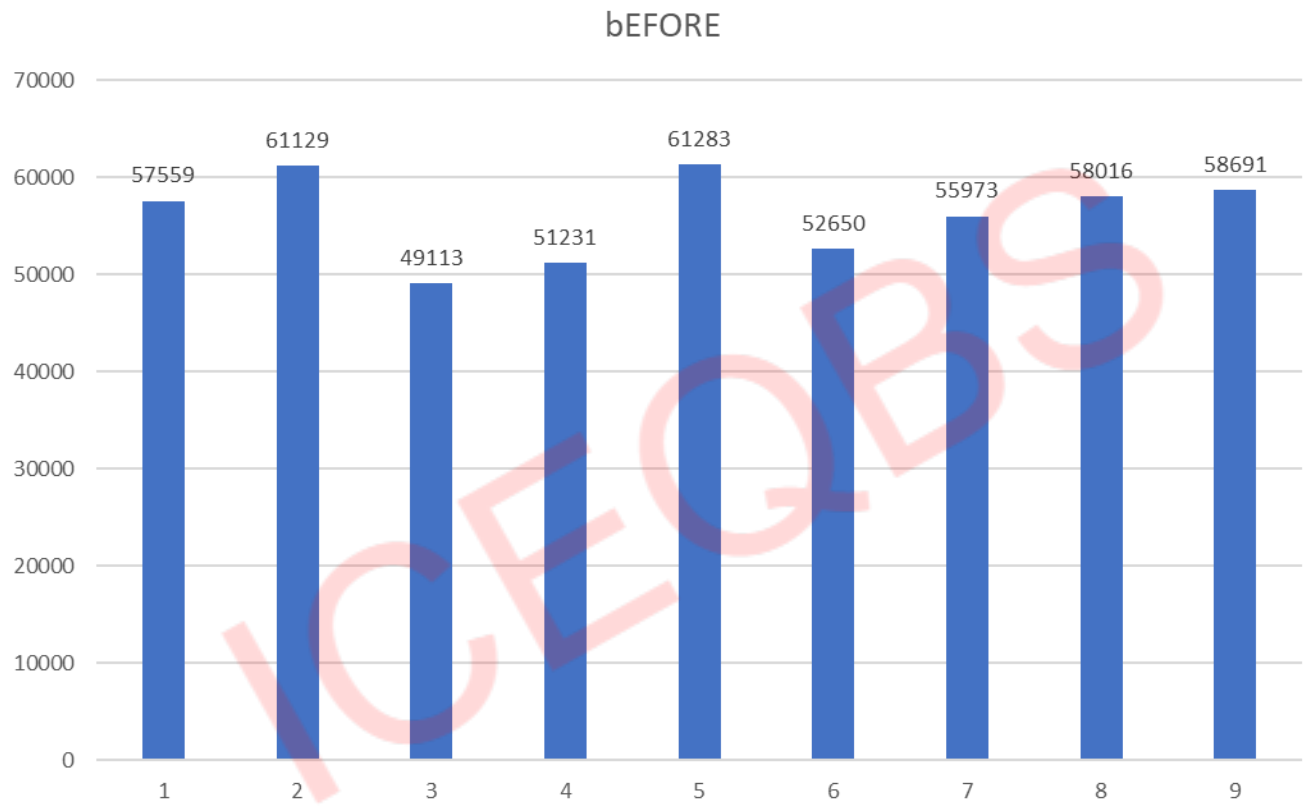


VOC & CTQ

CTQ Tree :

Voice of customer	Critical to X	Primary Metric for improvement
"We need reliable aircraft components that minimize unplanned maintenance and reduce additional maintenance costs."	CTC – Cost	Primary Metric - Y =Over & Above Cost per Check for Component failure maintenance in USD Secondary Metric - Component Failure Rate (%)

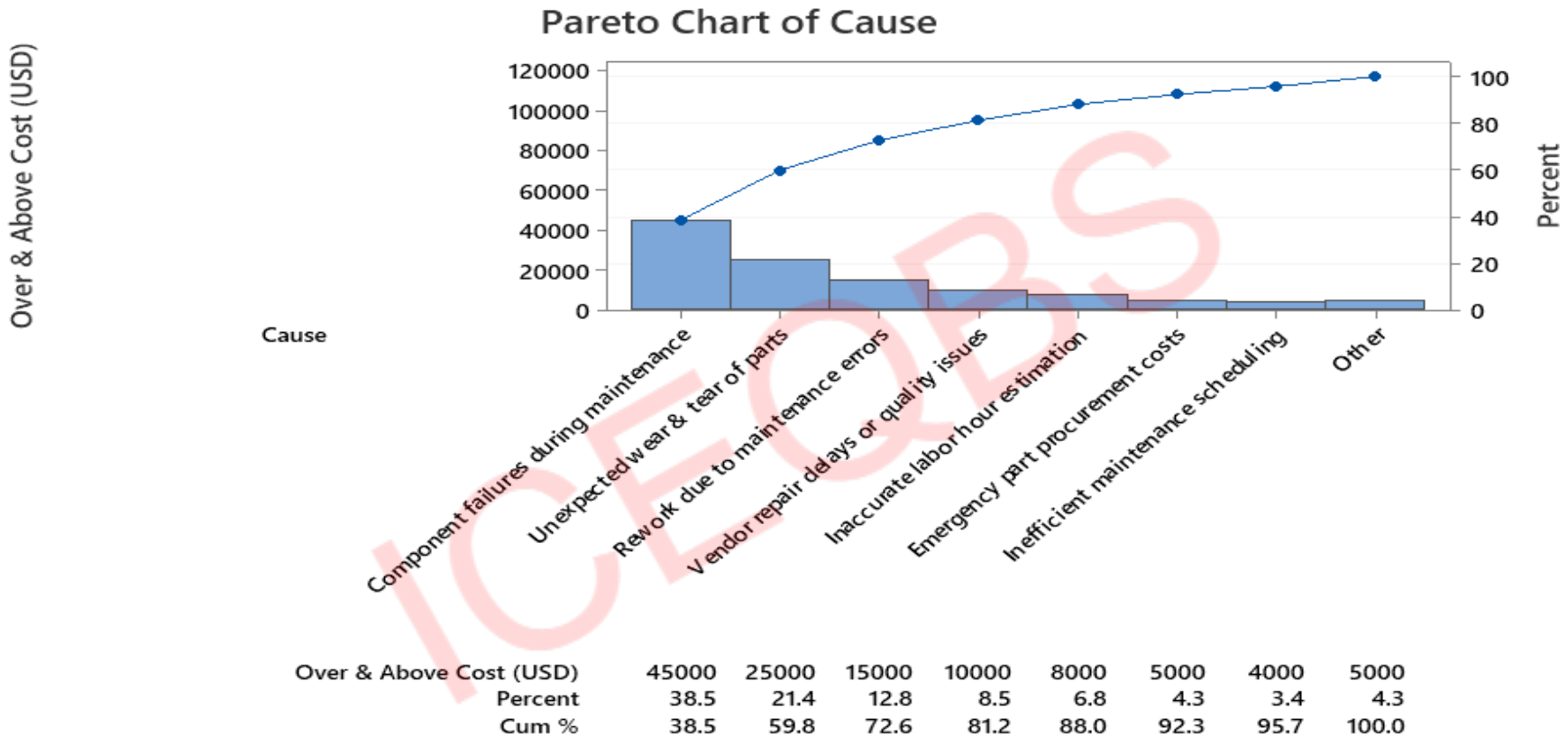
Baseline Performance of Primary Metric (9 months data as Line chart)



Inference :

- Last 9 months data shows a significant variation and hence ideal problem to be taken up as a Six Sigma Project.

Pareto chart



Over & Above Cost (USD)	45000	25000	15000	10000	8000	5000	4000	5000
Percent	38.5	21.4	12.8	8.5	6.8	4.3	3.4	4.3
Cum %	38.5	59.8	72.6	81.2	88.0	92.3	95.7	100.0

Inference :

- Component failures contributes substantially and included in the scope of the project

SIPOC

Suppliers (S)	Inputs (I)	Process (P)	Outputs (O)	Customers (C)
OEMs (Original Equipment Manufacturers)	Aircraft components/parts	1. Receive aircraft for scheduled check	Repaired aircraft components	Airline Operators
MRO Vendors / Repair Shops	Maintenance manuals, repair tools	2. Inspect components	Maintenance reports & cost data	Passengers (indirectly)
Materials & Inventory Team	Spare parts stock, consumables	3. Identify defective/failing components	Identified failed components	Maintenance Planning Team
Maintenance Planners	Work orders, schedules	4. Plan and schedule repairs	Repair plan and schedule	Quality / Engineering Team
Maintenance Technicians	Labor hours, tools	5. Perform repairs / replacements	Repaired/functional components	Finance / Cost Control Team

Project Charter

Project Title:	Reduction of over and above cost per check in Aircraft Maintenance

Project Leader	Project Team Members:
Shaik Mohamed Nagutha G	Sarah Ali Ahmed Khan Fatima Noor
Champion/Sponsors:	**Key Stake Holders**
Plant Head – Production	Maintenance/Production Planning Team Materials & Inventory Team Quality Assurance / Engineering Team Airline Operators / Flight Operations
Problem Statement:	**Goal Statement:**
Over the past 9 months, the **Over & Above Cost per Check** has averaged **51,389 USD** with monthly variability between 47,500 – 56,000 USD. High costs are primarily due to **component failures during maintenance**, causing unplanned repairs, rework, and delays.	Reduce **Over & Above Cost per Check** by **20% within 6 months** through process improvements in component reliability and preventive maintenance. Target Average Cost = **~41,000 USD per check**.
Secondary Metric	**Assumptions Made:**
Component Failure Rate (%)	Data Accuracy Stable Operating Conditions

Project Charter

Tangible and Intangible Benefits:

Estimated saving =

- $ 200,000

Other benefits –

- Customer Satisfaction
- Accuracy on delivery time

Risk to Success:

Unpredictable Component Failures
Implementation Delays

In Scope:

Scheduled aircraft checks (A, C, D)
Component failure analysis and repair optimization
Vendor performance monitoring
Preventive and predictive maintenance improvements

Out of Scope:

Modifications, retrofits, and non-scheduled maintenance

Changes to aircraft design or OEM-recommended procedures

Signatories:

Project Head : Shaik Mohamed Nagutha G

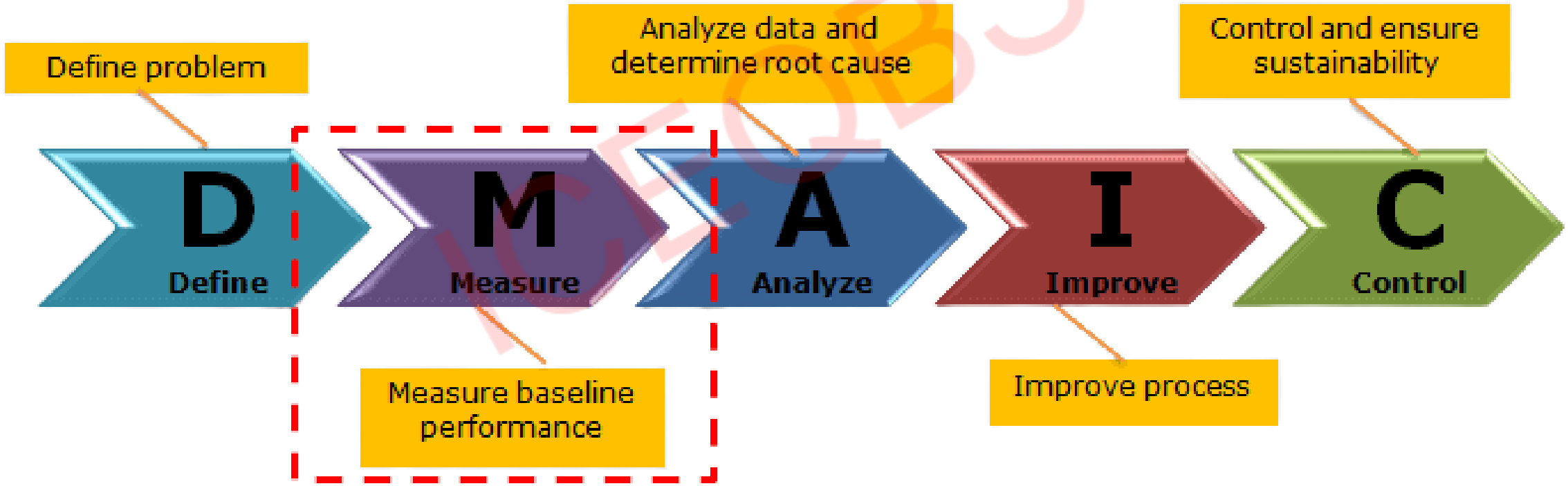
Sponsor : David Lee

Master Black Belt : Annamalai

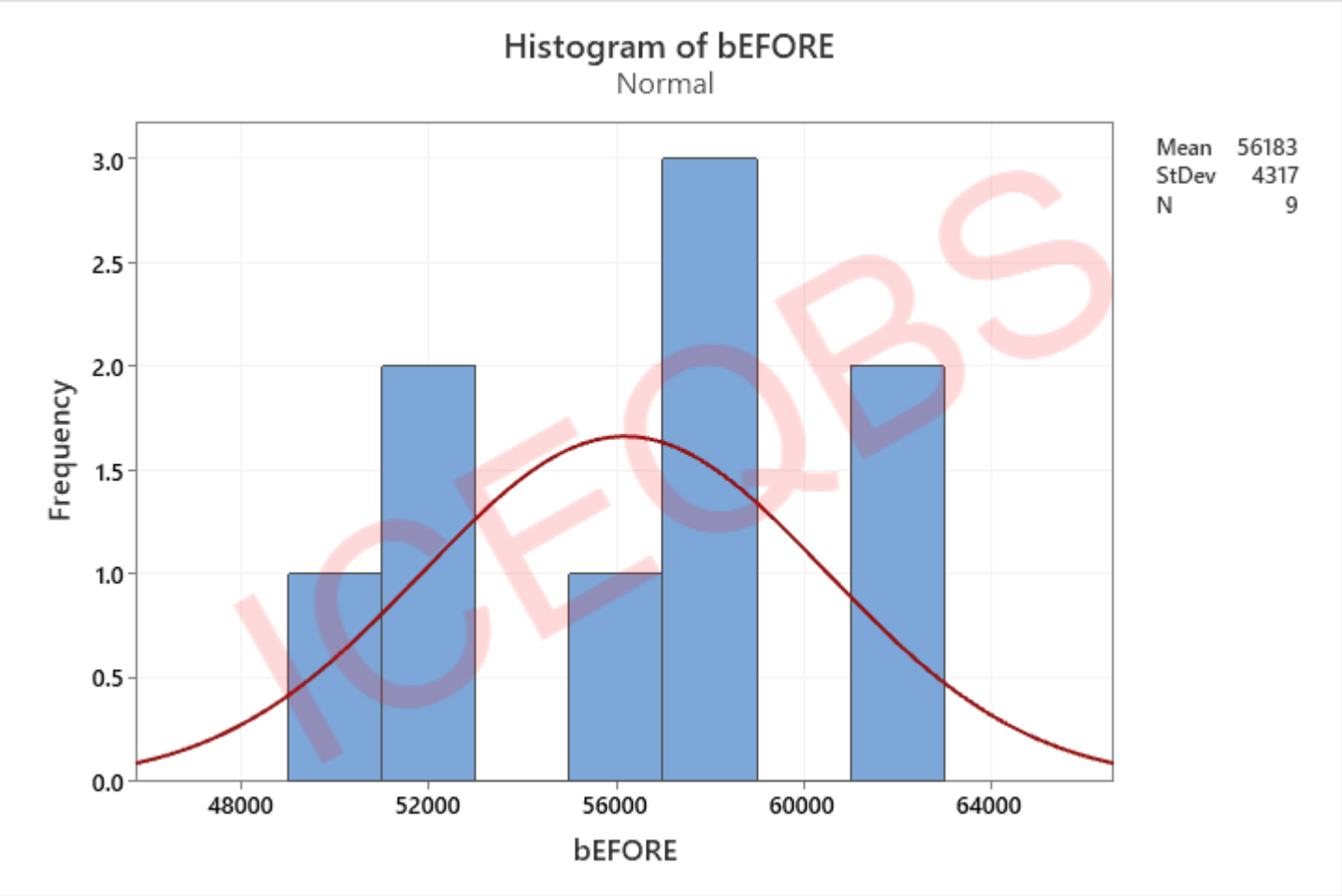
Project Timeline:

6 Months

MEASURE PHASE



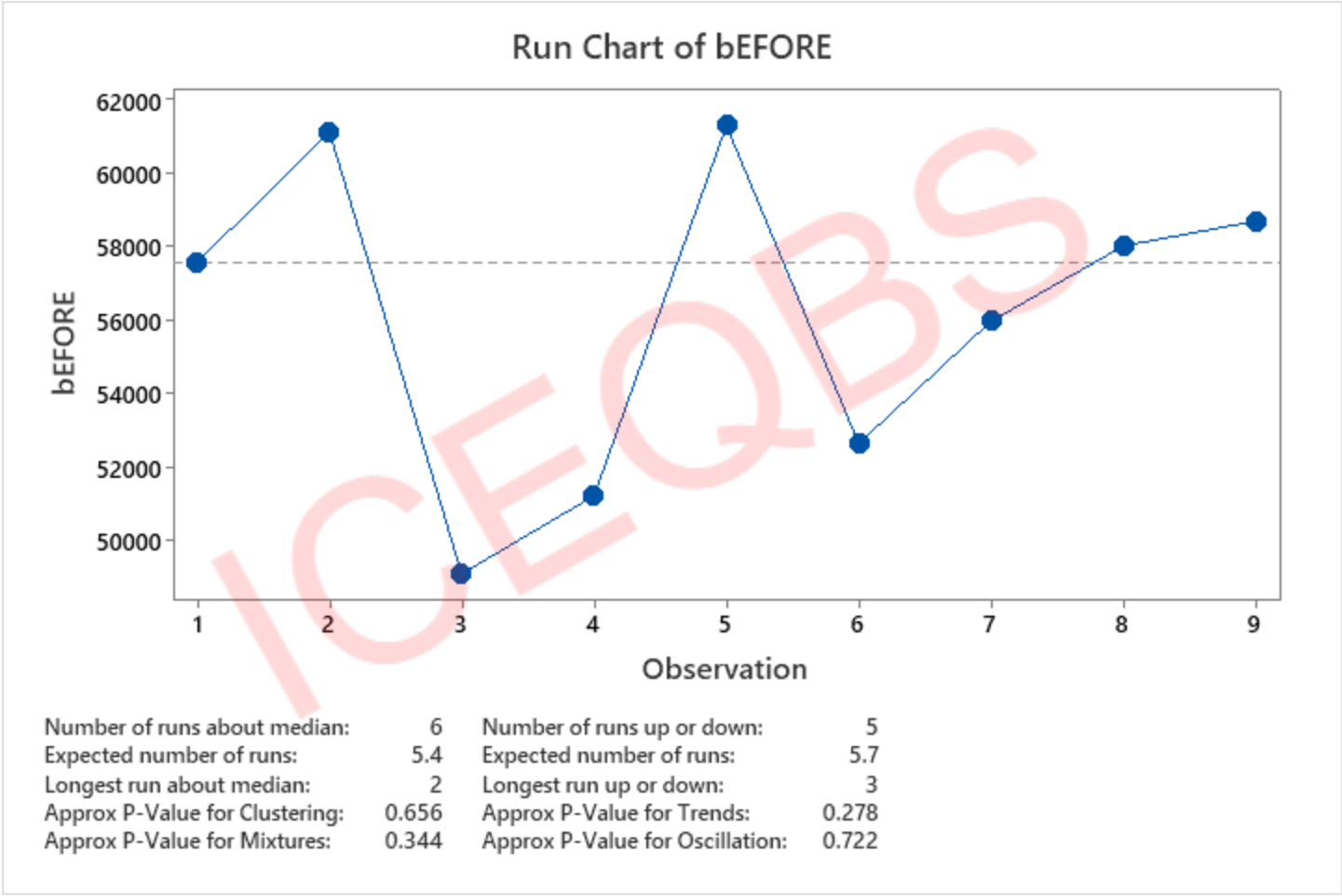
Data collection – Histogram (Before improvement)



Inference :

- Data is normally distributed over the mean

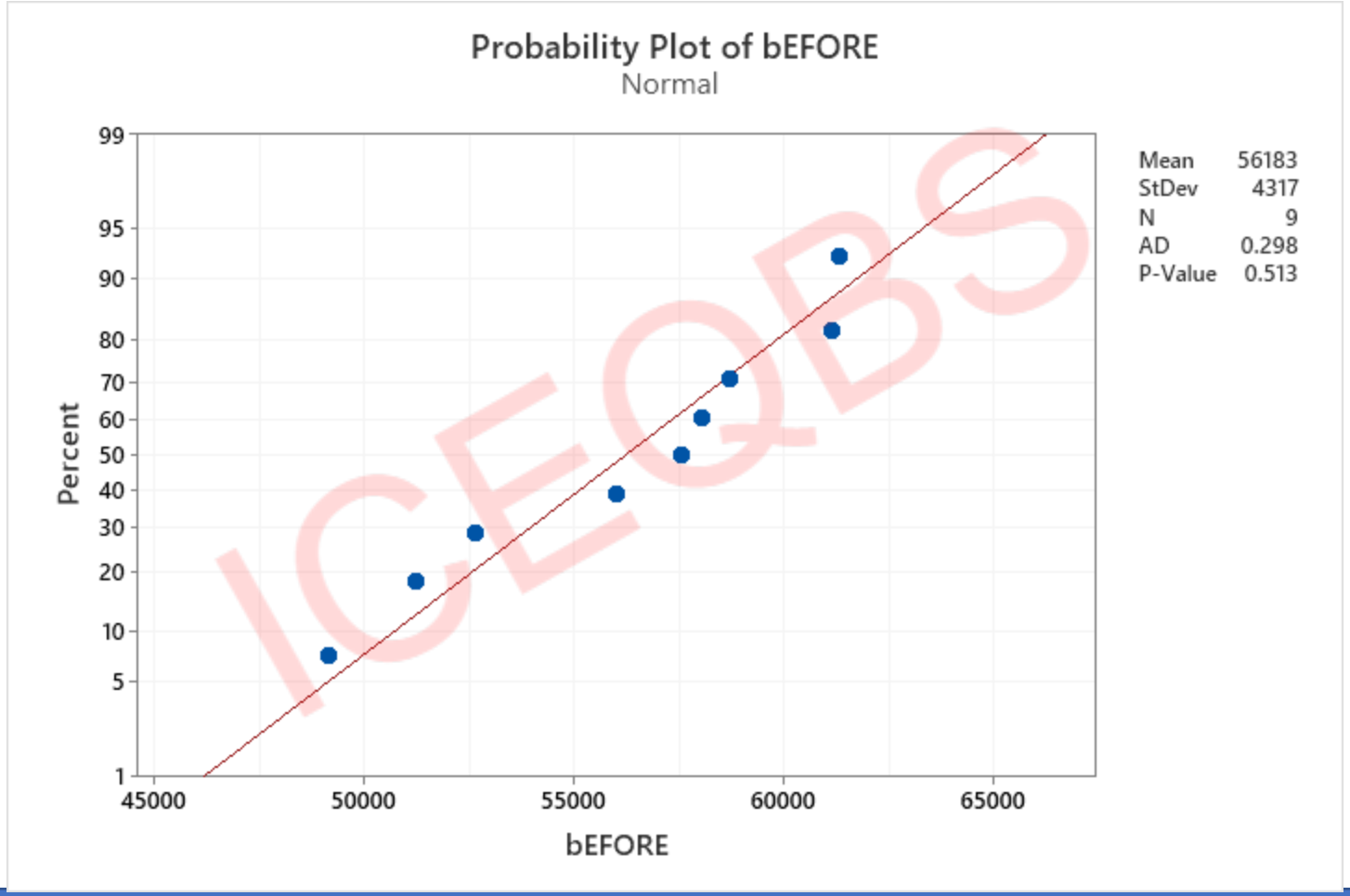
Data collection – Run Chart (Before improvement)



Inference :

P > 0.05 – No special causes in the process. Data can be used for further analysis

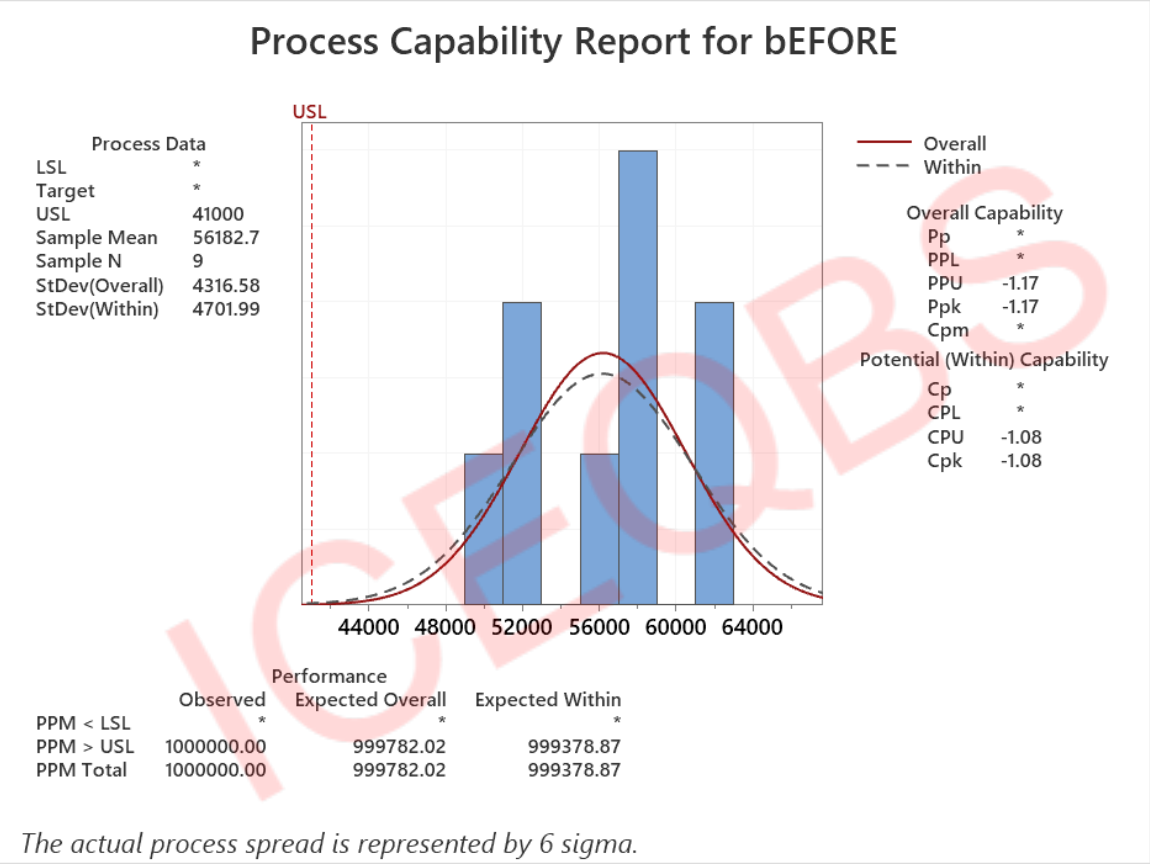
Data collection – Normality plot (Before improvement)



Inference :

- P > 0.05 in all scenarios, thus all the data is normally distributed

Process Capability (Before improvement)



Inference :

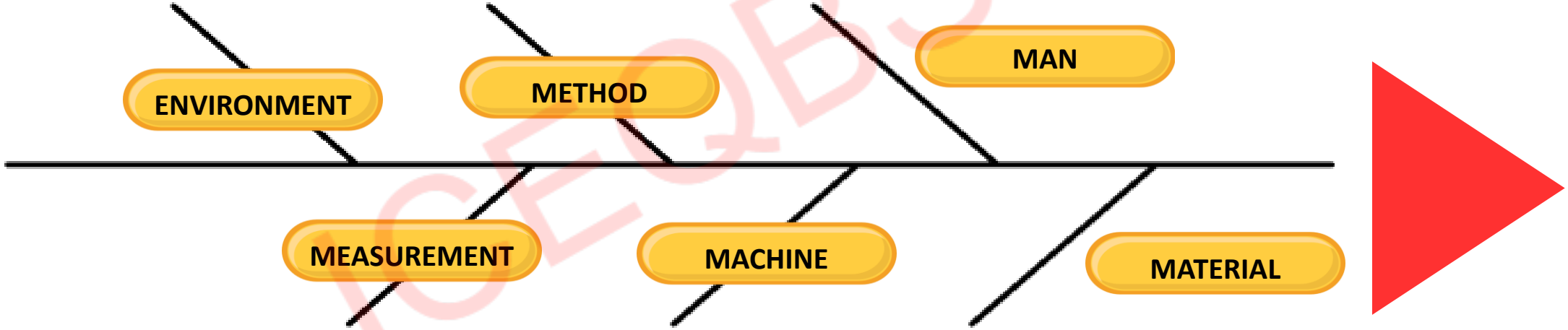
- Process is highly incapable

Fish Bone Diagram

- Humidity or moisture causing corrosion of parts
- Extreme temperatures affecting material properties
- Dust or contaminants in maintenance hangars
- Unexpected weather delays causing rushed maintenance
- Environmental regulations limiting repair methods or chemicals

- Incomplete or outdated maintenance procedures
- No standardized checklist for inspections
- Reactive maintenance instead of preventive approach
- Poor planning for component replacements
- Inconsistent vendor repair processes

- Technicians not following SOPs consistently
- Lack of proper training on specific components
- Fatigue or understaffing during checks
- Miscommunication between planning and maintenance teams
- Errors in component installation or assembly



- Inaccurate recording of component failure rates
- Lack of real-time monitoring of maintenance costs
- No trend analysis to predict failures
- Poor documentation of rework or repeat repairs
- Inconsistent reporting of vendor performance

- Calibration errors in testing/diagnostic tools
- Worn-out or faulty repair equipment
- Lack of specialized tools for certain components
- Inadequate maintenance of workshop machines
- Improper use of automated diagnostic machines

- Use of low-quality or counterfeit components
- Aging components beyond recommended lifecycle
- Parts supplied late or out of spec
- Improper storage leading to damage or degradation
- Frequent unavailability of critical spares

3M Analysis for Waste

MUDA

- Rework of components due to incorrect repairs
- Emergency procurement of parts that could have been forecasted
- Unnecessary movement of technicians or materials during check

Mura

- Variable repair times for the same type of component
- Inconsistent quality of parts from different vendors
- Fluctuating labor hours due to poor scheduling

Muri

- Technicians assigned too many components to repair in a single shift
- Diagnostic machines used beyond their capacity or maintenance schedule
- Maintenance staff performing complex repairs without proper training

8 Wastes Analysis

Defects	Component failures requiring rework Errors in installation or calibration causing repeated maintenance
Overproduction	Repairing components before actual need Producing duplicate maintenance reports or documentation
Waiting	Aircraft idle while waiting for parts or vendor repairs Technicians waiting for approvals or work orders
Non-Utilized Talent	Highly skilled technicians performing simple tasks Lack of staff involvement in process improvement initiatives
Transportation	Moving components multiple times between workshops and storage Unnecessary transport of parts to external vendors
Inventory	Overstock of rarely used spare parts Stockouts causing emergency procurement of critical components
Motion	Technicians walking long distances to fetch tools or parts Excessive movement during inspection due to poor layout
Overprocessing	Performing unnecessary inspections on components in good condition Rechecking components multiple times due to lack of standardization

Action Plan for Low Hanging Fruits

Focus Area	Issues Identified	Lean Tool / Approach	Action	Expected Benefit
Special Causes – Man / Labor	Fatigue, errors in installation, understaffing	Standard Work, Training, 5S	Conduct refresher training; implement shift rotation; develop SOP checklists	Reduced errors, consistent work quality, lower rework cost
Special Causes – Machine / Tools	Worn-out tools, improper use of machines	TPM (Total Productive Maintenance), 5S	Schedule preventive maintenance; proper labeling & storage of tools	Increased equipment reliability, reduced downtime
Special Causes – Method / Process	Reactive maintenance, poor vendor coordination	Kaizen, Standard Work, Visual Management	Standardize repair steps; improve vendor communication; implement preventive checklists	Faster turnaround, fewer unplanned repairs
Special Causes – Measurement / Data	Poor trend analysis, inconsistent reporting	Visual Management, Dashboards	Implement real-time dashboards; track component failure trends	Better decision- making, early problem detection
Special Causes – Material / Parts	Late supply, damaged or out-of-spec parts	Kanban, Supplier Scorecard	Implement Kanban for critical parts; monitor supplier quality	Reduced stockouts, fewer emergency procurements

Action Plan for Low Hanging Fruits

Focus Area	Issues Identified	Lean Tool / Approach	Action	Expected Benefit
Muda (Waste)	Rework, excess motion, waiting for parts	5S, Value Stream Mapping	Streamline material flow; reorganize workshop; pre-stage parts	Reduced waste, lower labor cost, faster turnaround
Mura (Variation)	Variable repair times, inconsistent vendor quality	Standard Work, SMED	Standardize work steps; introduce quick-change procedures	Reduced variation, predictable maintenance cost
Muri (Overload)	Overburdened technicians, overloaded machines	Workload Balancing, Job Rotation	Redistribute tasks; cross-train staff	Prevent burnout, improve quality, reduce errors
8 Wastes (TIMWOOD)	Transportation, Inventory, Motion, Waiting, Overproduction, Overprocessing, Defects, Underutilized talent	Lean tools (5S, Kanban, TPM, Standard Work)	Apply targeted lean solutions for each waste	Cost reduction, improved process efficiency, lower over & above costs

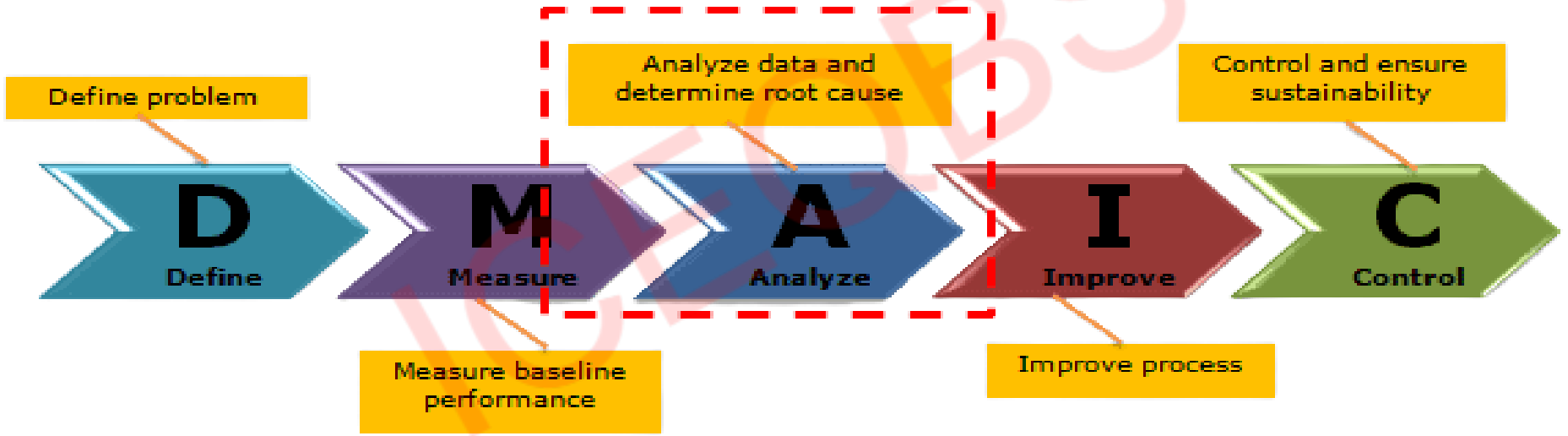
Top 12 Prioritized Root Causes (Based on Net Score)

Rank	Root Cause	Net Score
1	Technicians not following SOPs	243
2	Poor vendor repair quality	210
3	Lack of preventive maintenance	195
4	Errors in component installation	180
5	Fatigue / understaffing	150
6	Incomplete / outdated procedures	150
7	Reactive maintenance approach	150
8	Parts supplied late / out-of-spec	150
9	Worn-out / faulty tools	90
10	Lack of specialized tools	55
11	Improper storage of components	49
12	Inaccurate failure rate recording	49

Data Collection Plan

S.No	Root Cause / Input (X)	Data to Collect	Data Source	Collection Method	Frequency / Sample Size	Responsible Person	Notes / Comments
1	Technicians not following SOPs	Number of SOP deviations per check	Maintenance logs, QA reports	Observation, checklist review	All aircraft checks for 3 months	Quality Lead	Record type of deviation
2	Fatigue / understaffing	Staff shift hours vs workload	HR / Shift schedule	Observation, timesheets	Monthly review for all shifts	Maintenance Planner	Track overtime and understaffed shifts
3	Errors in component installation	Number of installation errors	QA / Maintenance reports	Audit, inspection	Each check, 10 components per aircraft	QA Team	Record severity of errors
4	Worn-out / faulty tools	Tool calibration status & breakdowns	Workshop logs	Inspection & log review	Weekly	Workshop Supervisor	Tag defective tools
5	Lack of specialized tools	Number of jobs delayed due to missing tools	Work order logs	Observation	Monthly	Maintenance Lead	Record delay duration
6	Incomplete / outdated procedures	Number of non-standard procedures used	SOP documentation, maintenance records	Document review	Monthly	Engineering Lead	Compare SOP vs actual process
7	Reactive maintenance approach	Number of unplanned repairs	Maintenance history	Report analysis	6 months retrospective	Project Lead	Identify recurring unplanned repairs
8	Poor vendor repair quality	Number of vendor rejections / delays	Vendor reports, invoices	Record review	Each vendor job	Vendor Liaison	Include turnaround time and defects
9	Parts supplied late / out-of-spec	Delay days, non-conformance reports	Inventory & procurement logs	System data extraction	All critical parts for 3 months	Materials Lead	Track cost impact
10	Improper storage of components	Number of damaged components	Inventory inspection	Physical inspection	Weekly	Materials Lead	Record type and cause of damage
11	Inaccurate failure rate recording	Discrepancies in reported vs actual failures	Maintenance database	Audit & cross-check	Monthly	QA / Data Analyst	Ensure consistency with actual inspections
12	Lack of preventive	Number of missed preventive	Preventive maintenance	Checklist review	Monthly	Maintenance Planner	Track tasks vs plan

ANALYSE PHASE



Analyse – Hypothesis testing

Regression Equation

Maintenance_Cost_Overrun_% = 10.50 + 0.5257 SOP_NonCompliance_% + 0.6414 Vendor_ReFail_30d_% - 0.3001 PM_Compliance_%

Coefficients

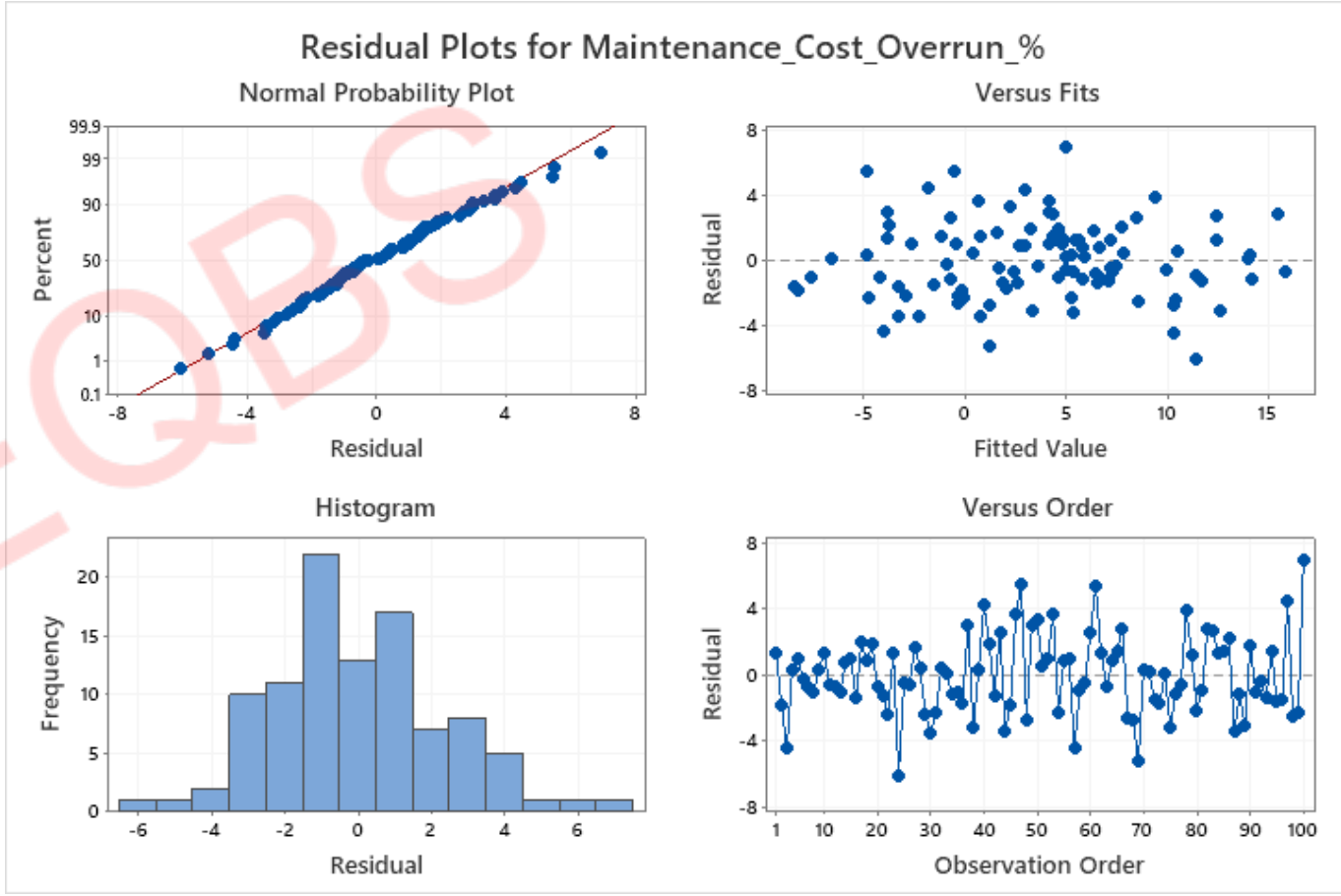
Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	10.50	1.88	5.59	0.000	
SOP_NonCompliance_%	0.5257	0.0403	13.03	0.000	1.03
Vendor_ReFail_30d_%	0.6414	0.0509	12.60	0.000	1.01
PM_Compliance_%	-0.3001	0.0230	-13.03	0.000	1.03

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
2.42846	84.35%	83.86%	82.94%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	3	3050.8	1016.94	172.44	0.000
SOP_NonCompliance_%	1	1001.3	1001.34	169.79	0.000
Vendor_ReFail_30d_%	1	936.5	936.48	158.79	0.000
PM_Compliance_%	1	1001.7	1001.75	169.86	0.000
Error	96	566.2	5.90		
Total	99	3617.0			

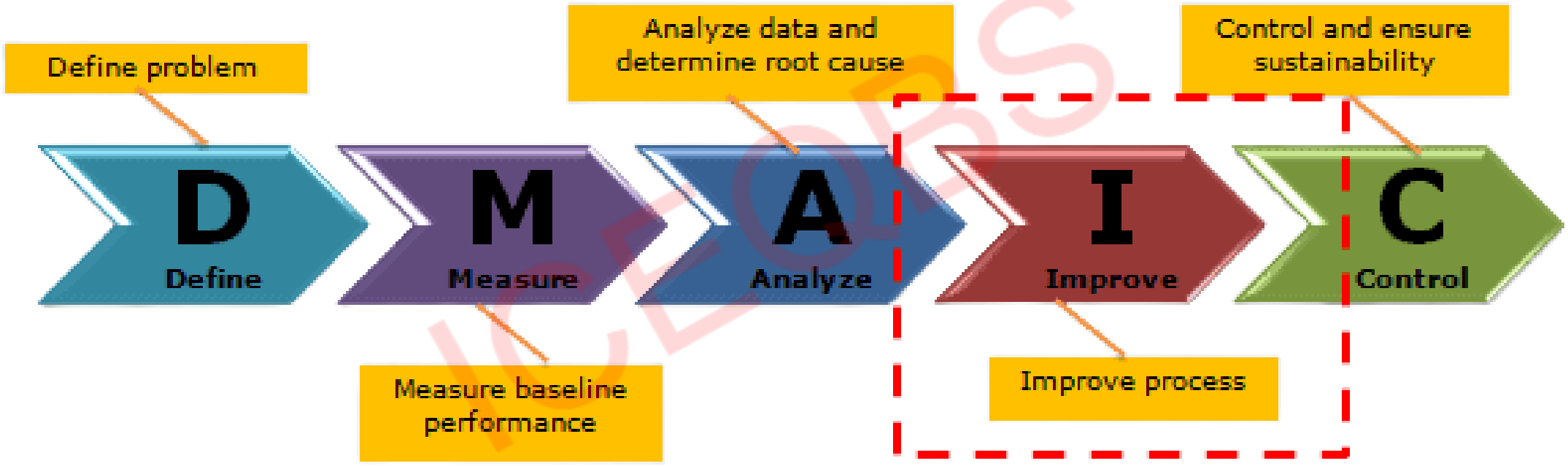


Inference :

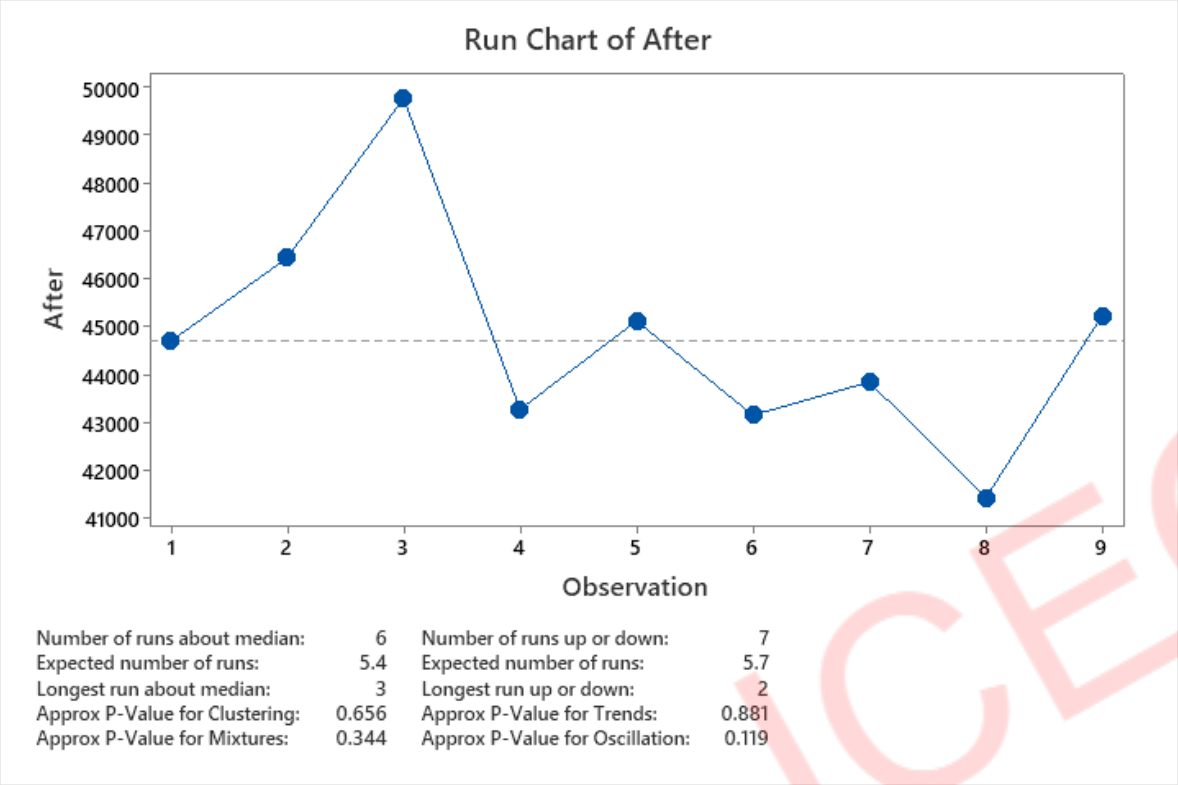
- Since $p < 0.05$, thus not all means are equal

Summary of Statistically validated Root causes

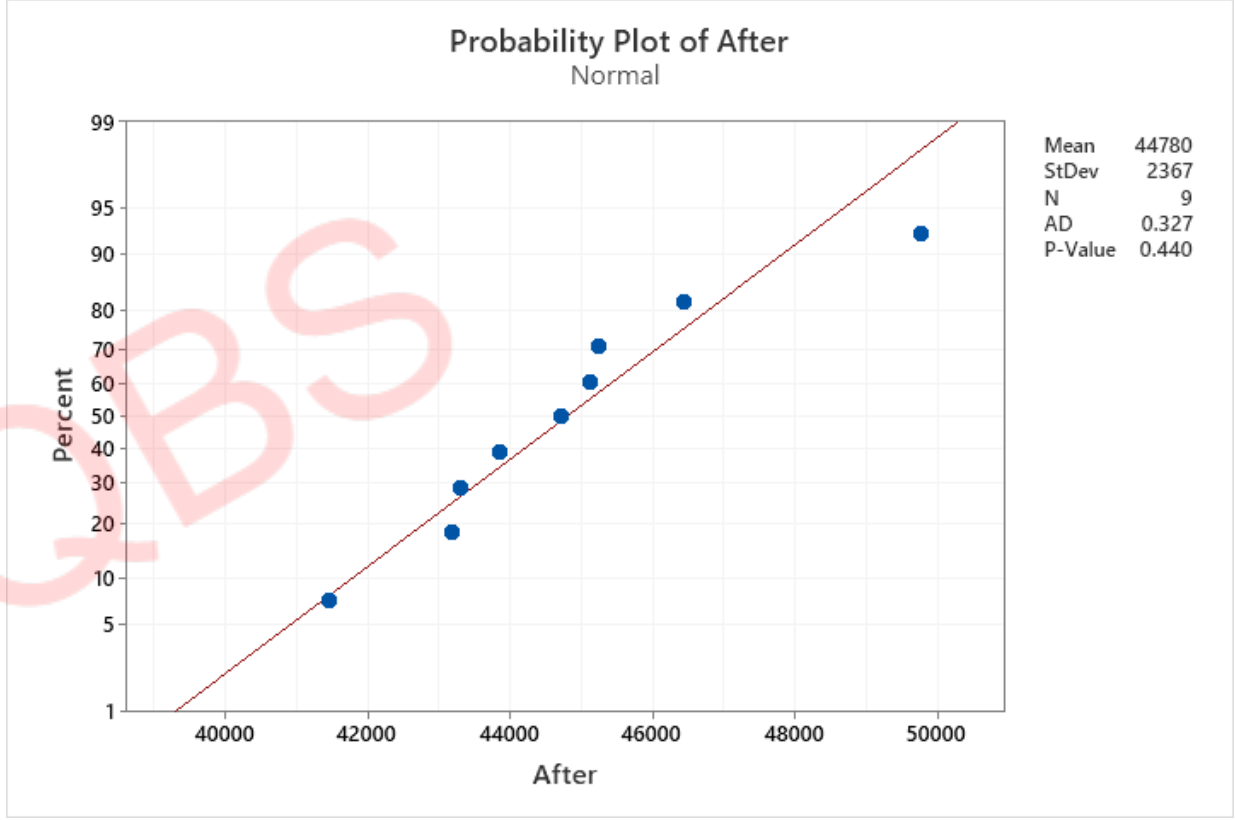
IMPROVE PHASE



Improve – Run chart and Normality Test (After Improvement)



Number of runs about median:	6	Number of runs up or down:	7
Expected number of runs:	5.4	Expected number of runs:	5.7
Longest run about median:	3	Longest run up or down:	2
Approx P-Value for Clustering:	0.656	Approx P-Value for Trends:	0.881
Approx P-Value for Mixtures:	0.344	Approx P-Value for Oscillation:	0.119



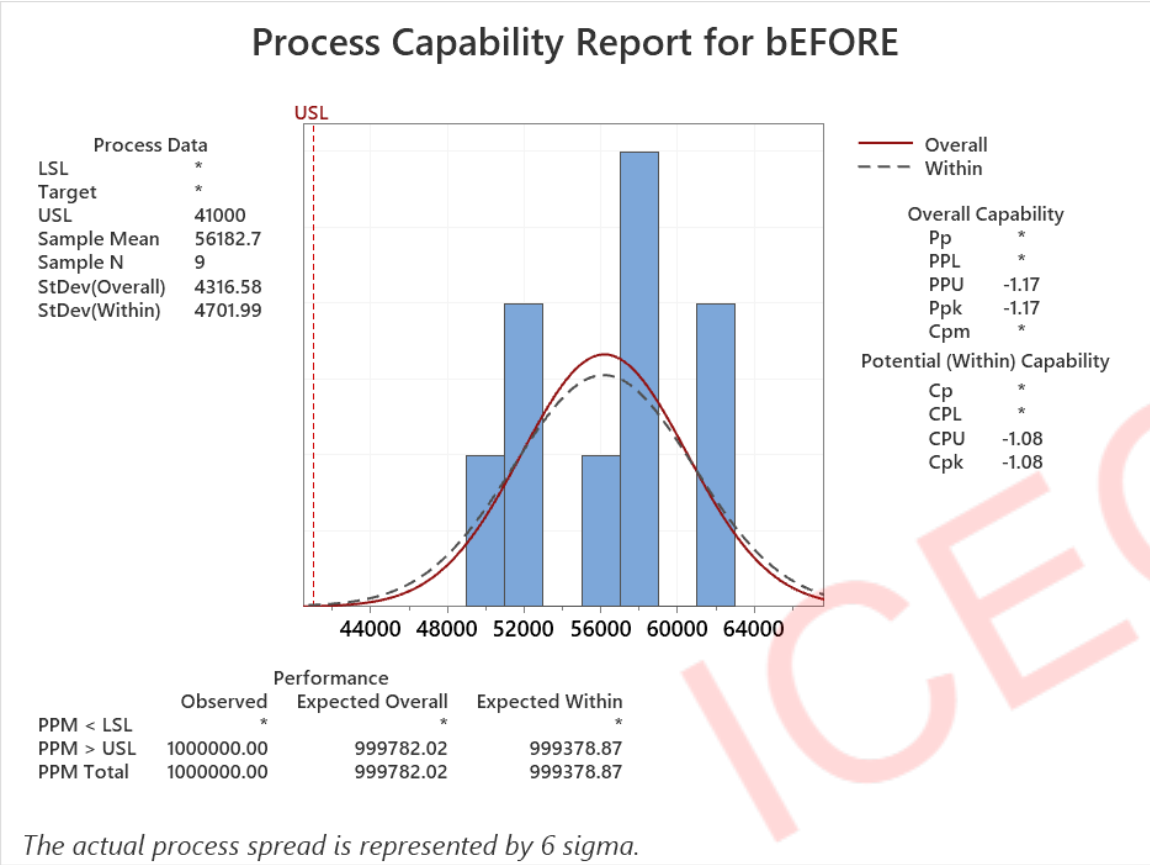
Inference:

- Run chart – process is stable there is no special causes in the process (p value > 0.05)

Inference:

- Normality test – Data are normally distributed

Improve – Process capability – Before & After Improvement



Inference :

- Before Cpk < After Cpk, which shows process is much more capable after improvement
- There is less variability in system since stdev reduced after improvement
- After improvement the data are normally distributed near the target within specified limit

Improve –After Improvement (Statistical validation for Improvement – Hypothesis Testing)

Two-Sample T-Test and CI: bEFORE, After

μ_1: population mean of bEFORE
μ_2: population mean of After
Difference: $\mu_1 - \mu_2$

Equal variances are not assumed for this analysis.

Descriptive Statistics

Sample	N	Mean	StDev	SE Mean
bEFORE	9	56183	4317	1439
After	9	44780	2367	789

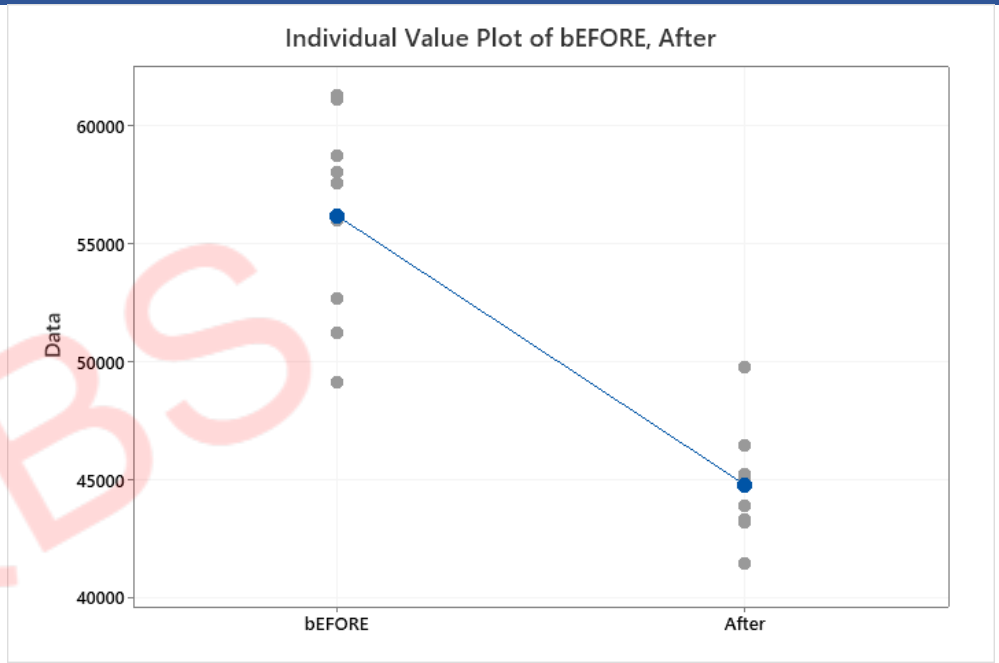
Estimation for Difference

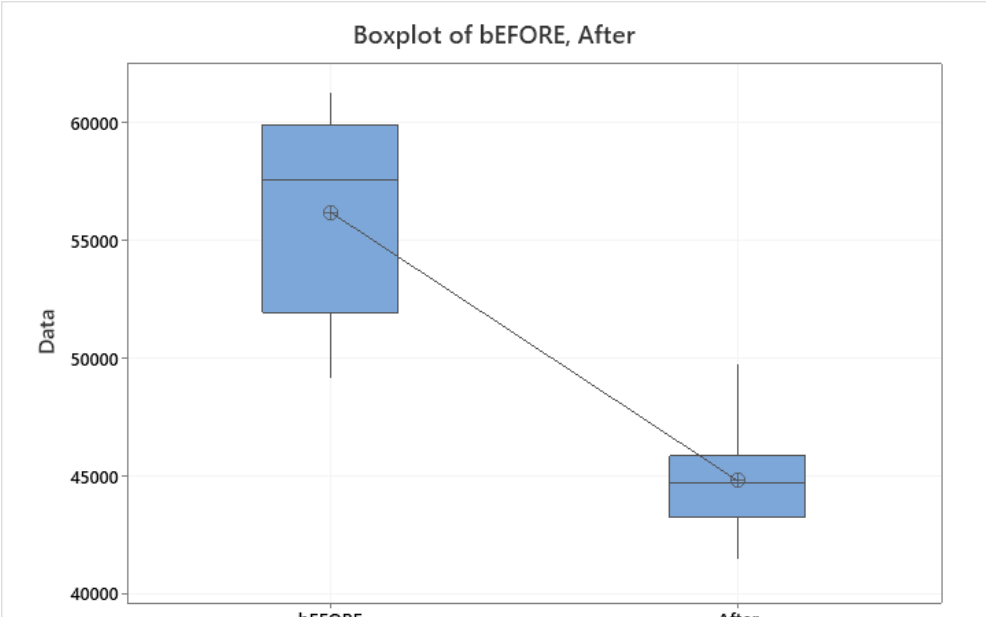
Difference	95% CI for Difference
11403	(7827, 14978)

Test

Null hypothesis	$H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis	$H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
6.95	12	0.000





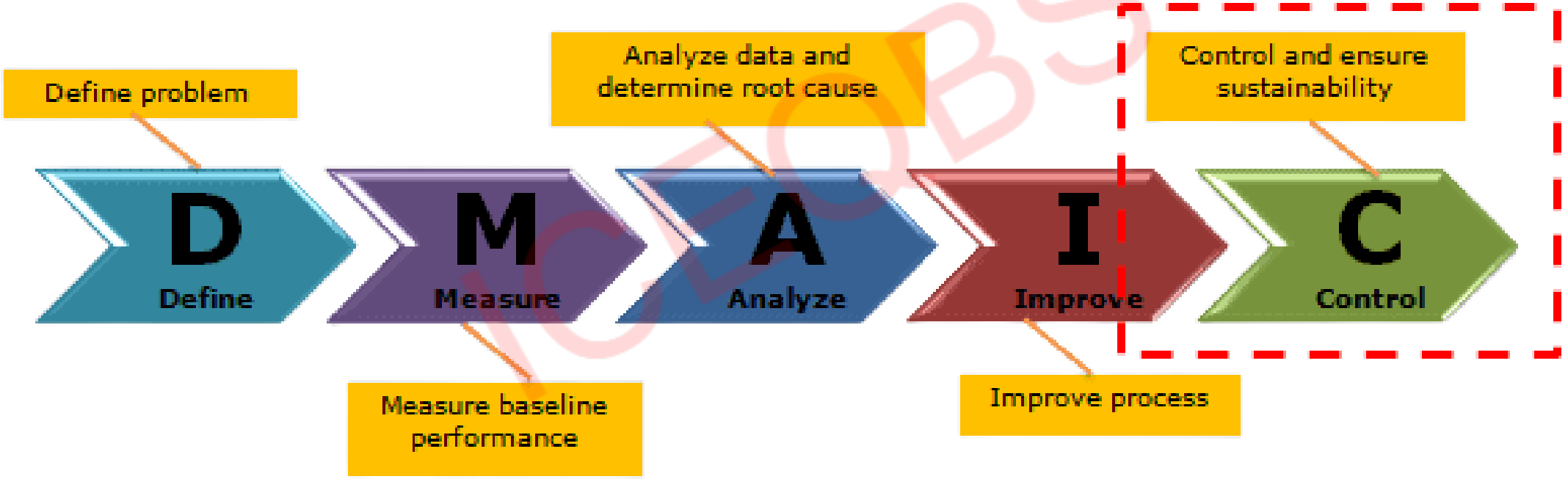
Inference:

- **Since P value is less than 0.05, there is enough evidence to reject the null hypothesis and we can conclude that the difference between the population means is statistically significant.**
- **It is also visible from the individual value plot & box plot, there is clear difference in mean after improvement which is closer to required % scrap**

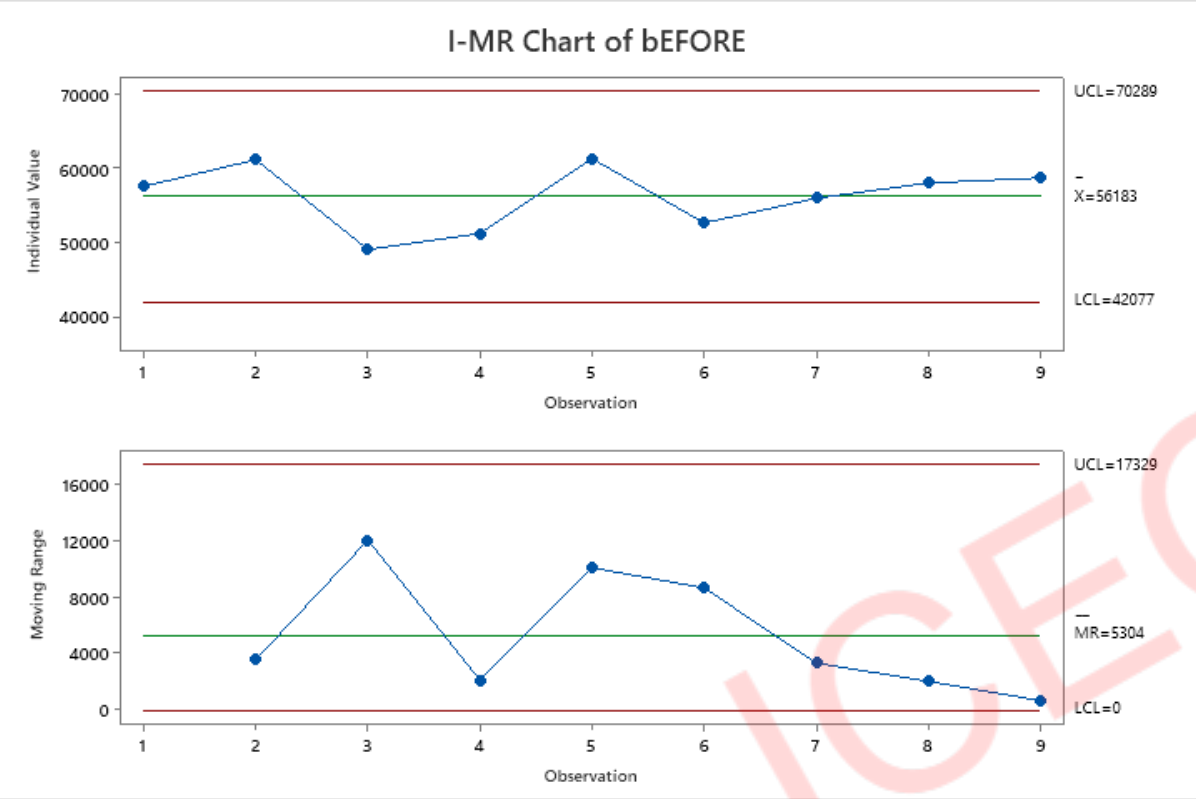
FMEA

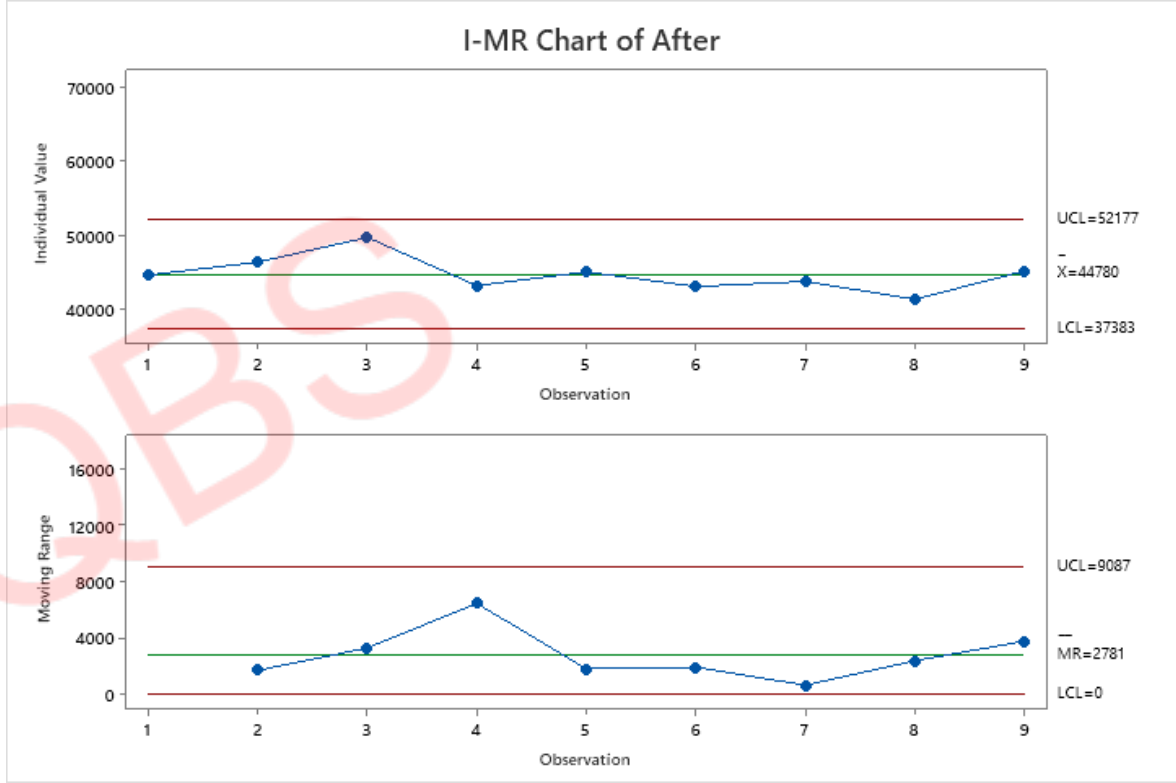
Process Step / Action	Potential Failure Mode	Effect of Failure	Severity (S)	Potential Cause	Occurrence (O)	Current Control	Detection (D)	RPN (S×O×D)	Recommended Action
SOP Compliance Enforcement	Technician skips steps	Increased maintenance cost, rework	9	Lack of awareness, time pressure	6	Checklist, supervisor sign-off	5	270	Training, digital checklists, periodic audits
Vendor Repair Quality Monitoring	Vendor returns faulty parts	Repeat failures, delayed maintenanc	8	Poor vendor QC	5	Vendor certification, inspection	4	160	Implement vendor scorecard, stricter QC
Preventive Maintenance (PM) Compliance	Corrective Maintenance Recording	Incorrect or missing entries	Missed follow-up actions	7	Manual logging errors	4	Manual verification	5	140	Digital logging, validation by supervisor
	Part Availability	Late or OOS parts	Work stoppages, delays	8	Poor inventory management	6	Stock monitoring	4	192	Safety stock, reorder alerts, inventory dashboard
	Installation Errors	Incorrect installation	Rework, increased downtime	9	Lack of training, complex procedure	5	Supervisor inspection	4	180	Error-proof tools (Poka-Yoke), training
	Overtime Management	Overworked technicians causing mistakes	Reduced quality, higher cost	6	Excessive workload	4	Work-hour monitoring	3	72	Optimize scheduling, additional staffing

CONTROL PHASE



Improve (Statistical validation for Improvement – I-MR Chart)





Inference:

- As seen in control chart, before improvement mean was high and there was high variability in the **Scrap reduction** and after improvement, it has achieved to target the Scrap reduction
- There is a significant reduction in Scrap reduction

Control Plan

Process Step / Area	Critical Parameter	Target / Standard	Measurement Method	Frequency	Responsible Person	Control / Preventive Action
SOP Compliance	Technician adherence to SOP	100% compliance	Checklist / Audit	Daily / Weekly	Maintenance Supervisor	Periodic audits, digital SOP checklists, reminder alerts
Vendor Repair Quality	Vendor repair success rate	≥ 95% pass rate	Vendor inspection / QA report	Per delivery / Monthly	Procurement & QA Team	Vendor scorecards, pre-approval checks, feedback meetings
Preventive Maintenance (PM)	PM completion on schedule	100% on-time completion	PM schedule tracking system	Daily / Weekly	Maintenance Planner	Automated PM alerts, escalation for missed tasks
Installation Accuracy	Installation error rate	≤ 2 errors per 100 installations	Inspection / Error logs	Per job / Weekly	Lead Technician	Poka-Yoke tools, peer review, supervisor sign-off
Process Step / Area	Critical Parameter	Target / Standard	Measurement Method	Frequency	Responsible Person	Control / Preventive Action
						inventory dashboard
Overtime Management	Overtime hours per technician	≤ Standard working hours	Timesheet / HR report	Weekly	Maintenance Manager	Load balancing, shift scheduling, hire temporary staff if needed
Continuous Improvement	Reduction in Maintenance Cost Overrun %	Reduce by X% (baseline: 13%)	Monthly financial report	Monthly	Maintenance Manager / Team	Review meetings, action item follow-up, update control plan

Conclusion

Results after improvement

- **Project has achieved its intended results after improving thickness by identifying the variation cause and reducing scrap rate.**