10G Optical Transponder Defect Reduction
Six Sigma Black Belt Project

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Business Problem Overview

- Problem Statement

  Data from past six months shows that approximately 40% of the 10G Transponders failed testing.

  High rework levels, increased operating costs, lost revenue and low customer satisfaction when defective products are delivered to customers.

- Project Objective

  Investigate the root cause of the defects, reduce defect losses, rework and warranty costs by reducing test failures on production line from 40% to 20% by December 2007.

Executive Summary-Define

- Project selection tied to strategic and operational business needs
- Scope limited to 10G Transponder Assembly and Test Process
- Goal is to improve yield by 20%
- Projected savings of $500K over 12 months
- Resources available for project $80,000

- Define Phase Tools
  - Project Charter
  - Financial Analysis
  - Risk Assessment
  - Stakeholder Analysis
  - Gantt Chart
  - SIPOC
  - VOC

Financial Analysis Summary

Goals and Benefits

Defect Levels/Goals:

	Date	DPMO(lt)	Zbench(st)
Baseline	6/8/2007	66555	
Goal	8/31/2007	33000	
Stretch Goal	12/31/2007	25000	

Estimated Financial Benefits:

Hard Savings	$500,000
Soft Savings	$100,000
Implementation Costs	$80,000

Based on how many months: 12

Voice Of The Customer (VOC)

Voice of the External Customer	The "Why"	Critical Customer Requirement
"We always have problems with your company".	Product shipping delays	Product Shipped within 7 days of delivery appointment.
"We are going to cancel your contract. Your quality sucks".	High out of box failures.	Less than 1% Out of Box Failures.
"You never send us our product back".	High turnaround time for RMAs.	1 day Turnaround time.

Voice of the Internal Customer	The "Why"	Critical Customer Requirement
"Assemblies constantly failing".	Poor quality from supplier.	Overall Yield of 90% required.
"Shipping dates missed."	Long rework time.	Overall Yield of 90% required.
"Material/Parts not available".	Production parts used for rework.	Stock repair parts at 5% of forecast.
'Boards must work when pluged in.'	High board failures from CM	Overall Yield of 90% required

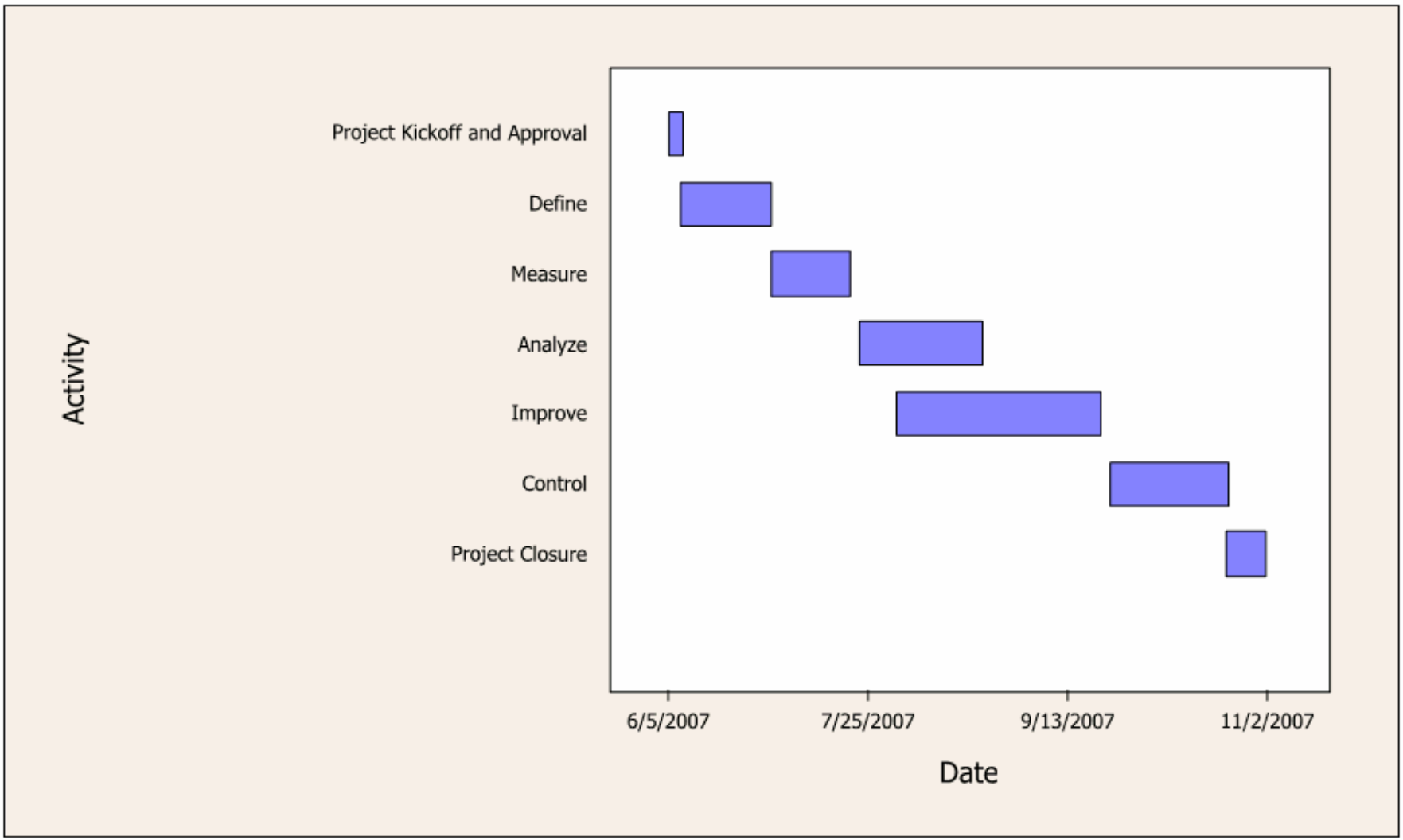
SIPOC

Suppliers	Inputs	
	Description	Requirements
Equipment Manufacturer	Optical Splicer/Cleavers	Maintenance - Calibration every 15 Days
Contract Manufacturer	Lasers/Assembly Boards	7 Weeks lead Time/2 WeekDays
Assembly supervisor	Labor (Test/Assember/Splicer/Reapir)	5 Employees 40hr/wk
Material Management	Weekly Forecast	Stock Material 5% of forecast

Process
Receive Unit from CM
Incoming inspection
Fiber Assembly
Board Level test
Burn in Test
Repair
Ship to Final Customers

Outputs		Customers
Description	Requirements	
Failed Units	Repair to meet specs/Test	Manufacturer Repair/Rework
Finished Goods	Meets all requirements of external customer	External Customer
Defects/ FailureReports	Track Weekly Failures/Rework Costs	Upper Managament

Project Gantt Chart

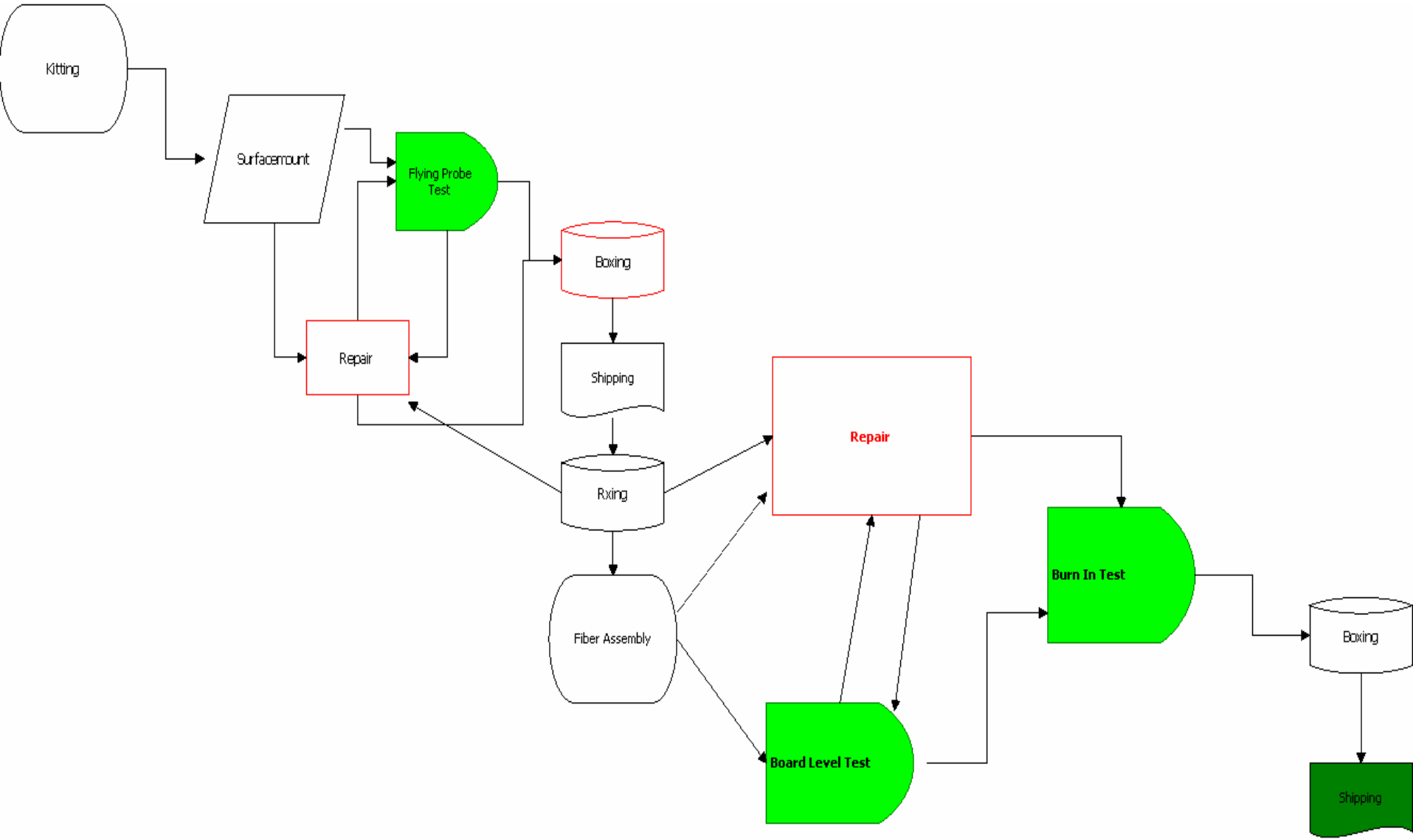


Executive Summary- Measure

- KPIVs & KPOVs identified
- CTQ
  - On Time Shipment
  - Out of box failures
  - % Defectives
  - Average Repair Cost
- Baseline DPMO 66555
- MSA conducted on defect data proved data accurate and reliable.
- Baseline capability analysis shows poor process performance

- Measure Phase Tools
  - High Level Process Map
  - Process Performance Baseline
  - KPIs Time Series
  - Histograms
  - Capability Analysis
  - Run Chart
  - Attribute Agreement Analysis

High Level Process Map



Process Performance Baseline

ROLLED THROUGHPUT YIELD (RTY)

Before				
	PRC A	PRC B	PRC C	PRC D
Initial In	100	100	100	98
Initial Out	100	100	98	98
Scrap	0	0	4	0
Rework	2	3	37	5
True Yield	0.98	0.97	0.58	0.94
Rolled Throughput Yield	**.52**			

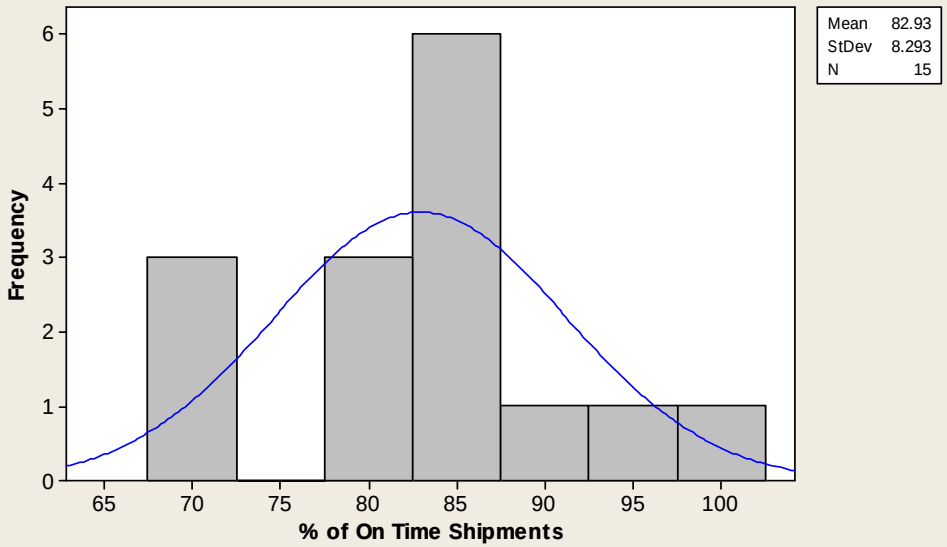
Defects Per Unit (DPU)

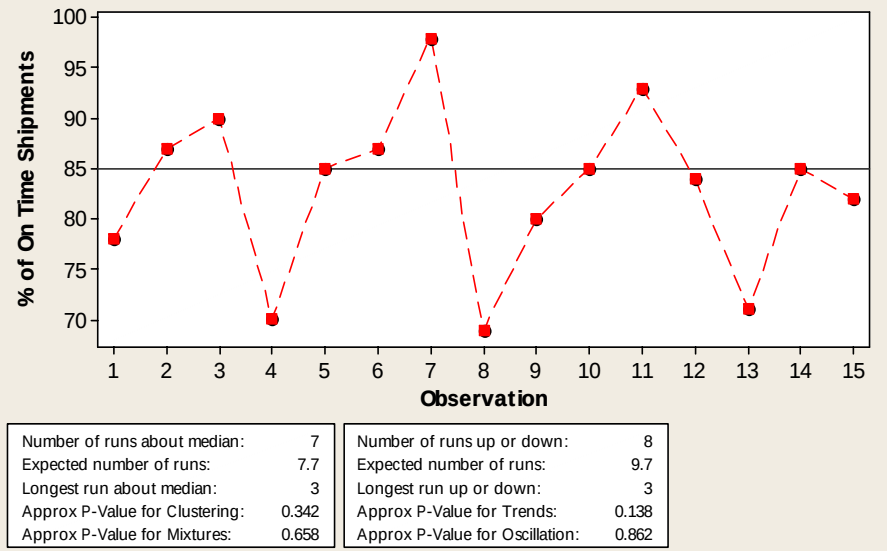
Before	
Total Assemblies	2096
Defects	837
DPU	.39

Defects Per Million Opportunities (DPMO)

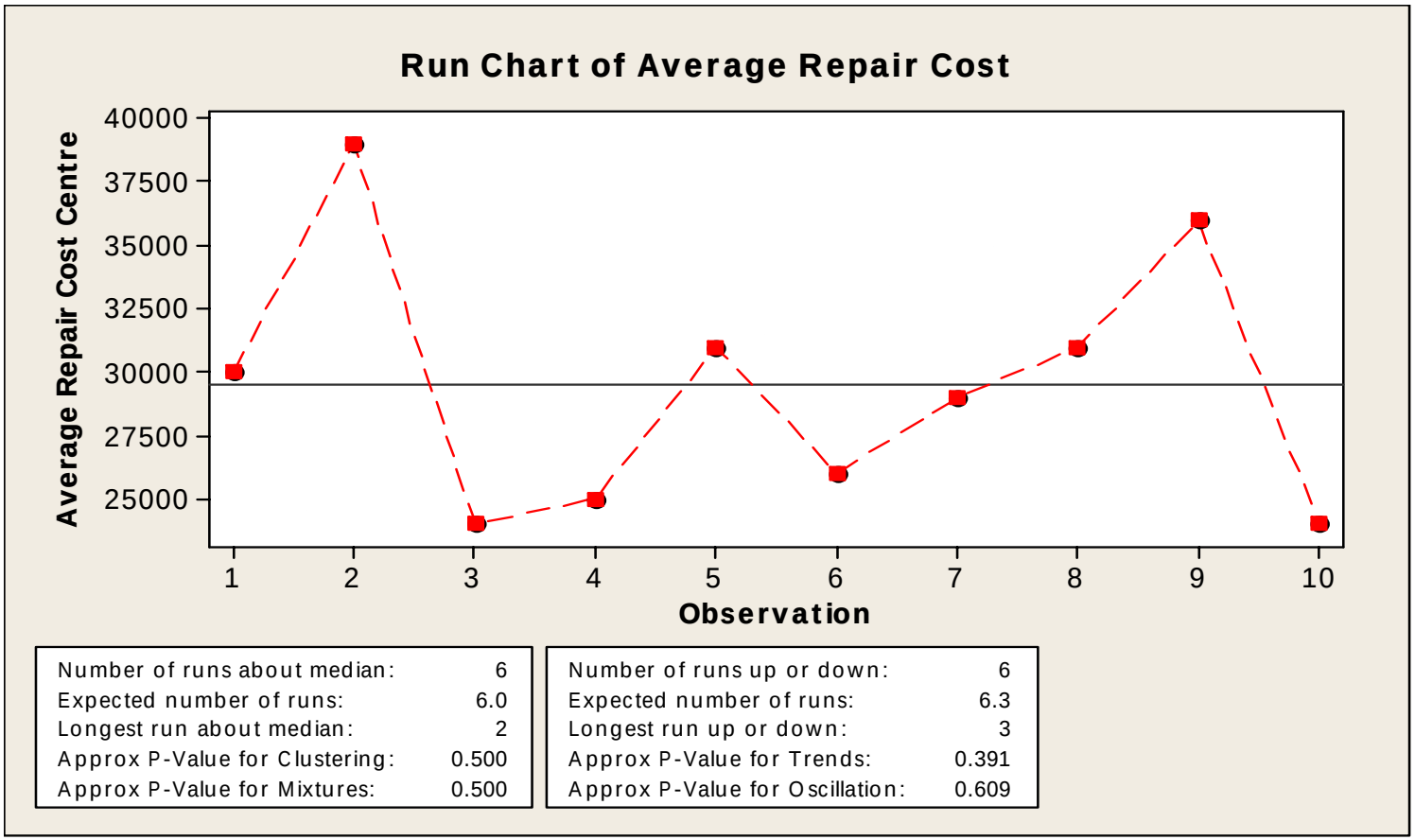
Before	
Total Opportunities	12576
Defects	837
DPMO	66555
Z or Sigma Level	1.5

CTQ- On Time Shipment

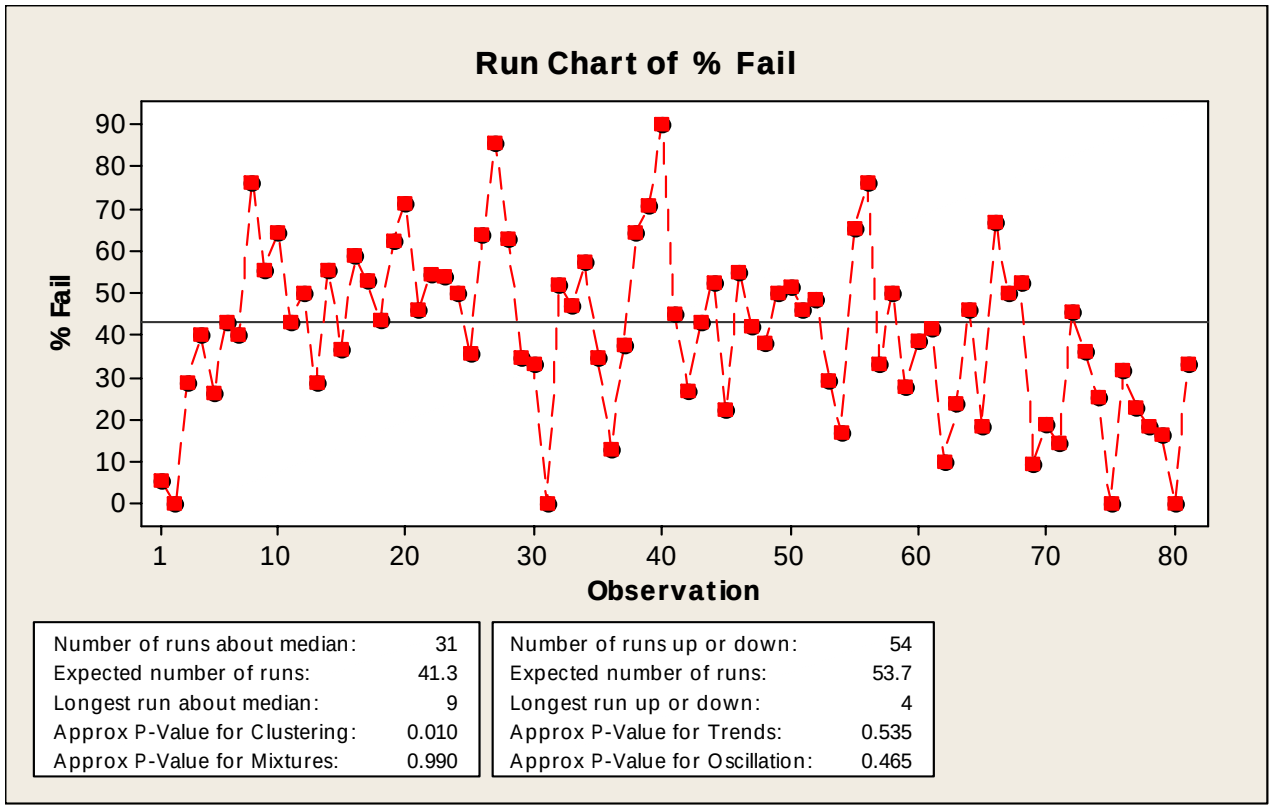




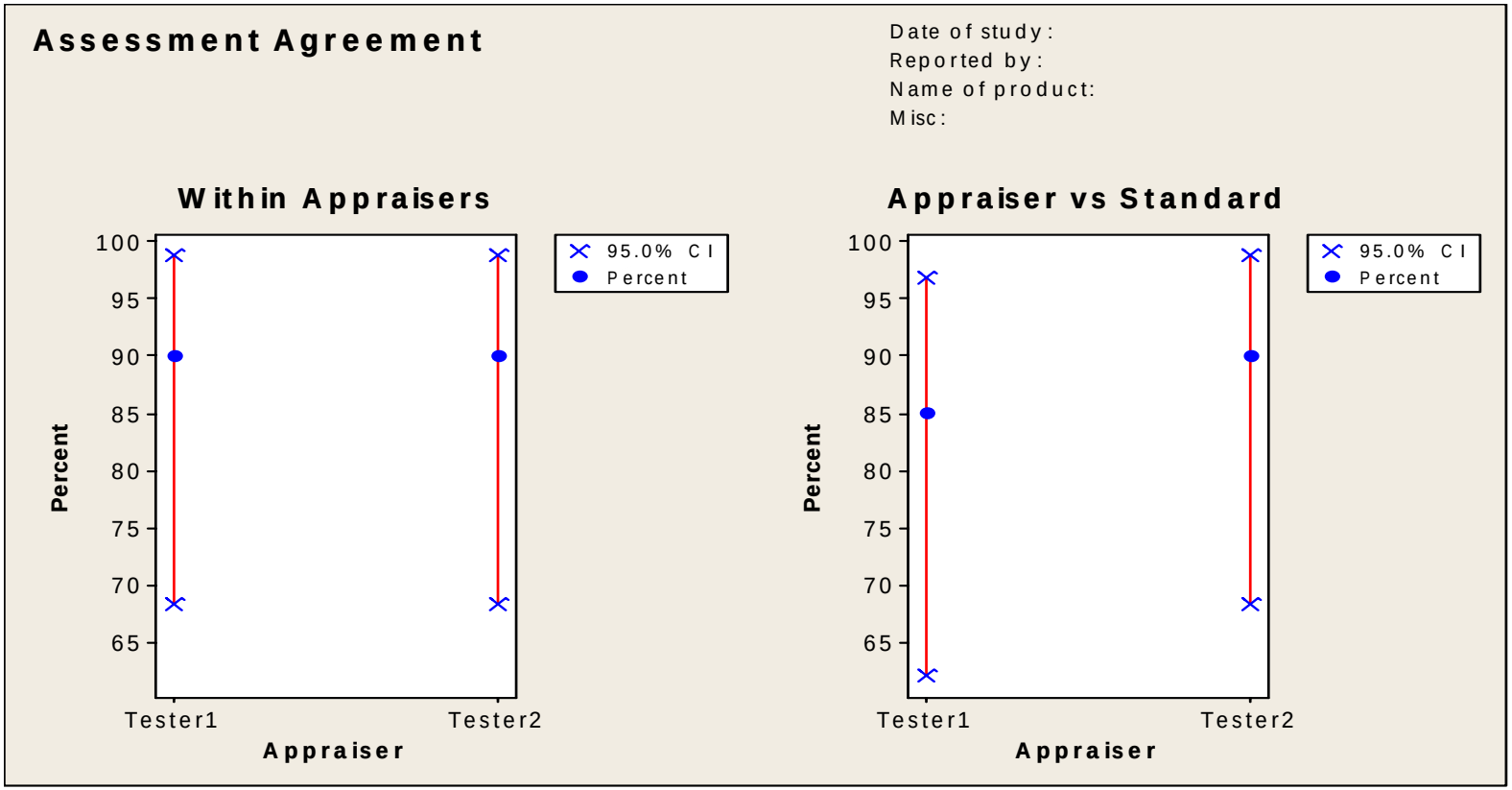
CTQ- Repair Cost



CTQ- Yield (% Defective)



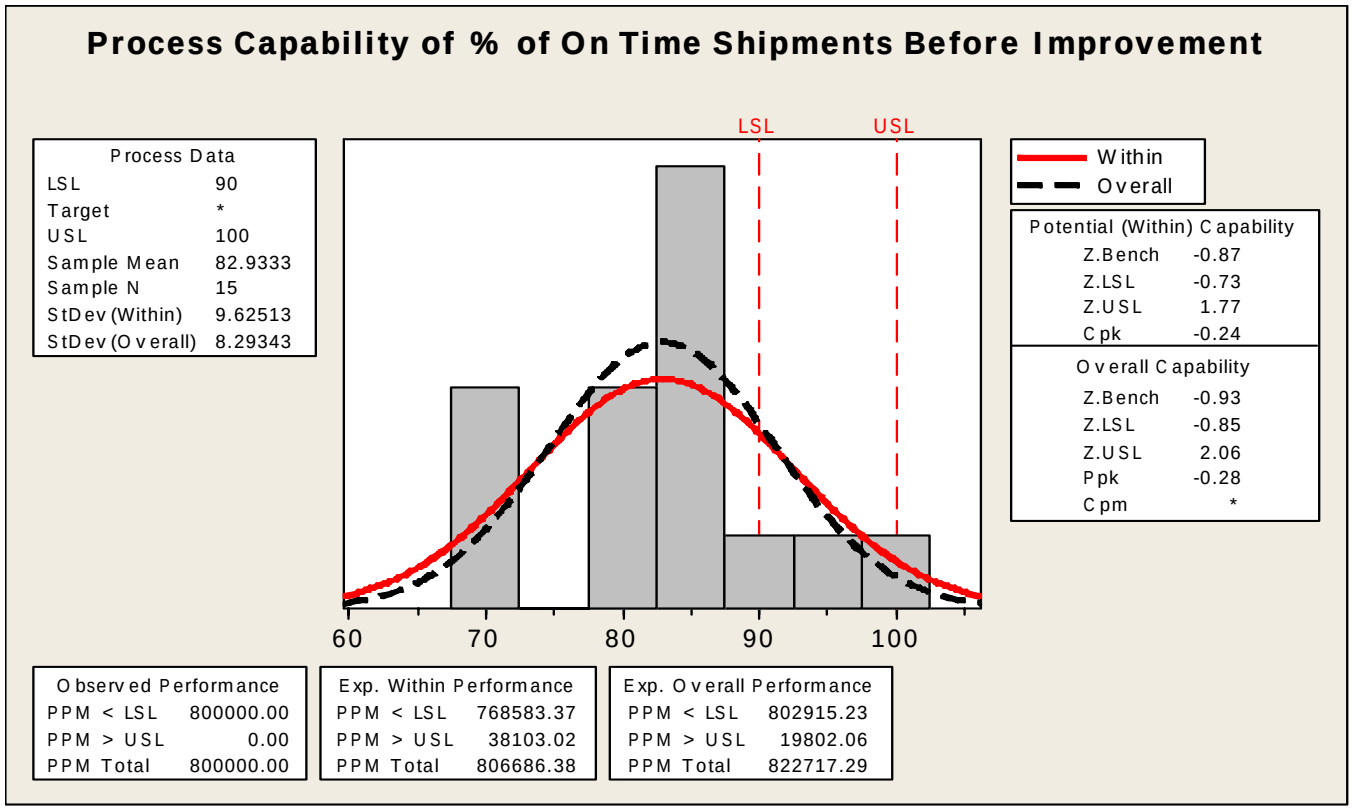
Attribute Agreement Analysis (MSA)



Attribute Agreement for testers with same lot of defective product.

% Agreement of "All Appraisers vs. Standard" 85%

Baseline Capability On Time Shipment

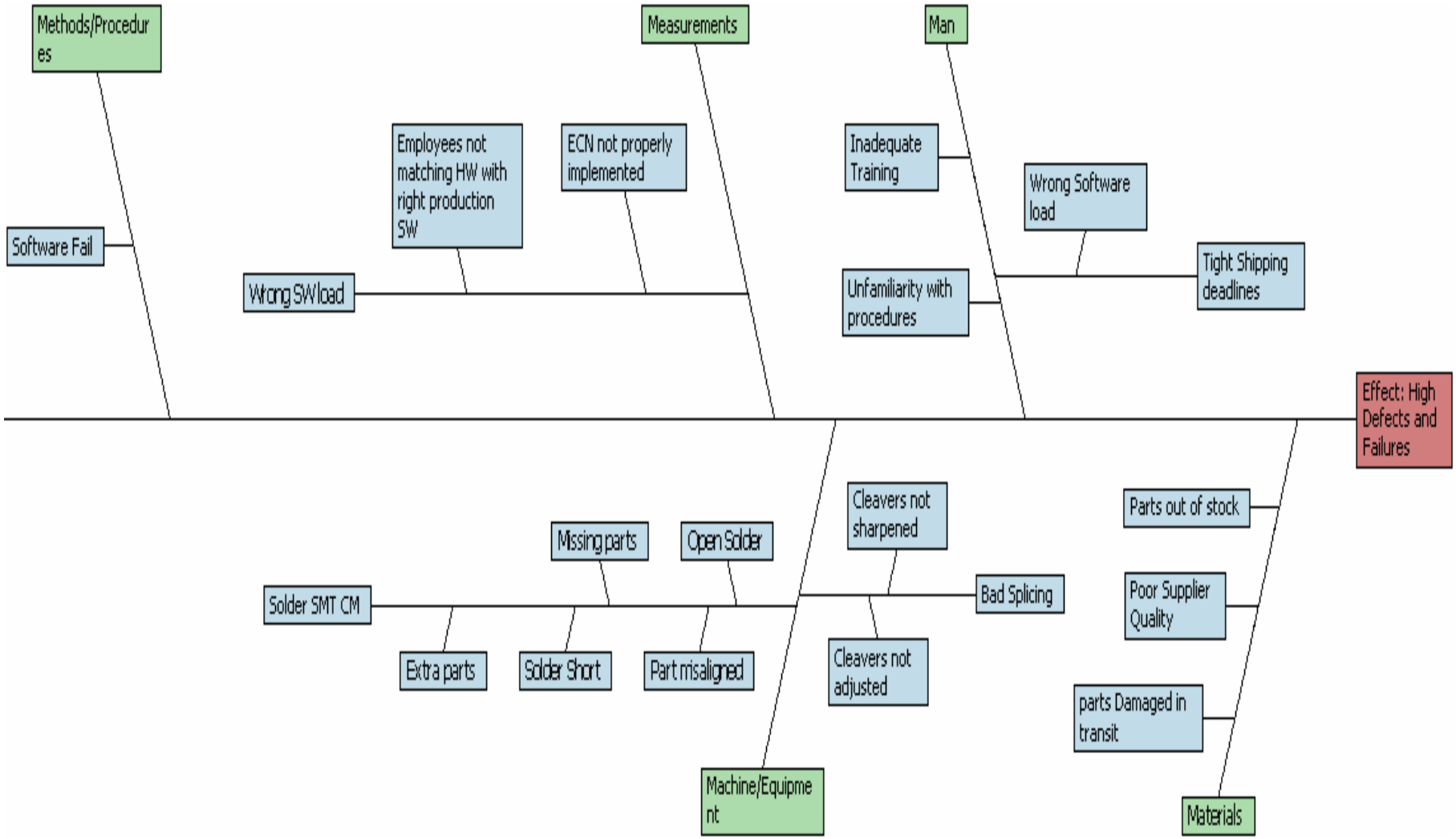


Executive Summary-Analyze

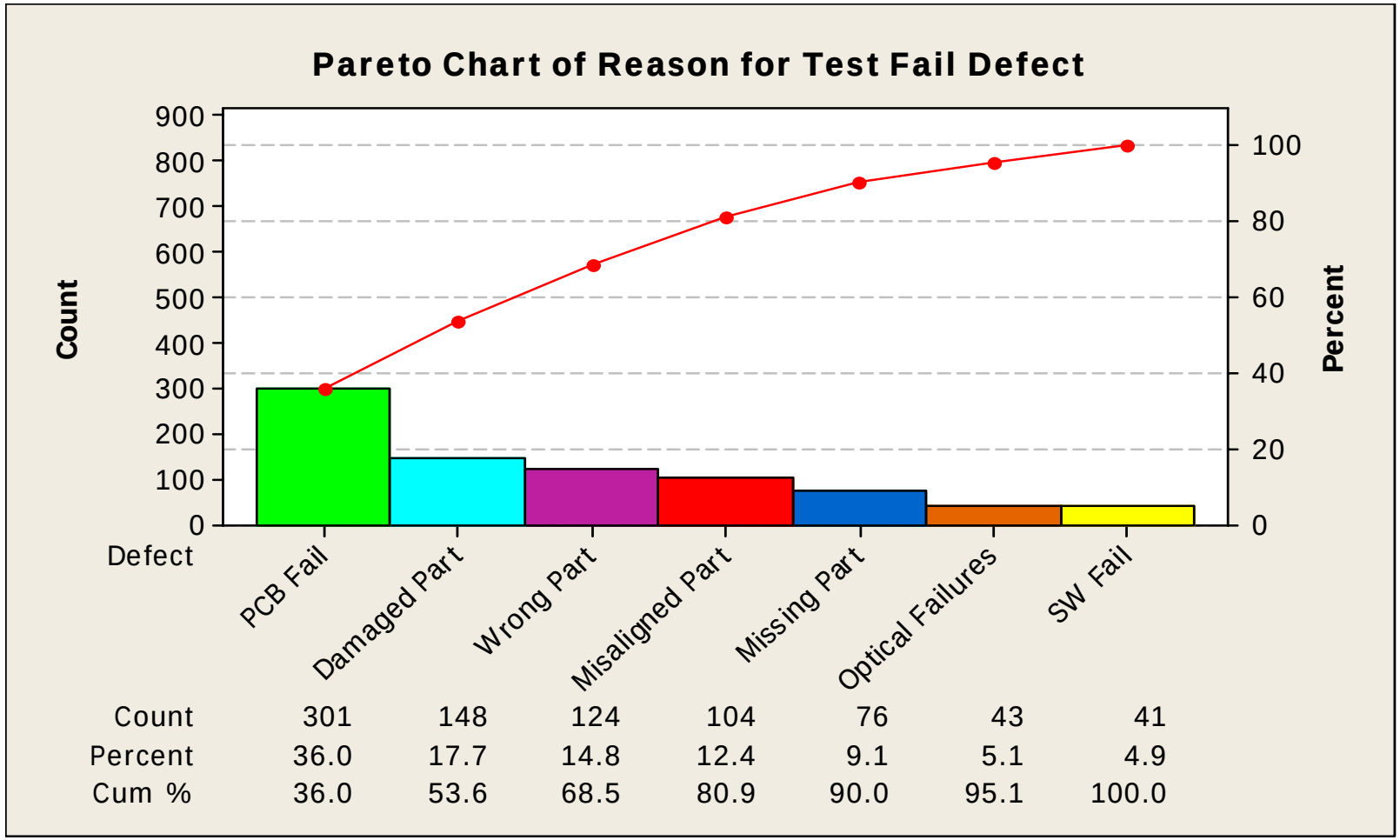
- Analyzed defect data for root cause analysis about critical inputs
- Both qualitative and quantitative data analysis was conducted.
- FMEA and Pareto used to prioritize root causes

- Analyze Phase Tools
  - Pareto chart
  - Ishikawa Fishbone
  - FMEA
  - DOE

Ishikawa Fishbone



Pareto Chart Analysis



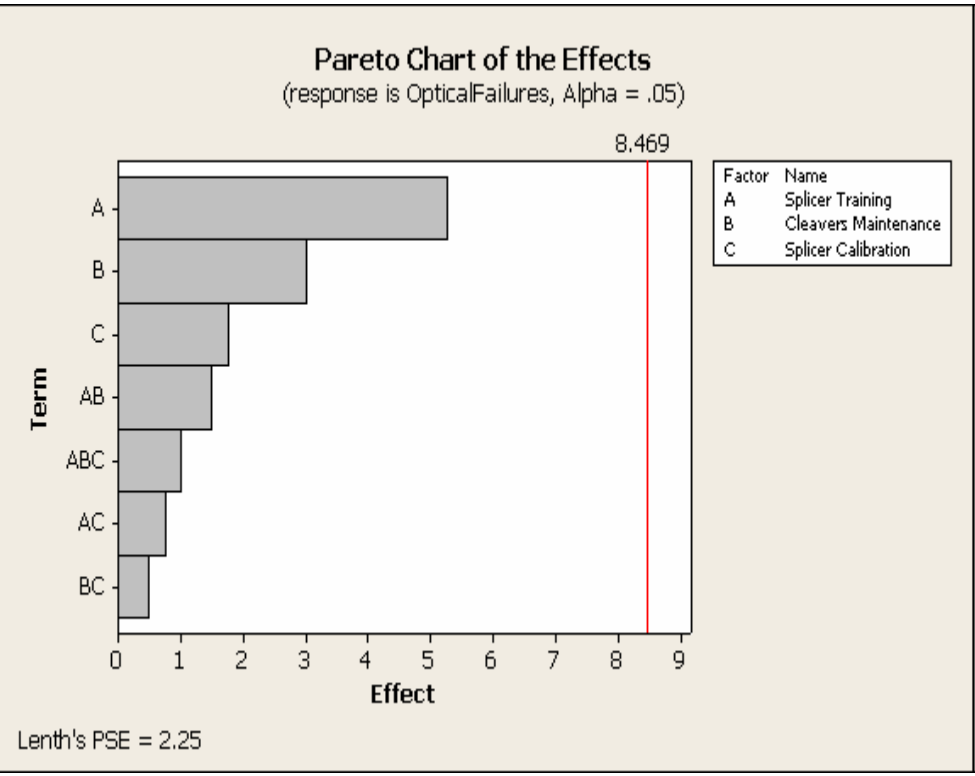
Process FMEA

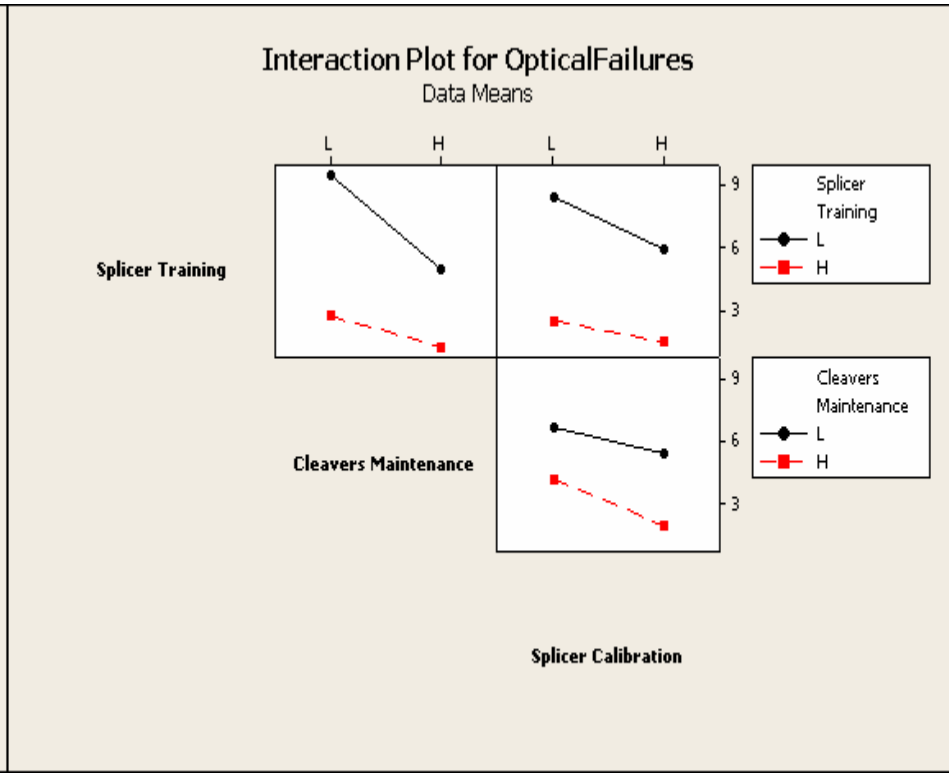
Step#	Process Map - Activity	Key Process Input	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Controls	DET	RPN	Actions Recommended	Responsibility
1	Receiving	Receive kits from supplier	Delayed shipment	production delays	3	Forecast errors	4	Stock 5% of forecast	3	36	Reduce forecast errors	Procurement Team
			Wrong parts in kit	production failures	5	Supplier error	5	Supplier Spec	4	100	Supplier outgoing inspection	
			Missing parts from kit	production failures	5	supplier error	5	Incoming inspection of material list (BOM)	4	100	supplier outgoing inspection	
			Damaged Parts	unusable part	8	Supplier shipping/packaging,mishandling of parts/Supplier Quality	7	No Control	7	392	Suppler packaging improvement project	procurement/product team
2	Fiber Assembly	Assembly labor	Scheduling conflicts	production delays	3	Forecast errors, drop-ins, RMAs	6	Materials Manager	8	144		
			Poor workmanship	High failures/rework	6	Inadequate training, poor equipment, no equipment	5	No Control	5	150	Initial training of new hires/periodic training	HR
		Splicing	Bad splices	Rework	8	Equipment not maintained	8	No Control	8	512	Equipement maintenence training from supplier.	ProductionSupervisor

FMEA (cont'd)

Step#	Process Map - Activity	Key Process Input	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Controls	DET	RPN	Actions Recommended	Responsibility
3	Board Level Test	Assemblies ready for test	Soldering defects (short,open,misaligned parts)	High Rework, customer delays, dis-satisfaction	10	solder shorts, opens, and misaligned parts	8	Board level test, flying probe test	8	640	Supplier SMT technology improvements	
			Bad SMT material (missing, extra, damaged, or wrong parts)	High Rework, customer delays, dis-satisfaction	9	SMT placement, settings, precison	7	Flying probe test	7	441	Determine feasibility of In-circuit test	Test Engineer
			Software Failures	High Rework, customer delays, dis-satisfaction	6	Human error, incompatible sw, HW changes	2	Board level test	3	36	Determine feasibility of In-circuit test	Software Engineer Integration testing
			Defective Lasers	High Rework, customer delays, dis-satisfaction	9	Laser out of spec, wrong wavelength, tolerances wrong	2	Board level test	2	36	Laser Vendor Improvement project	
4	Burn in Test	Assemlies ready for test	Burn test failure	Rework	2	Software wrong loads	2	Burn test failures	1	4		
5	Boxing/shipping	Finished Goods	Screws loose, missing documentation	Additional time and rework for missing items	2	Rush to meet deadlines	5	No control	4	40		

DOE Optical Failures





Executive Summary-Improve

- Potential solutions generated and prioritized.
- Risk analysis conducted
- Pilot run conducted with improvements and data collected and analyzed

- Improve Phase Tools
  - Prioritization Matrix for Solutions
  - Pilot Testing
  - Implement
  - 2 Sample t-Test
  - VSM

Potential Solutions

- **Implement In Circuit Test**
- Redesign the assembly PCB
- Contract manufacturer to add new testing PCB
- New manufacturer with better quality
- **Train employees on Splicing Maintenance**
- **Change PCB handling and shipping packaging**

Prioritization Matrix for Solutions

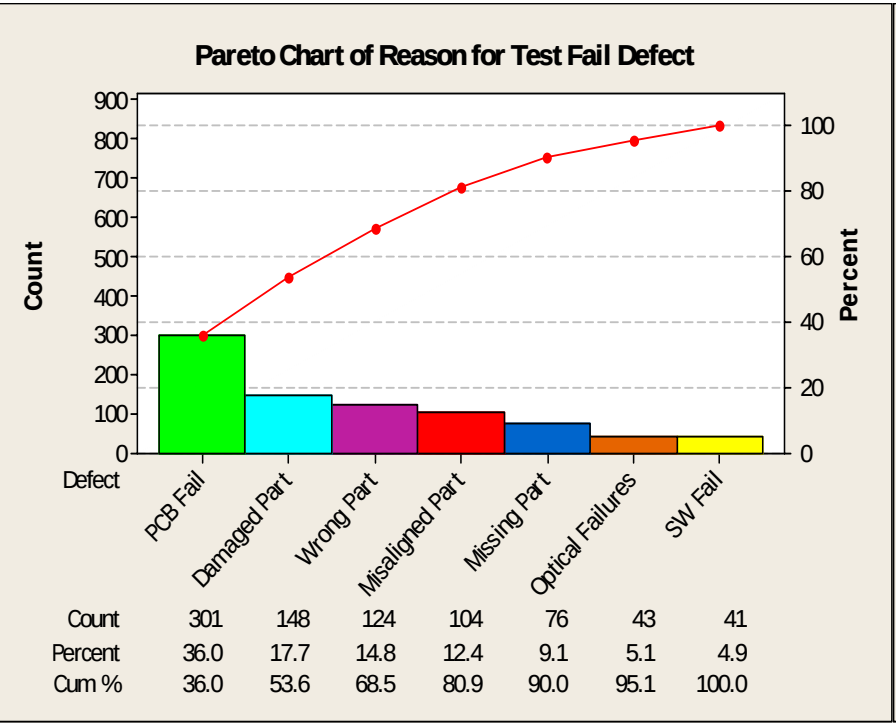
Criteria	Can be implemented Quickly	Will solve problem fully	Costs less than $50K	Won't impact customer	Low Risk	Final Weighted score	Overall Ranking
Weighting	0.09	0.48	0.13	0.21	0.09		
In Circuit Test	8	7	9	9	9	7.95	1
Redesign PCB Assembly	1	3	2	3	5	2.87	5
CM Test PCB	3	7	2	3	2	4.7	4
New CM	1	3	3	1	1	2.22	6
Train Employees Splicing	7	6	10	6	9	6.88	2
PCB Handling Packaging	5	7	4	7	9	6.61	3

Pilot Testing

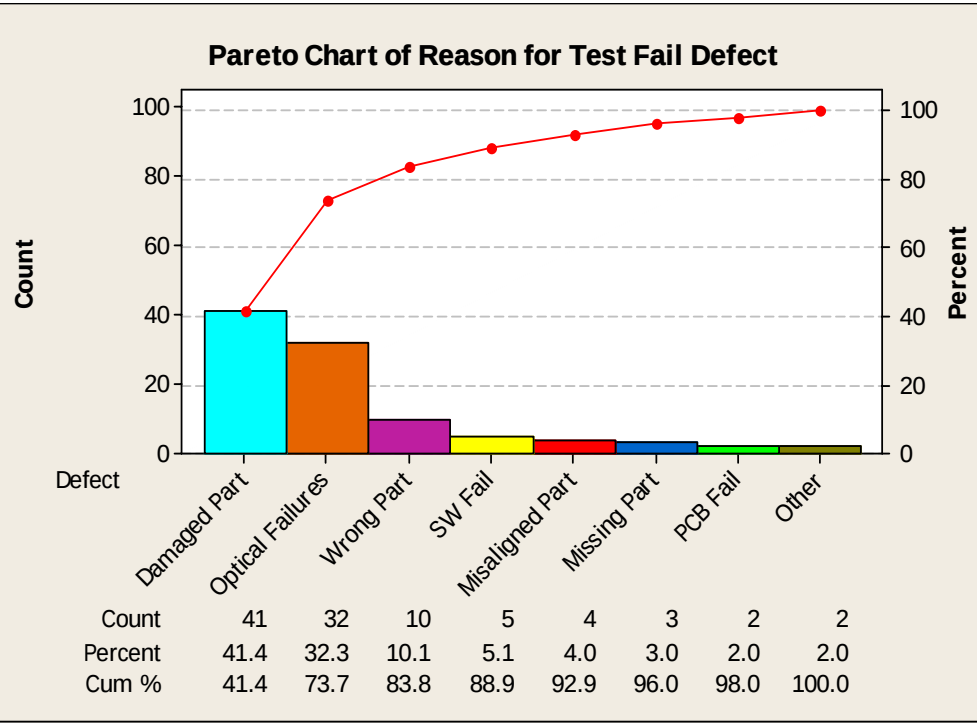
- Risk
  - Capital
  - Barriers to implementation
  - Duplicate test such as flying probe
  - Training costs
- Pilot Testing
  - 4 weeks duration
  - Data collection plan
  - Buy in from key stakeholders

Pilot Run Pareto Chart for Reason for Defect

Before

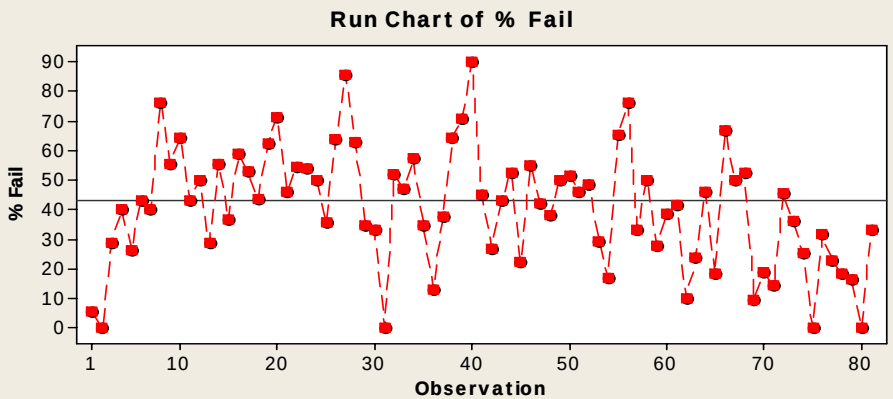


After



Pilot Run Data Analysis

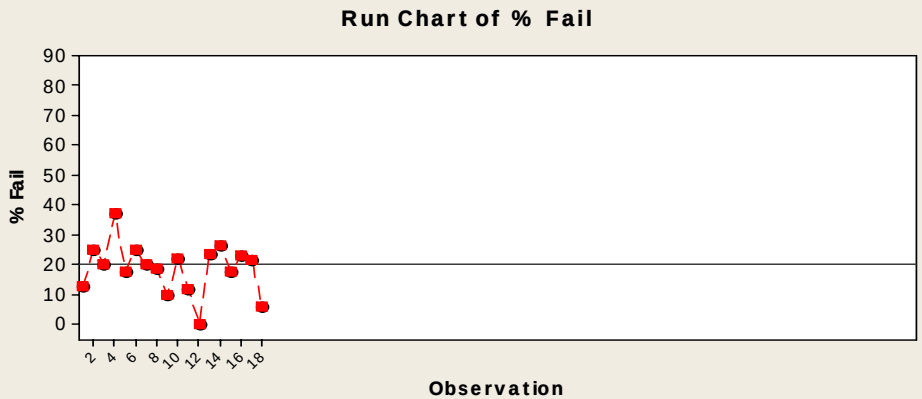
Before



Number of runs about median:	31
Expected number of runs:	41.3
Longest run about median:	9
Approx P-Value for Clustering:	0.010
Approx P-Value for Mixtures:	0.990

Number of runs up or down:	54
Expected number of runs:	53.7
Longest run up or down:	4
Approx P-Value for Trends:	0.535
Approx P-Value for Oscillation:	0.465

After

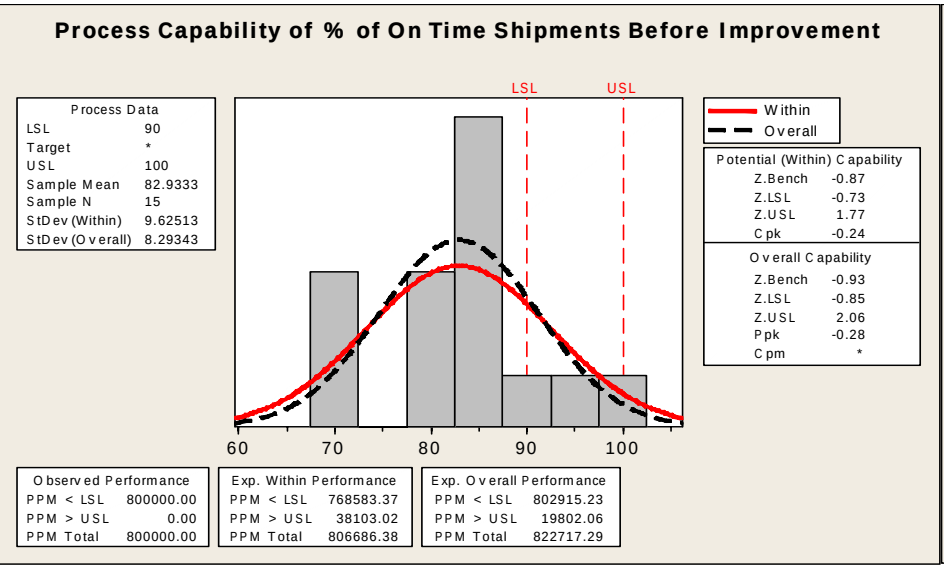


Number of runs about median:	13
Expected number of runs:	9.9
Longest run about median:	3
Approx P-Value for Clustering:	0.937
Approx P-Value for Mixtures:	0.063

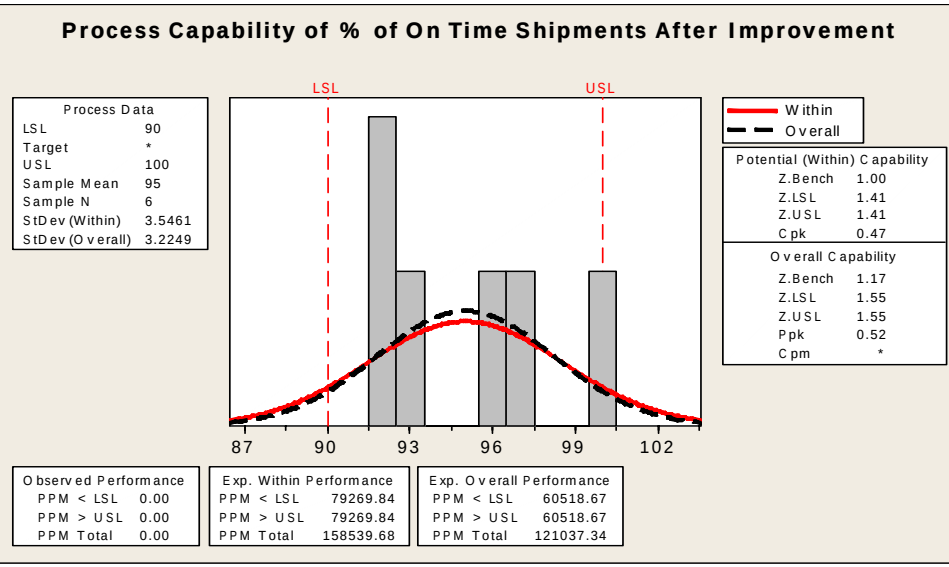
Number of runs up or down:	12
Expected number of runs:	11.7
Longest run up or down:	3
Approx P-Value for Trends:	0.578
Approx P-Value for Oscillation:	0.422

Updated Capability – On Time Shipment

Before

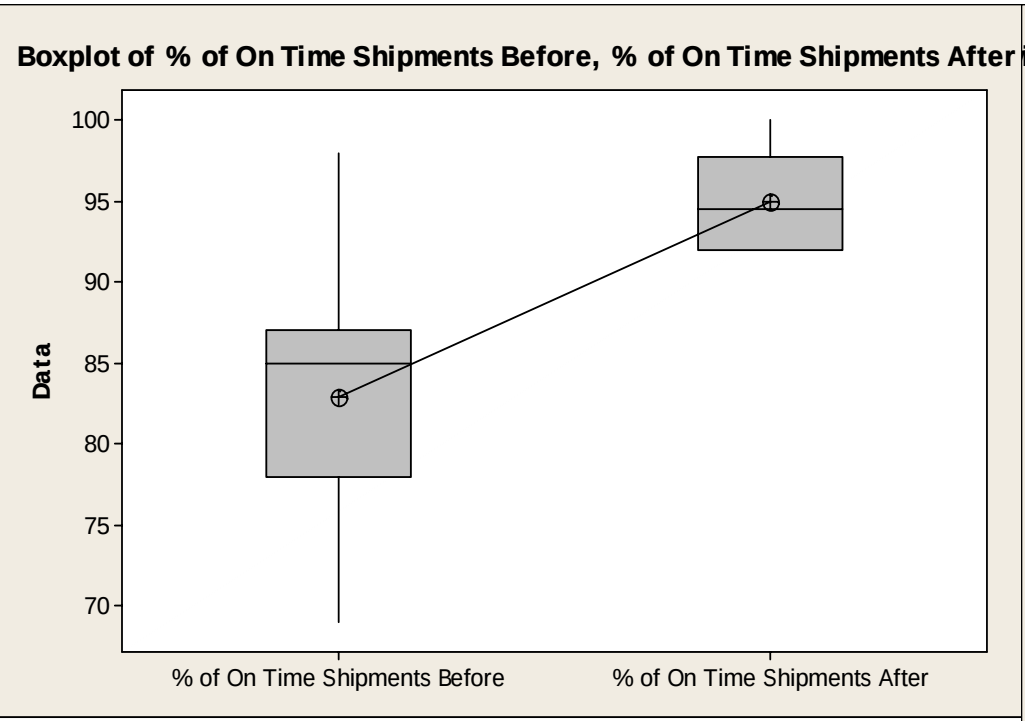


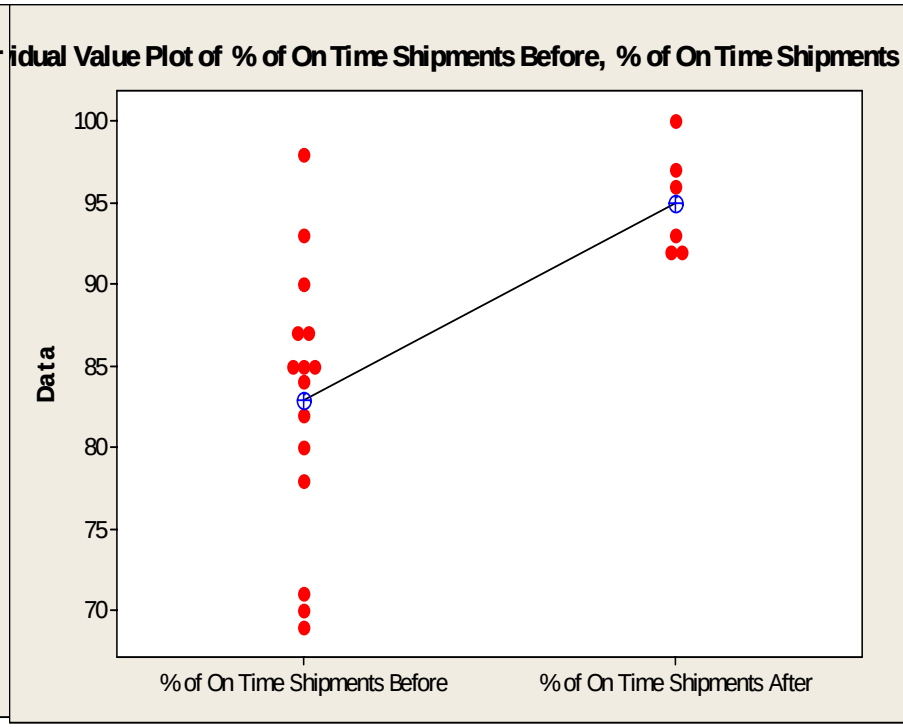
After



Hypothesis Testing

- 2 sample T-test for Improved On Time Shipment





Improved Yield Analysis

ROLLED THROUGHPUT YIELD (RTY)

Before				
	PRC A	PRC B	PRC C	PRC D
Initial In	100	100	100	98
Initial Out	100	100	98	98
Scrap	0	0	4	0
Rework	2	3	37	5
True Yield	0.98	0.97	0.58	0.94
Rolled Throughput Yield			**.52**	

After				
	PRC A	PRC B	PRC C	PRC D
Initial In	100	100	100	99
Initial Out	100	100	99	98
Scrap	0	0	2	0
Rework	1	1	18	1
True Yield	0.99		0.8	0.99
Rolled Throughput Yield			**.78**	

Defects Per Unit (DPU)

Before	
Total Assemblies	2096
Defects	837
DPU	.39

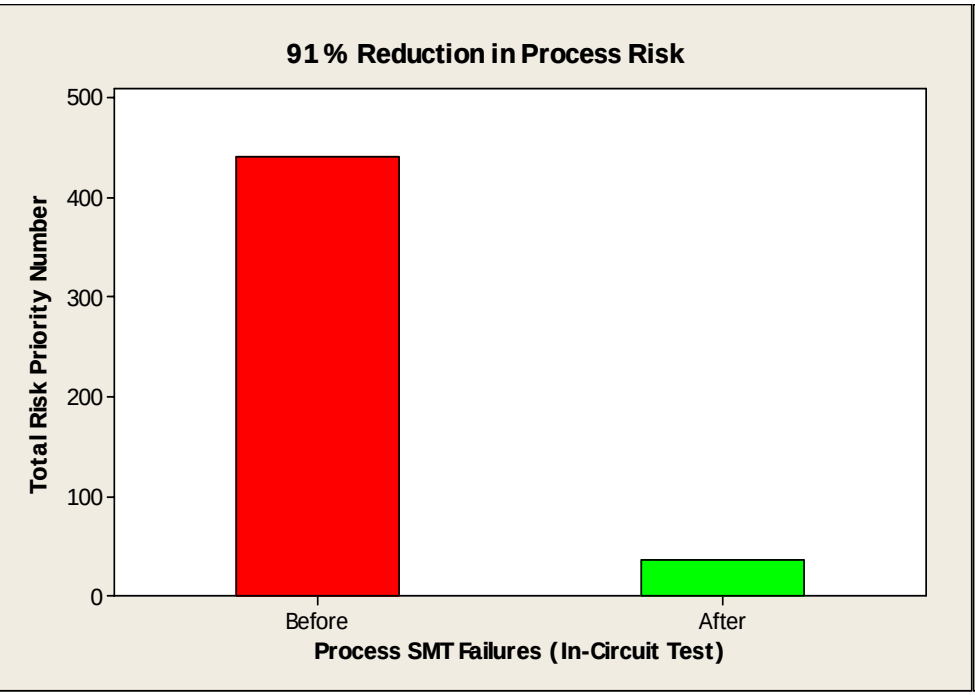
After	
Total Assemblies	524
Defects	94
DPU	.18

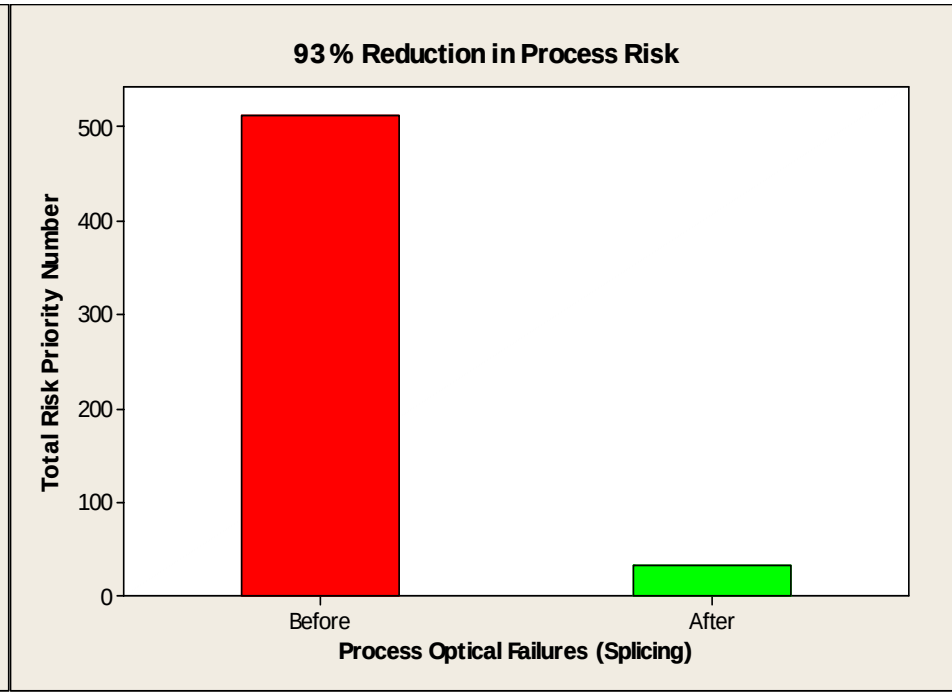
Defects Per Million Opportunities (DPMO)

Before	
Total Opportunities	12576
Defects	837
DPMO	66555
Z or Sigma Level	1.5

After	
Total Opportunities	3144
Defects	94
DPMO	29898
Z or Sigma Level	1.86

Impact of Improved Process (RPN)

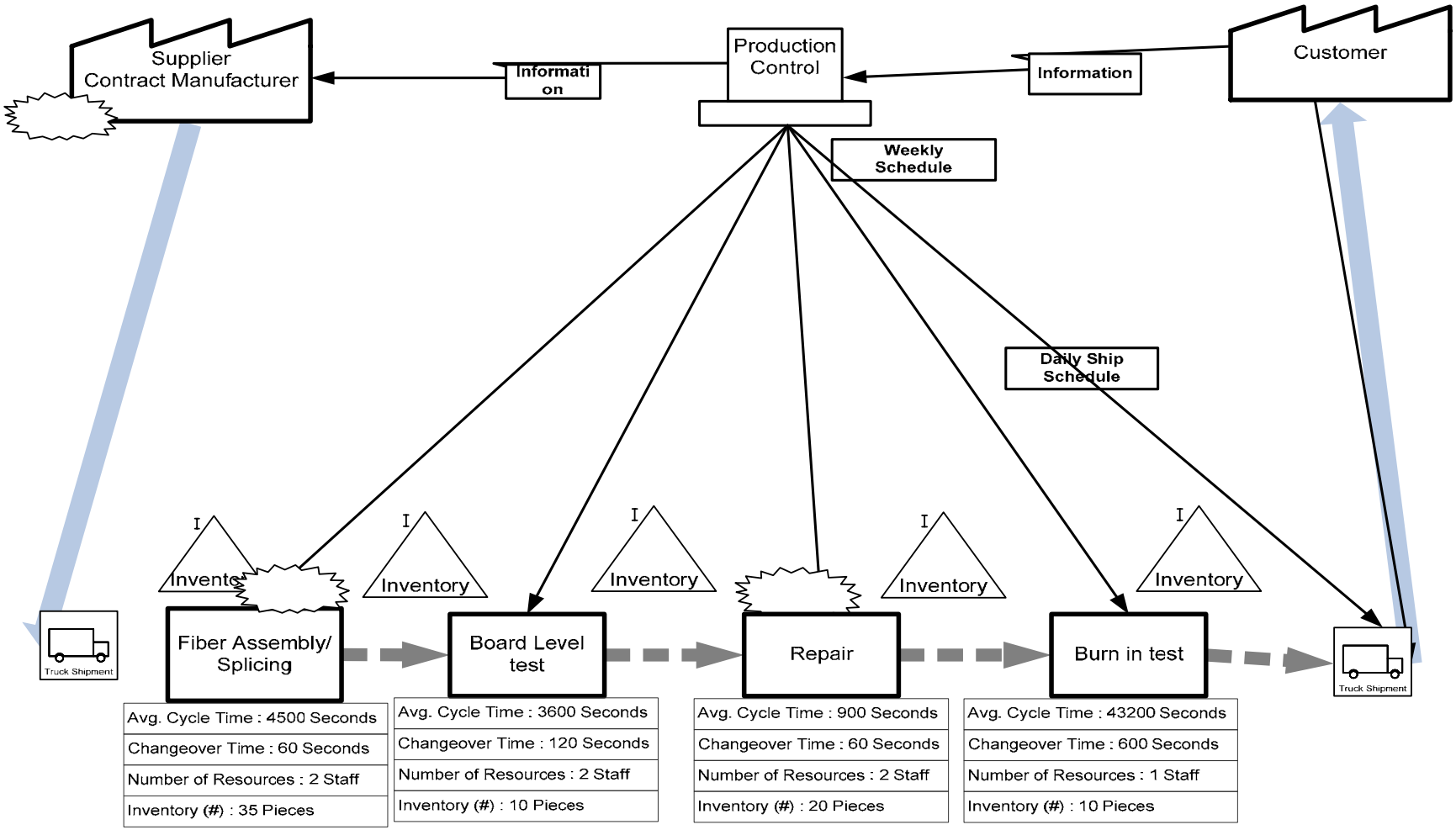




Next Steps

- Implement new handling and component shipping packaging to address damaged parts.
- Value Stream Map

Value Stream Map



Executive Summary-Control

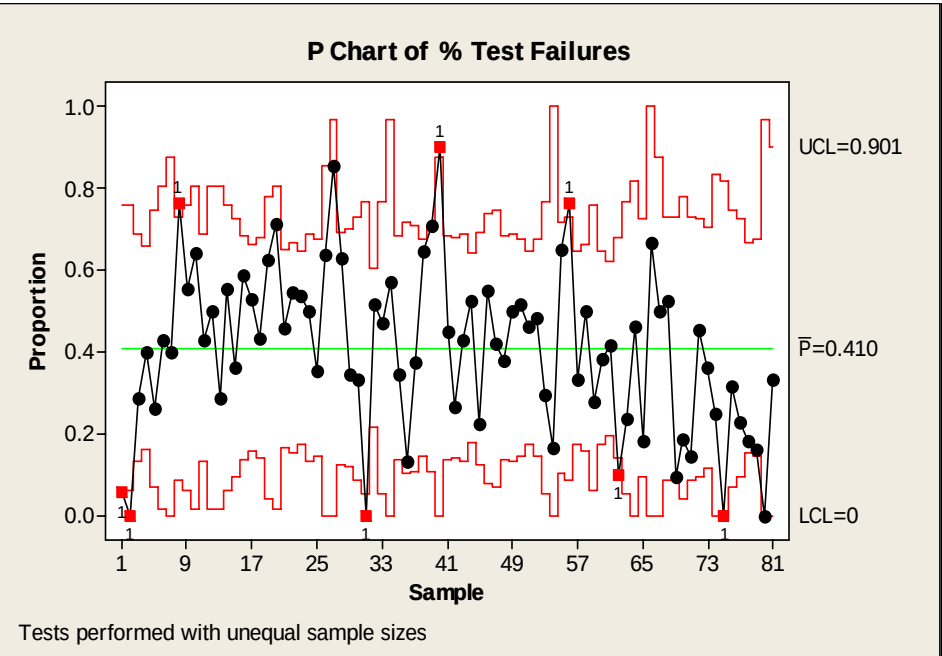
- Recommended CTQ dashboards and Control Charts
- Weekly quality meetings
- Documented SOPs
- Developed Control Plan
- Validated performance and financial results

- Control Phase Tools
  - Mistake Proofing
  - Documenting Control Plan Guidelines/SOP
  - Risk Management plan
  - Control Charts
  - Control Plan

Control Chart
P Chart % Defectives

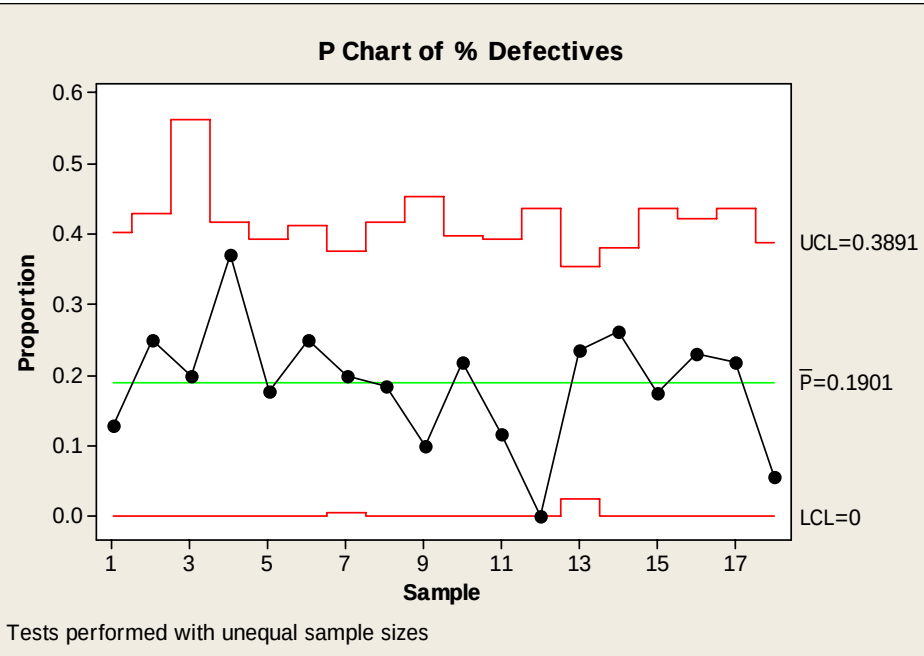
D M A I C

Before



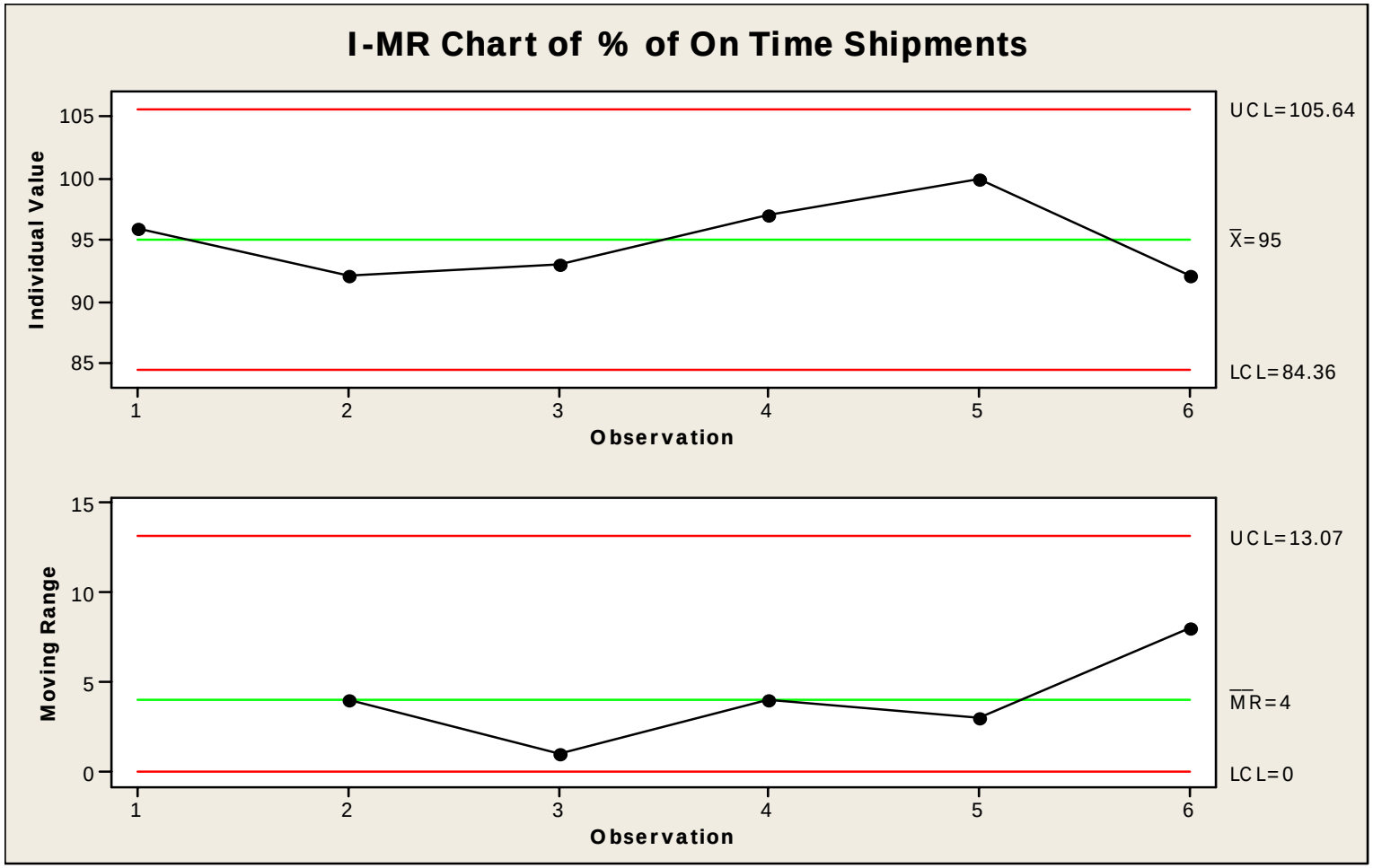
Tests performed with unequal sample sizes

After

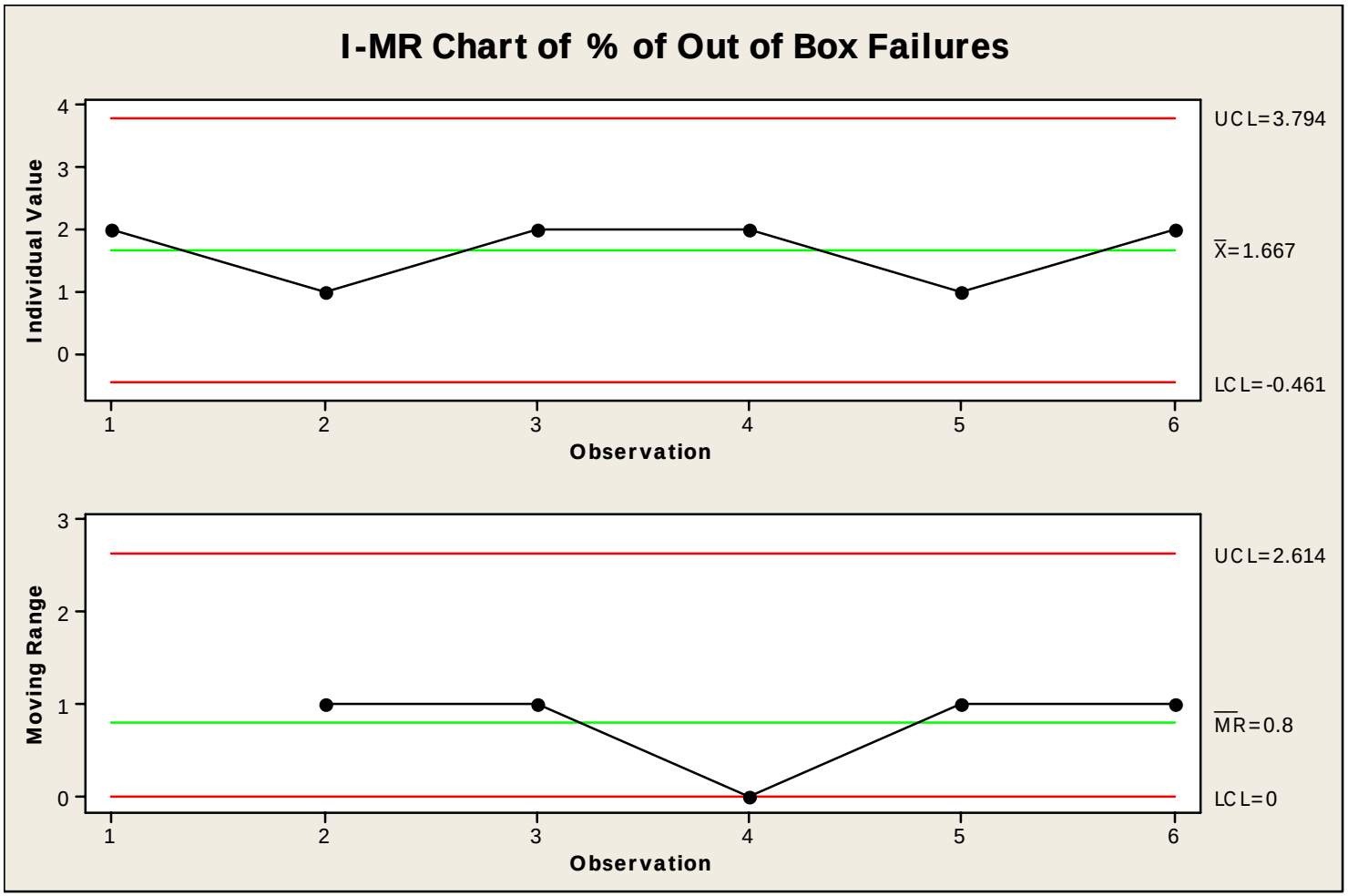


Tests performed with unequal sample sizes

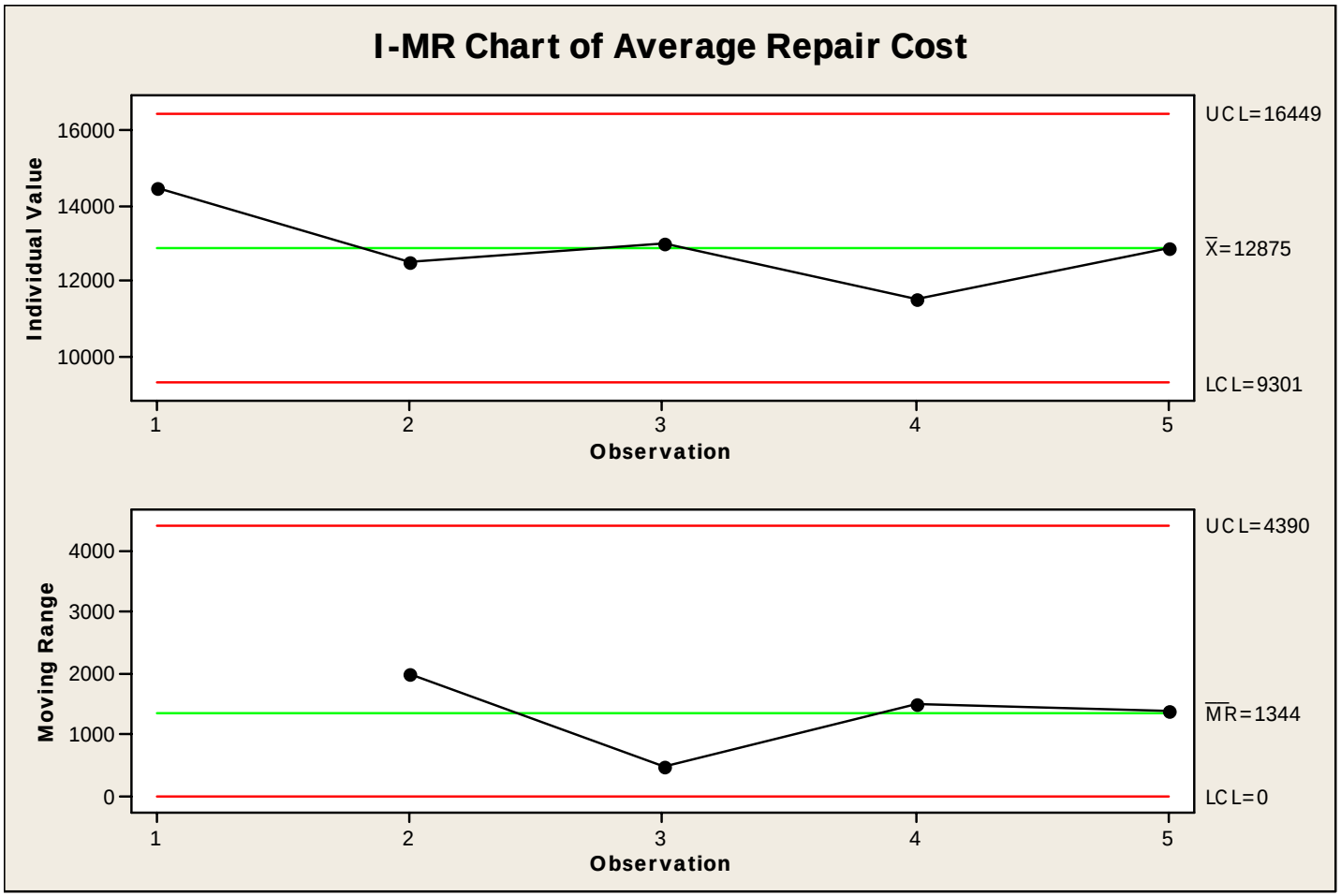
Control Charts
I-MR On Time Shipment



Control Charts
I-MR Chart Out of Box Failures



Control Charts
I-MR Chart Average Repair Cost



Validate Financial Benefits

Cost of Goods Sold Reduction	Final ($/Mon)
Direct labor Solder Certify 1 Headcount Reduction	$2,000
Variable overhead	$250
Total	**$2,250**
Cost of Poor Quality Reduction	**Final ($/Mon)**
Material Scrap (Lasers, Circuit Boards & Components)	$12,000
Rework Labor (Additional testing)	$1,500
Customer Rejects Warranty RMA	$2,000
Additional freight (including return and priority premiums)	$500
Containment inspection	$500
Total	**$16,500**
Other Categories (Including Revenue Enhancement	**Final ($/Mon)**
Increased revenue from additional sales	$25,000
Increased revenue from price increase	
Total	**$25,000**
Total Gross Monthly Savings ($/Mon)	**$43,850**
Savings for First 12 Months ($/Year)	**$526,200**
Project Costs	**Final ($)**
IT expenses	$2,000
Capital equipment	$56,000
Retraining or severance	$2,000
Travel and living	$1,000
Total	**$61,000**
Net Project Savings (based on 12 months)	**$465,200**

Lessons Learned

- Resist jumping to conclusions and solutions before analyzing root causes first.
- Manage expectations and perceptions during each phase.
- Manage Stakeholders (Senior Leadership Buy-in is critical to project success).

Questions ?

“It is not necessary to change. Survival is not mandatory”.

W. Edwards Deming