Six Sigma-Lean Impacting the Top and Bottom Line

$$Y = f(x_1, x_2, x_3, \ldots . x_n)$$

Overview

- Six Sigma-Lean Introduction
- Six Sigma at M/A-COM
- Case Studies

What it is *NOT*

- It is *NOT* the “Program of the Month”
  - –Honeywell 1999 - Allied Signal ~1994
    - “Six Sigma is one of the most potent strategies ever developed to accelerate improvements in processes, products, and services, and to radically reduce manufacturing and/or administrative costs and improve quality. It achieves this by relentlessly focusing on eliminating waste and reducing defects and variations.

Six Sigma Is….

- Systematic, Focused, Data Driven Approach to Improvement leading to Breakthrough.
- Combining the *Right People* with *Right Projects* using a proven road map produces the *Right Results* $$

It is the way we make things

better every day

Philosophy Change

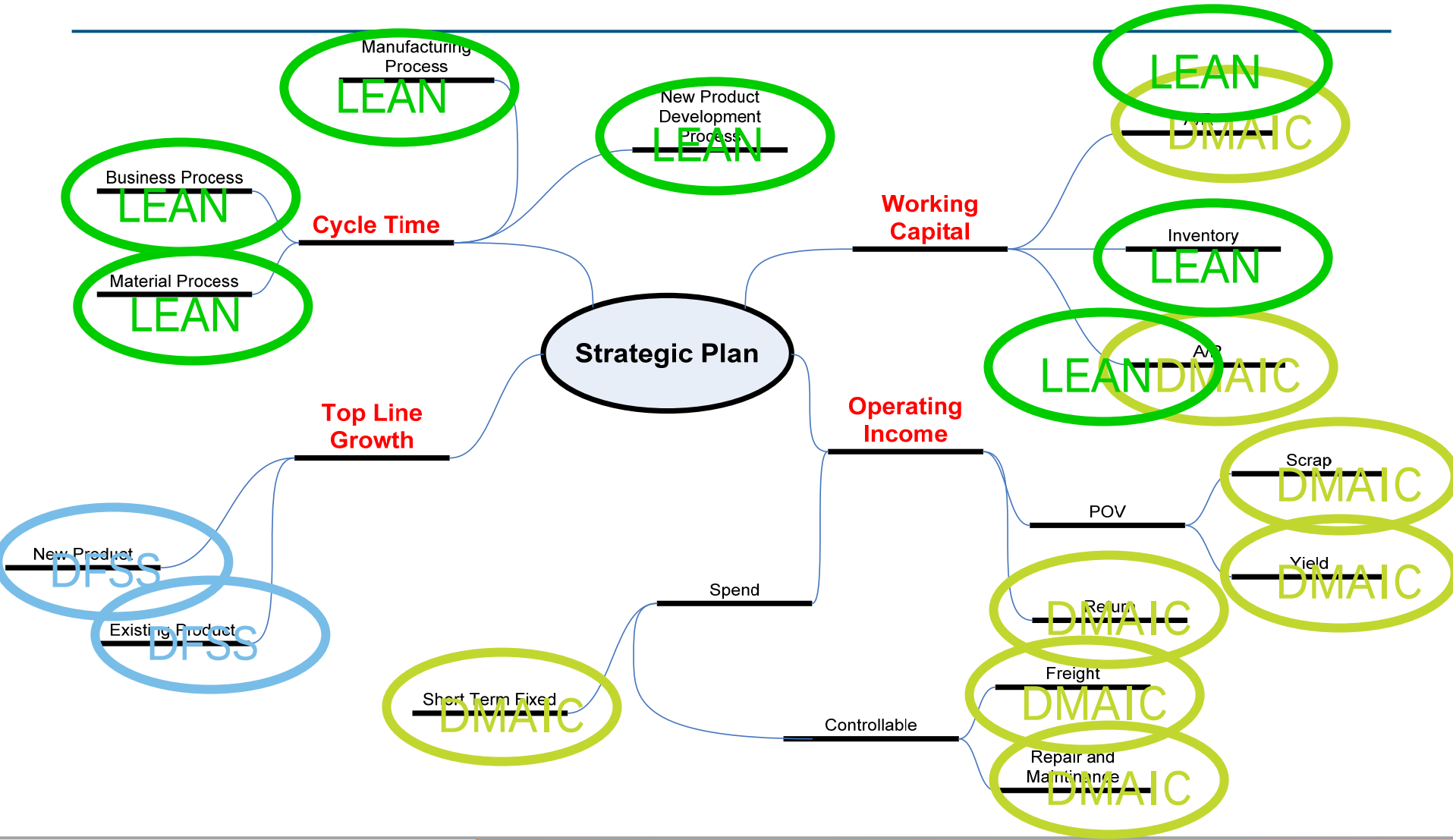
- Operational Excellence
  - –Philosophy for managing process improvement
  - –More hands using the tools daily
  - –Data driving decision process
  - –Cultural Change
    - Excellence in all things we do

Approach

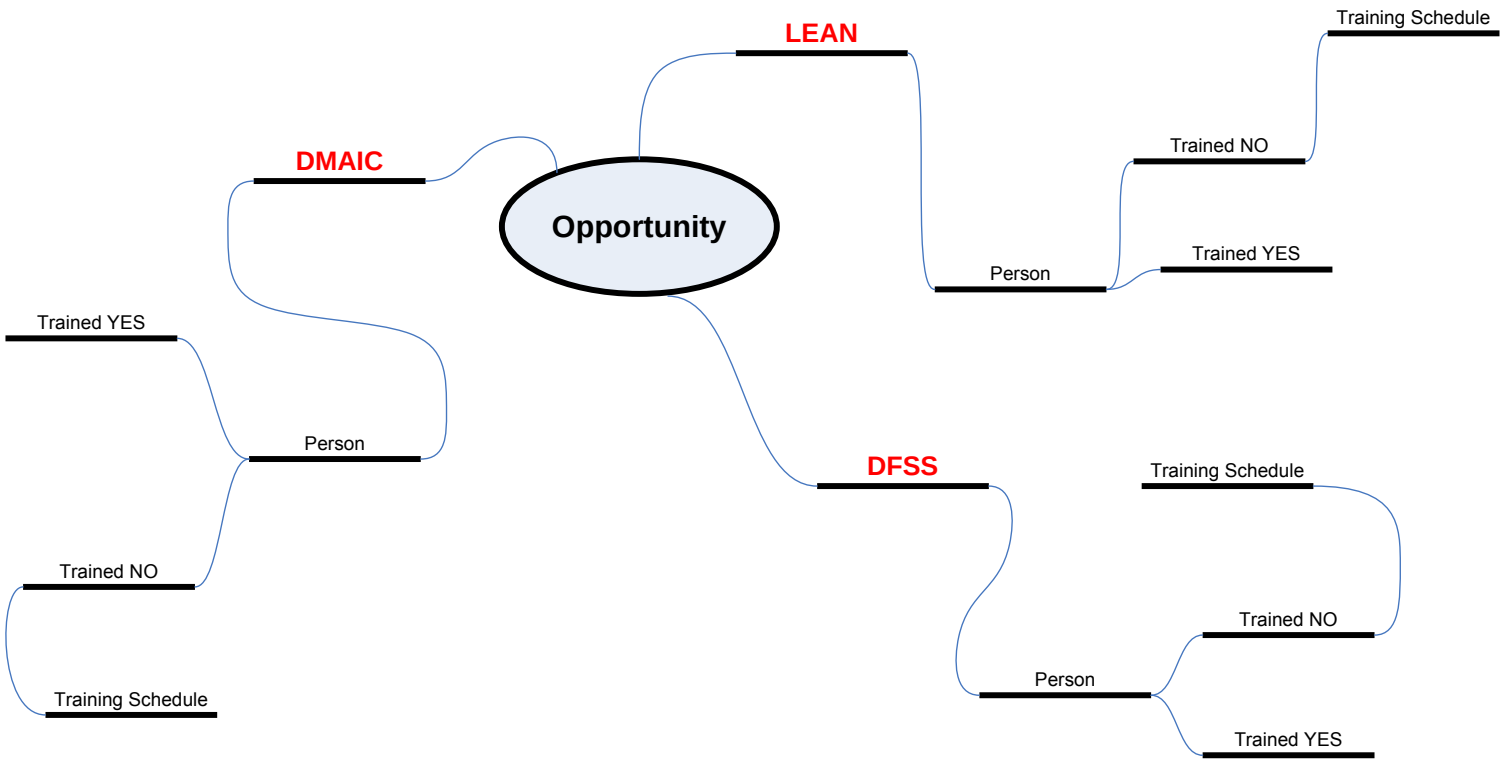
- **The Right Projects**
  - **Charters**
  - ***LINKED TO BUSINESS***
- **The Right People**
  - **The Best-of-the-Best from across our company**
- **The Right Roadmap and Tools**
  - **Well proven and effective**

New Project Opportunity Road Map

New Project Opportunity Road Map



Tool Box Approach - People



Belts

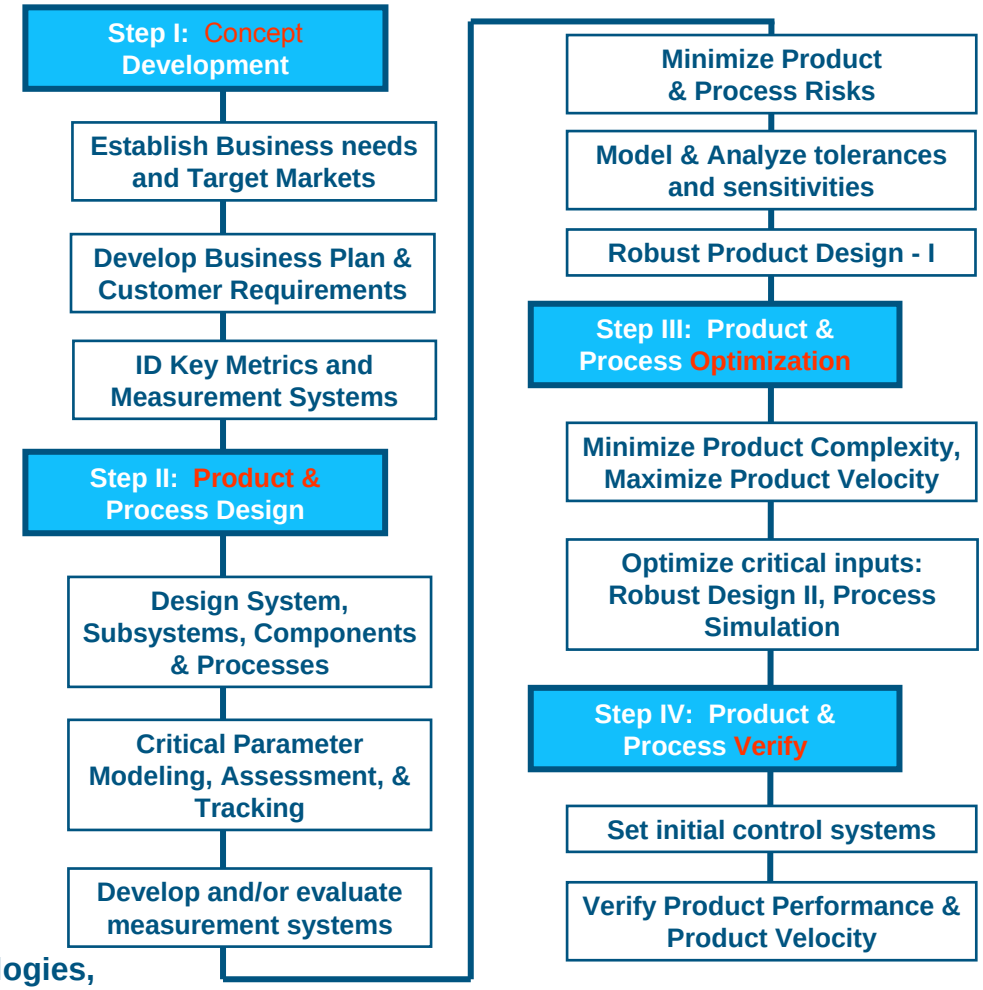
- Champions
  - 3 Days
- Blue Belt (Yellow Belt)
  - 1 Day
- Green Belt
  - 2 Weeks (Operational – Transactional)
  - 3 Weeks (Design)
- Black Belt
  - 4 Weeks (Operational)
  - 5 Weeks (Design)
- Master Black Belt
  - Black Belt + 5 Weeks Core + 2 Weeks Electives
    - Black Belt Training + Elective Focus defines Design or Operational

Road Maps

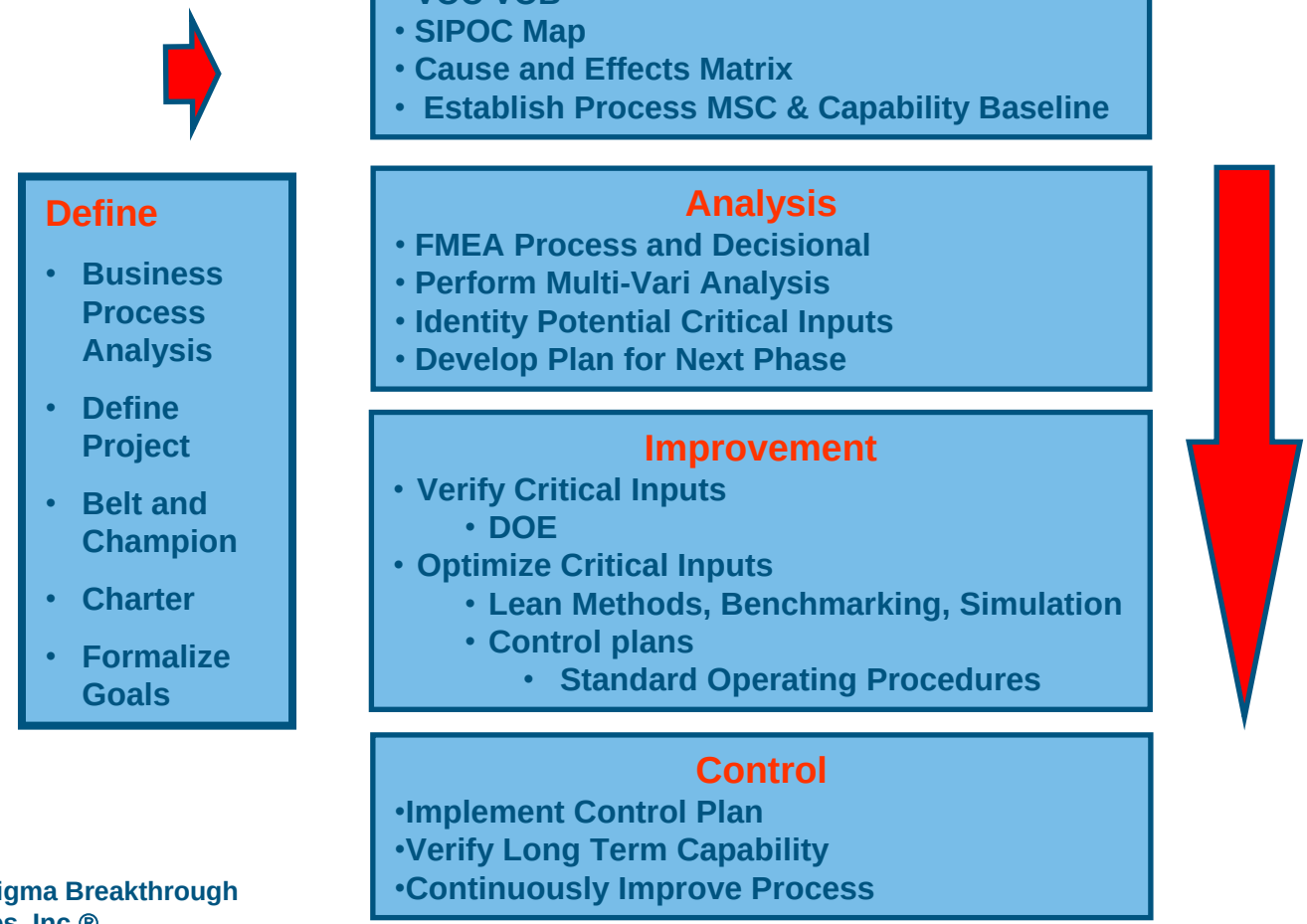
- Design **CDOV**
  - –Concept, Design, Optimize, Verify
- Operations **DMAIC**
  - –Define, Measure, Analyze, Improve, Control
- Transactional **DMAIC**
  - –Define, Measure, Analyze, Improve, Control
- Lean **DMAIC**
  - –Define, Measure, Analyze, Improve, Control

Lean-Design™ Roadmap

C
D
O
V



Transactional



Operational

Define

- Business Process Analysis
- Define Project
- Belt and Champion
- Charter
- Formalize Goals

Measurement

- Map process and Identify Inputs and Outputs
- Cause and Effects Matrix
- Establish Measurement System Capability
- Establish Process Capability Baseline

Analysis

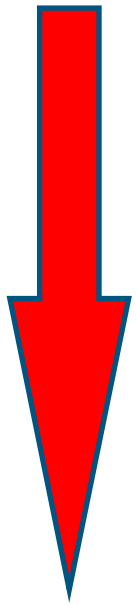
- Complete FMEA
- Perform Multi-Vari Analysis
- Identity Potential Critical Inputs
- Develop Plan for Next Phase

Improvement

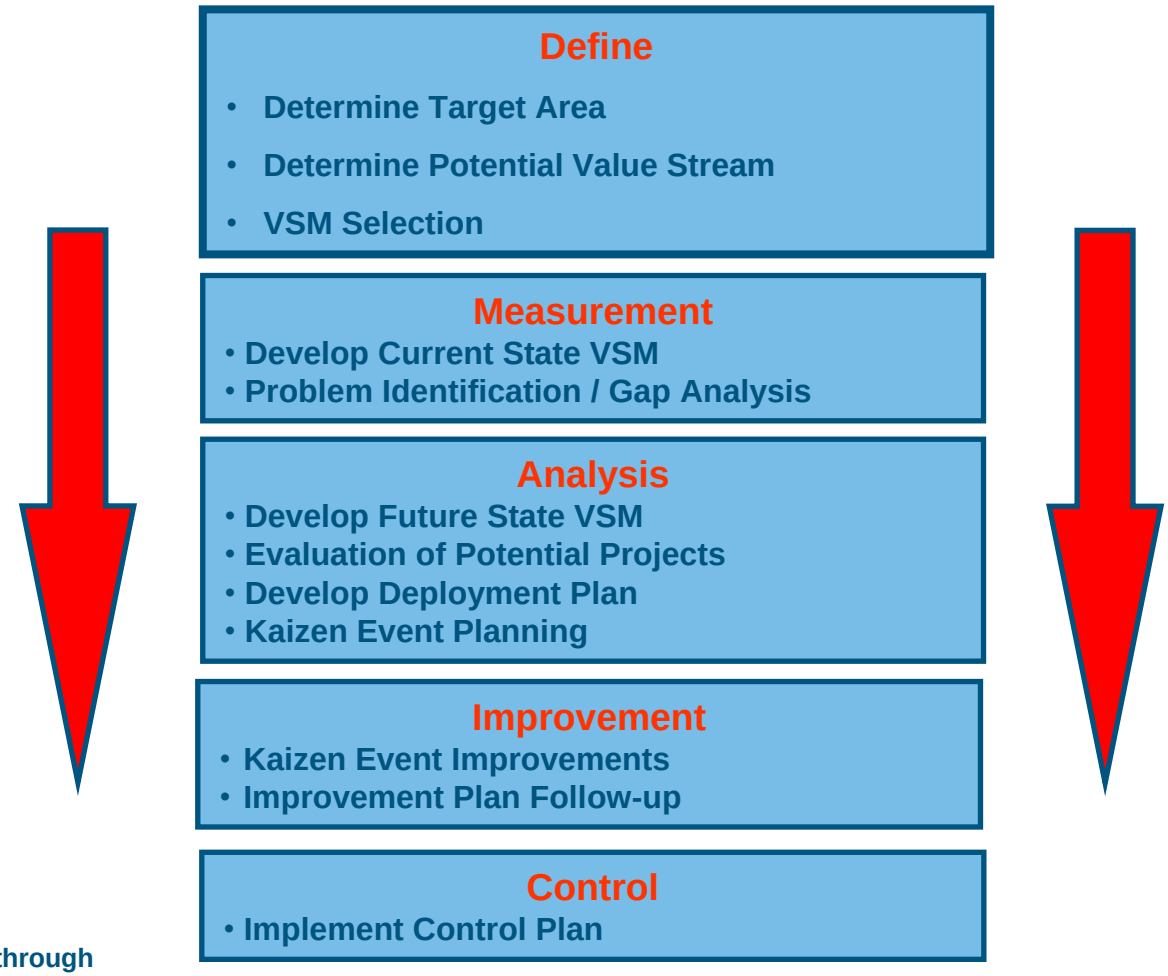
- Verify Critical Inputs
- DOE
- Optimize Critical Inputs

Control

- Implement Control Plan
- Verify Long Term Capability
- Continuously Improve Process



LEAN



Implementation

- What to do first
  - Design
  - Operational
  - Transactional
- Belts
  - Full Time or Part Time
  - It Depends
- Key to Success
  - MBB's – Strong Technical – Strong Leader
    - Real Champion Driving the Day to Day
    - In Each Major Location

Driving Excellence

Six Sigma at M/A-COM

February 23, 2007

tyco Electronics M/A-COM

Tyco Electronics

Operational Excellence Program History

1998
- First Black Belt Belt
- Trained by Customer

2001
- Black / Green Belts Operation
- Black / Green Belts Design

2002
- MBBs Development Wave 1
- Black / Green Belts Operation

2003
- Lean Incorporated into Six Sigma Operational Excellence
- Green Belts Transactional
- MBB Development Wave 2

2004
- First Deployment of Lean Design
- First Supplier Black Belt Trained

2005
- Lean Design continued Evergreen program in place
- First Customer Black Belts Trained
- Lean Leader Implement
- MBB Development Wave 3
- Greater than 10% of all Employees Belts

2006
- Strategic Focus Key Business locations
- Crossed the $100M Mark Saved
- MBB Development Wave 4
- Sales & Marketing – VOC Development
- Deployment of Blue Belt Training

2007
- Strategic linkage
- Expanded Lean - Host site lean leader
- VOC /VOB
- Expanding DFSS, Ops, Exceeding 20%
- MBB Development Wave 5

Current Status

- Mature Program
  - 6 years of deployment complete
  - >10% of all employees are Belts
  - >20% of all Design Engineers are Belts
- Full Global Deployment
  - Design, Operational, Transactional,
- Six Sigma and Lean Fully integrated
- Six Sigma Moving into Supply Base

Design

Understanding Variance

Sources of variation

- Recorded production data
  - Component attach operator
  - 7/10 Wire bond operator
  - 1 Wire bond operator
  - MIC Wafer lot
  - Test stand calibration date
  - Tester

What is the main source of variation

Analysis of variation model

Source	DF	Seq SS	Adj SS	Adj MS	F	P
MIC	6	262.434	64.284	10.714	6.98	0.000
Date	8	203.966	150.085	18.761	12.22	0.000
Test	1	13.757	17.461	17.461	11.37	0.001
Assemble	7	24.708	24.708	3.530	2.30	0.025
Error	1142	1753.517	1753.517	1.535		
Total	1164	2258.381				

MAIN SOURCE OF VARIATION FROM RECORDED DATA

S = 1.23914 R-Sq = 22.36% R-Sq(adj) = 20.86%

70+% Error term!!! – where is it from???

Sources of variation

- Suspect 70% error term is due to diodes
  - –Diodes now selected for parameter value
  - –Optimum selection value must be determined
- DOE on ADS model to assess impact of diode types
- Microwave Integrated Circuit (MIC) operational 6σ work is underway

C & E Matrix

Place Components	Diode B
Place Components	Schottky Diode
Place Components	Diode A

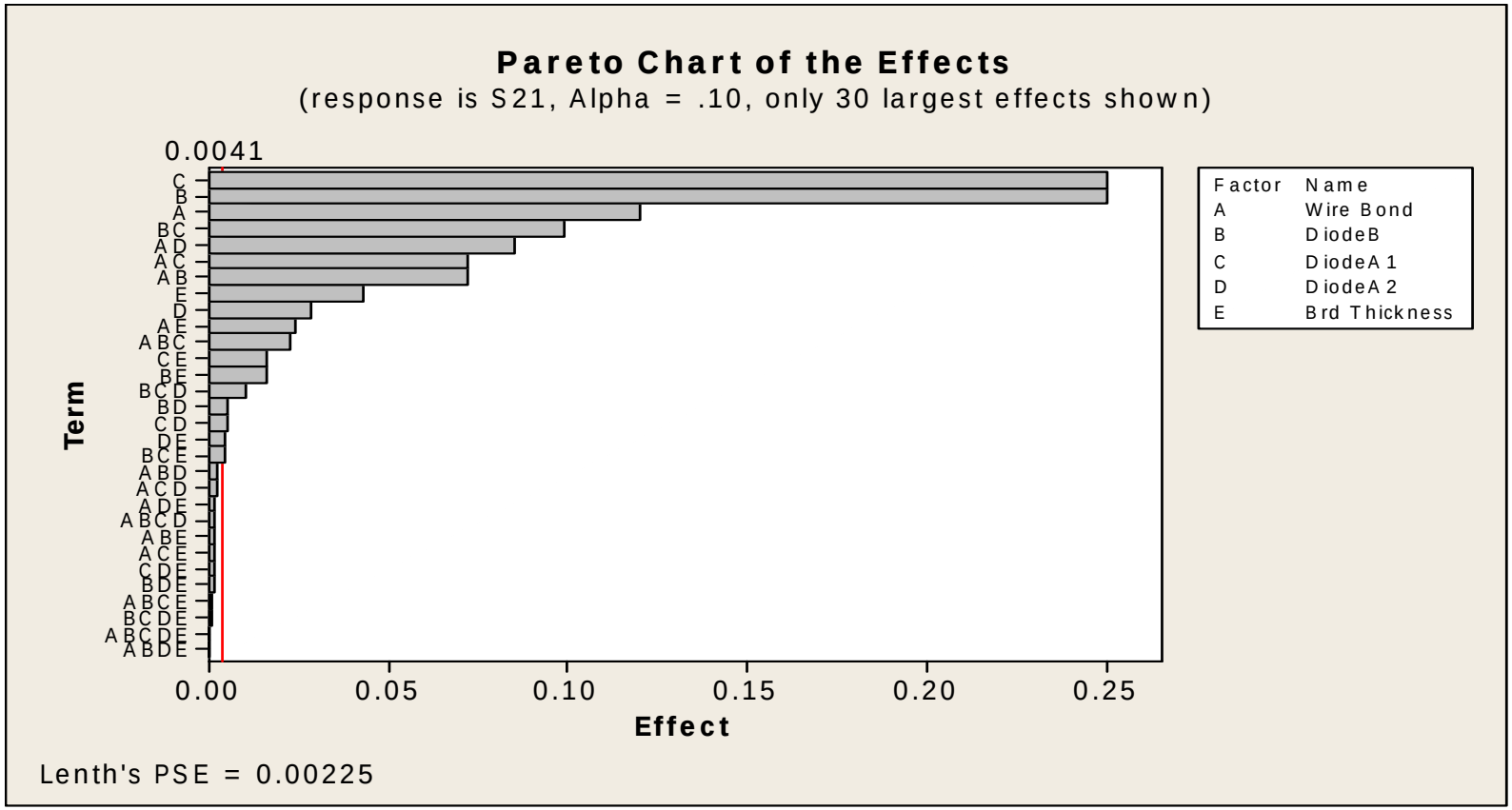
Critical X's

			10	10	9	8	10	8	10	9	7	8	10	10	
			Power Handling	Insertion Loss	Recovery Time	IP/OP return loss	Isolation	Environmental	OTD	Price	Size	Ease of Use	Reliability	Quality	TOTAL
		Process Input													
		Jig	0	1	0	1	0	0	0	1	0	0	0	0	27
		MIC	9	9	1	9	3	3	9	3	9	9	9	9	747
		Operator	3	3	0	1	1	1	0	3	0	0	0	3	143
		Mix Ratio	3	3	1	1	1	1	0	0	0	0	3	3	155
	Epoxy Mix	Contaminates	1	1	1	1	1	1	0	0	0	0	3	3	115
3	Epoxy Dispense	Operator	1	1	1	1	1	1	0	3	0	0	1	3	122
	Place Components	Location	1	3	1	3	1	1	0	0	0	0	1	3	131
	Place Components	Population Dexterity	1	3	1	3	1	1	0	0	0	0	0	3	121
	Place Components	**Diode B**	**9**	**9**	**9**	**9**	**9**	**3**	**3**	**1**	**0**	**0**	**9**	**3**	**606**
	Place Components	Schottky Diode	9	1	1	1	9	3	3	1	0	0	9	3	390
	Place Components	**Diode A**	**9**	**9**	**9**	**9**	**9**	**3**	**3**	**1**	**0**	**0**	**9**	**3**	**606**
5	Cure Epoxy	Time	1	1	1	1	1	3	1	0	0	0	3	3	141
	Cure Epoxy	Oven Temp	1	1	1	1	1	3	1	0	0	0	3	3	141
	Cure Epoxy	Location in Oven	0	0	0	0	0	1	0	0	0	0	1	0	18
	Cure Epoxy	Oven Type	0	0	0	0	0	1	0	0	0	0	1	0	18
	Cure Epoxy	Operator	0	0	0	0	0	1	0	1	0	0	0	3	47
6	Wire Bond Attachment 7/10	Operator	0	1	1	3	1	1	1	3	0	0	0	3	128
	Wire Bond Attachment 7/11	Wedge Bonder	1	1	1	3	1	3	3	1	0	0	3	3	186
	Wire Bond Attachment 7/12	Hot Plate Temperature	1	1	1	1	1	3	3	1	0	0	3	3	170
		Wire	1	1	1	3	1	1	1	1	0	3	3	3	174
7	Wire Bond Attachment 1"	Operator	0	1	1	3	1	1	1	3	0	0	0	3	128
	Wire Bond Attachment 1"	Wedge Bonder	1	1	1	3	1	3	3	1	0	0	3	3	186
	Wire Bond Attachment 1"	Hot Plate Temperature	1	1	1	1	1	3	3	1	0	0	3	3	170
		Wire	1	1	1	3	1	1	1	1	0	3	3	3	174
8	Test														

Design of Experiments

- 5 factor 32 run DOE
  - Y1
  - Y2
  - Y3
- Sensitivity of S-parameters to (KPIV's):
  - Diode Type A
  - Diode Type B
  - Wire Bond Length
  - Dielectric thickness

Pareto of Y2


Pareto Chart of the Effects
(response is S21, Alpha = .10, only 30 largest effects shown)
0.0041
Term
C
B
A
BC
AD
AC
AB
E
D
AE
ABC
CE
BE
BCD
BD
CD
DE
BCE
ABD
ACD
ADE
ABCD
ABE
ACE
CDE
BDE
ABCE
BCDE
ABCDE
ABDE
0.00
0.05
0.10
0.15
0.20
0.25
Effect
Factor Name
A Wire Bond
B DiodeB
C DiodeA1
D DiodeA2
E Brd Thickness
Lenth's PSE = 0.00225

Results Model

Analysis of Variance for Y2

Source	DF	SS	MS	F	P
Wire Bond	1	0.115681	0.115681	8112.46	0.000
DiodeA1	1	0.501001	0.501001	35134.22	0.000
DiodeA2	1	0.501001	0.501001	35134.22	0.000
DiodeB1	1	0.006328	0.006328	443.78	0.000
Brd Thickness	1	0.014878	0.014878	1043.37	0.000
DiodeA2 * DiodeA1 *Brd Thicknes	1	0.000136	0.000136	9.55	0.009
Lim*Brd Thickness	1	0.000171	0.000171	12.00	0.004
DiodeA1 *DiodeB	1	0.000221	0.000221	15.46	0.002
DiodeA2 *DiodeB	1	0.000221	0.000221	15.46	0.002
DiodeA2 * DiodeA1 *Lim	1	0.000820	0.000820	57.51	0.000
DiodeA2 *Brd Thickness	1	0.002048	0.002048	143.62	0.000
DiodeA1 *Brd Thickness	1	0.002048	0.002048	143.62	0.000
Wire Bond*DiodeA2*Pin1	1	0.004050	0.004050	284.02	0.000
Wire Bond*Brd Thickness	1	0.004704	0.004704	329.92	0.000
Wire Bond* DiodeA1	1	0.041616	0.041616	2918.46	0.000
Wire Bond*DiodeA2	1	0.041616	0.041616	2918.46	0.000
Wire Bond*DiodeB	1	0.058141	0.058141	4077.28	0.000
DiodeA2 *DiodebA1	1	0.078606	0.078606	5512.50	0.000
Error	13	0.000185	0.000014		
Total	31	1.373471			

S = 0.00377619 R-Sq = 99.99% R-Sq(adj) = 99.97%

Value low

Statistically significant but practically not Significant

Reduced Model for Y2

Analysis of Variance for S21

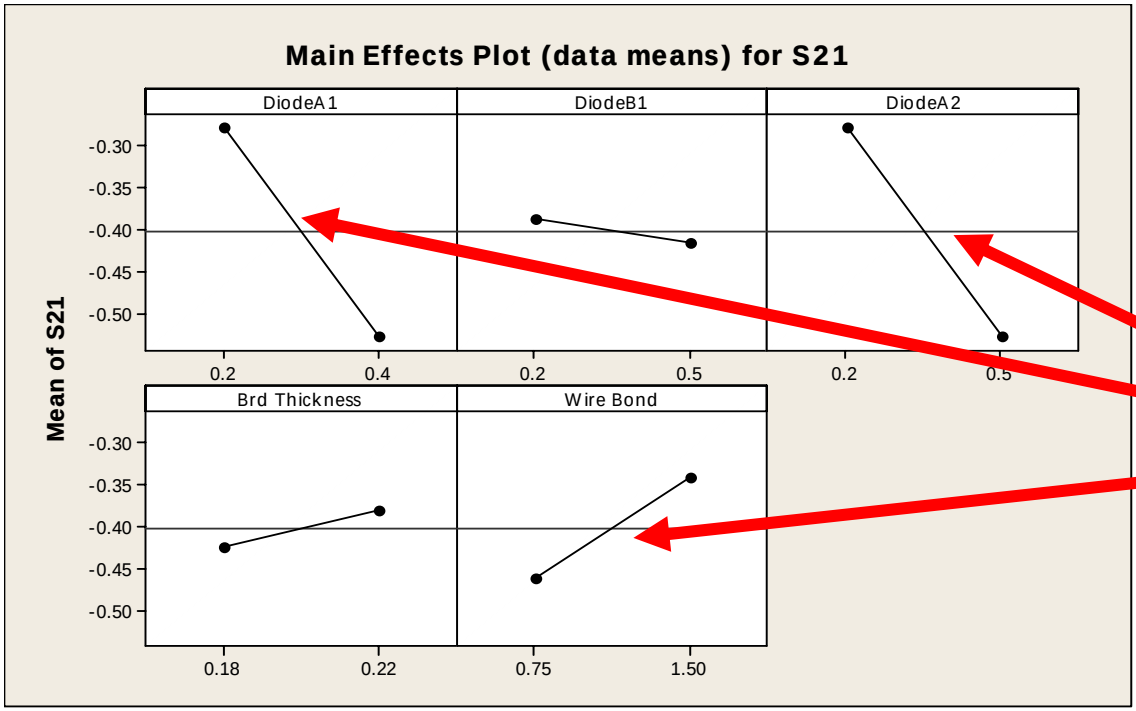
Source	DF	SS	MS	F	P
DiodeA2	1	0.50100	0.50100	54.84	0.000
DiodeA1	1	0.50100	0.50100	54.84	0.000
Wire Bond	1	0.11568	0.11568	12.66	0.001
Error	28	0.25579	0.00914		
Total	31	1.37347			

73% of Variation due Properties

S = 0.0955789 R-Sq = 81.38% R-Sq(adj) = 79.38%

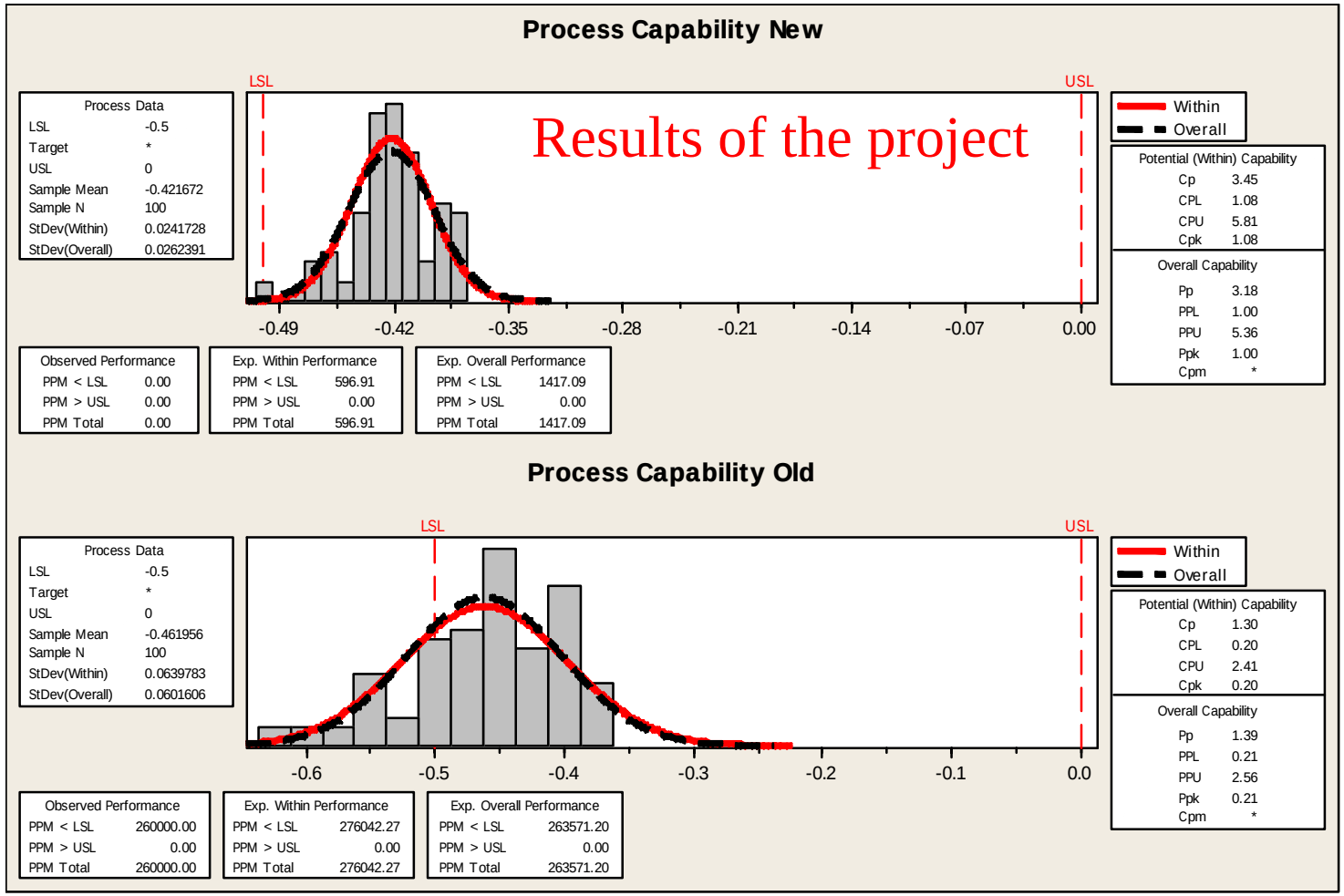
81% of variation still accounted for with reduced model.

Effect Plot for Y2

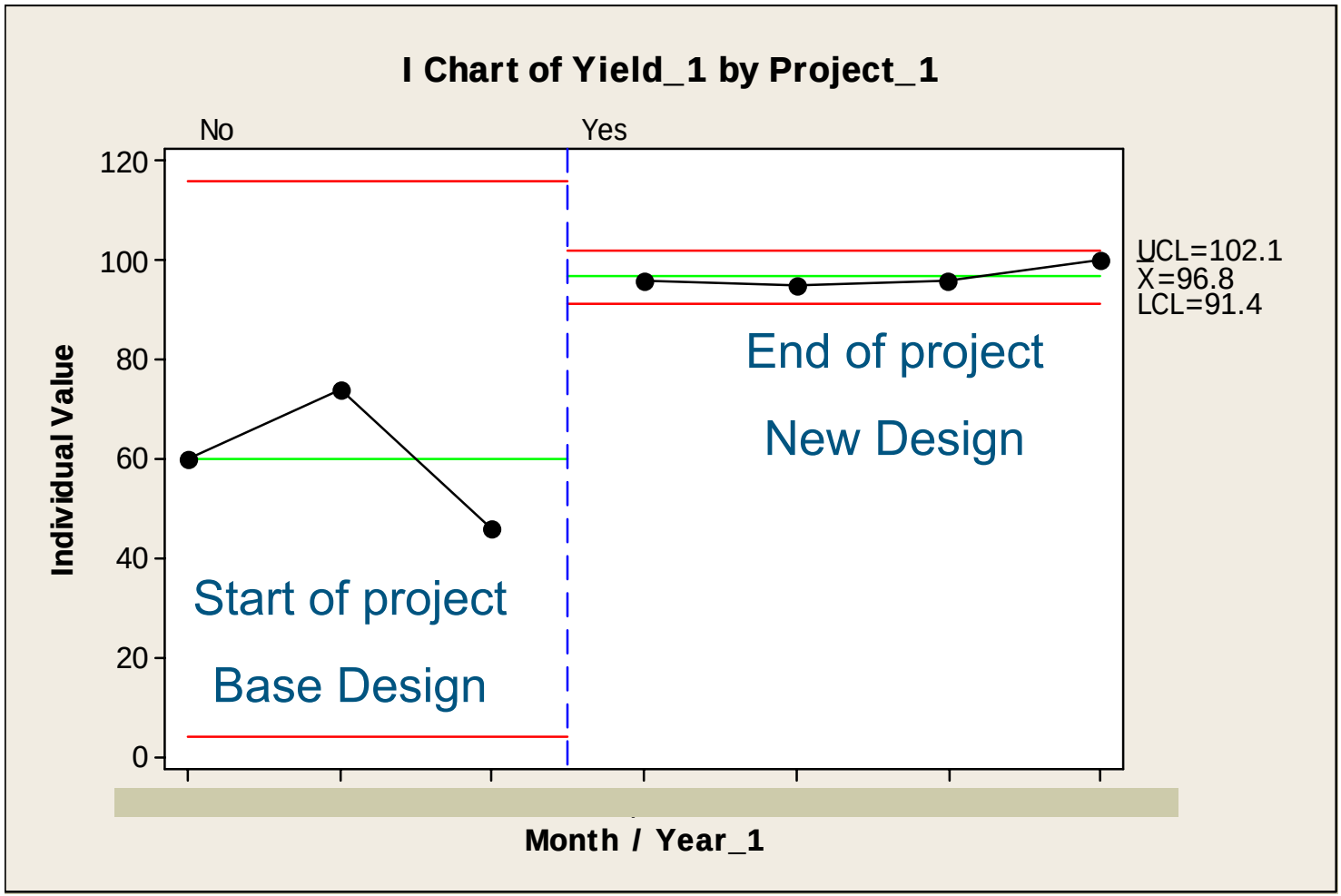


Key Drivers Of Variance

Yield improvements by project end



Yield improvements by project end



Transactional

Pushing on the Right X's
Freight Cost Reduction

February 23, 2007

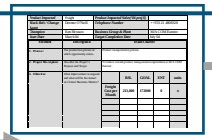
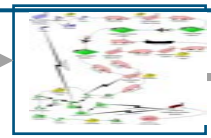
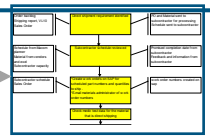
tyco Electronics MACOM

Tyco Electronics

Measure

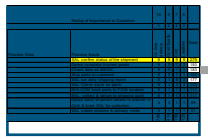
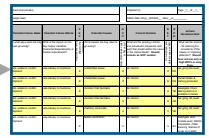
Date Used:

Key Learning:

Project Description	MSA	1st Capability Study & SPC	Value Stream Map	Process Map
	Invoices manually checked to SAP			
Project Y	Validated measurement system	Baseline capability: process not capable	Pcss. inputs/outputs	KPIV's

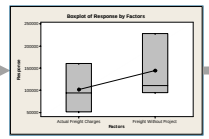
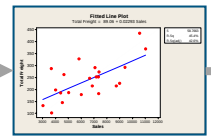
Continuous Improvement

Analyze

C & E Matrix	Preliminary FMEA
	
X's that we needed to study. Controls in place.	X's that we needed to study. Controls in place.

Improvement Activity.	ANOVA, t-test	ANOVA, t-test	Regression
03/06/04			

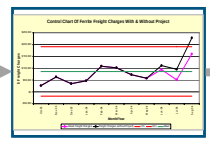
Improve

S&OP Improvement / Implementation				Identify new projects
				
	Confirm results. Look for improvement	Confirm results. Look for improvement	Look at relationship of freight charges Vs Sales	3 potential projects identified.

Continuous Improvement

Control Plan	Hand Off Training	Capability Study & SPC	Owner Sign-Off	Final Project Report

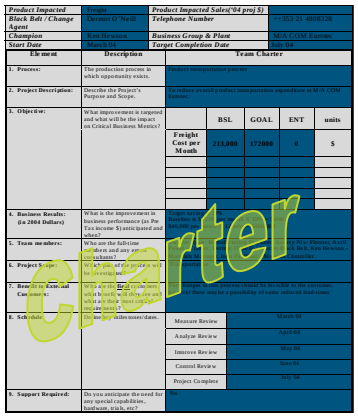
Control

	On site Training in Hong Kong		Complete	
				
Identified Key Controls		Process in control		

Baseline

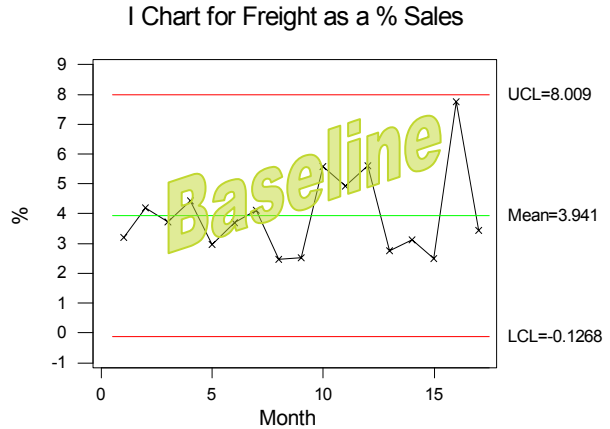
- **The problem statement:**
  - To investigate the product transportation process at M/A-COM Facility, to find methods of reducing overall monthly Variation, expenditure & understand the total cost of ownership.

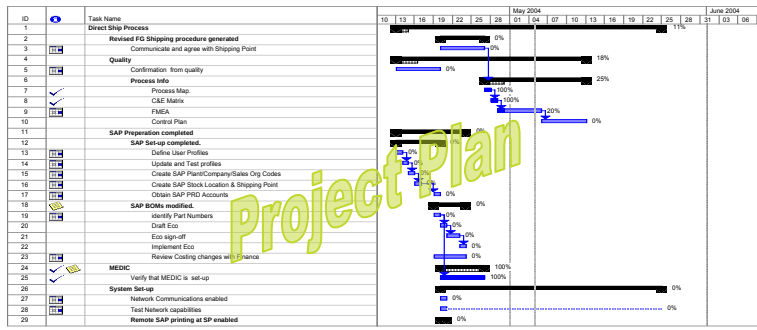
- **The "Y"**
  - **$ Cost of Product Transportation.**
  - **Baseline** the current process from historical data.
    - **19% Savings** per month of total baseline Freight Cost



- CTQ Standards.
  - **Lead-time reduction**. On-time Delivery.

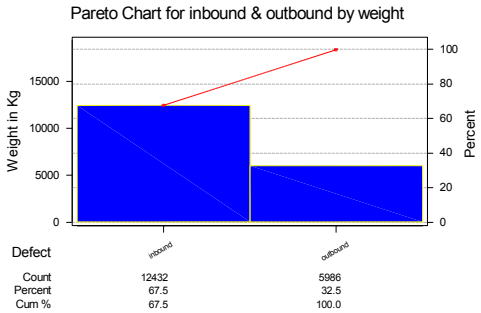
- Drafted a project **Charter** & **Project Plan.**



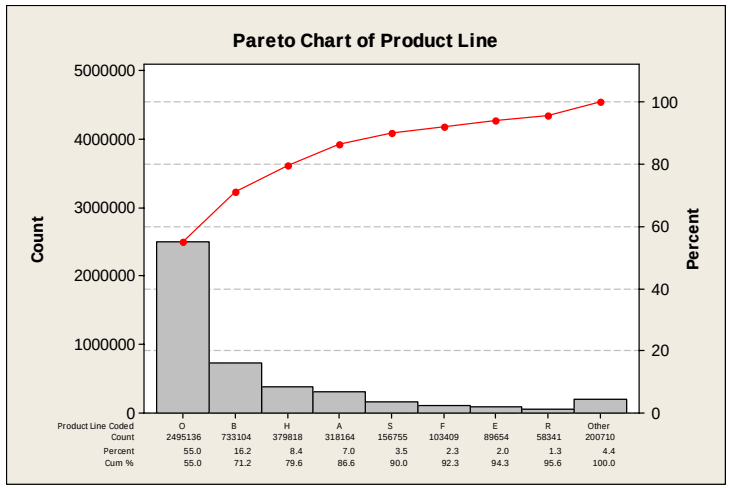


Measure Phase

- This Measurement Systems Analysis MSA processed shipping invoices & manually correlating them to SAP.

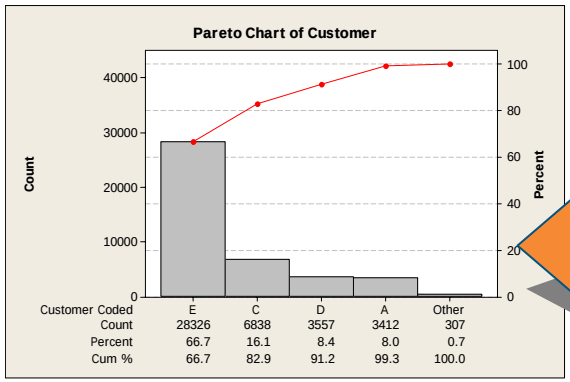


- **Pareto Analysis** identified Inbound freight as major contributor to product transportation costs.



- **Product** line contributes to 72% of the total Inbound weight shipped from Asia Region to Facility

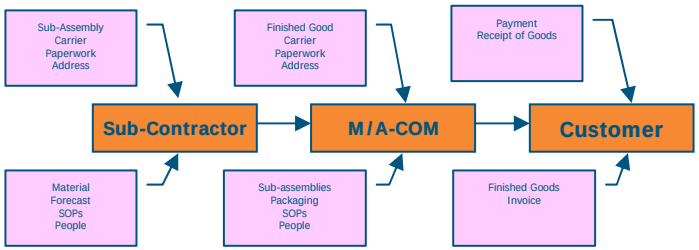
Sum of Projected $ Cost of Freight (25%)	
Part Number	**Total**
7N264-S004	$8,861
7N264-S012	$6,378
MAFRIN0216	$5,850
MAFRIN0231	$3,496
MAFRIN0045	$3,465
MAFRIN0085	$2,637
MAFRIN0175	$2,030
FR11-0002	$1,932
FR11-0003	$1,288
MAFRIN0016	$1,272
MAFRIN0044	$1,196
7N264-S011	$1,043
MAFRIN0177	$944
MAFRIN0015	$905
7N264-S062	$368
MAFRIN0142	$307
7N264-S063	$215
FR12-0002	$192
MAFRIN0103	$61
Grand Total	**$42,439**



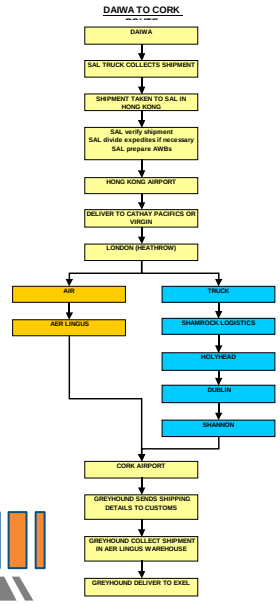
- Product **Customers** & **Part Numbers** identified.

Measure Phase

- Initial **Macro view** of Product Family Transportation Process.

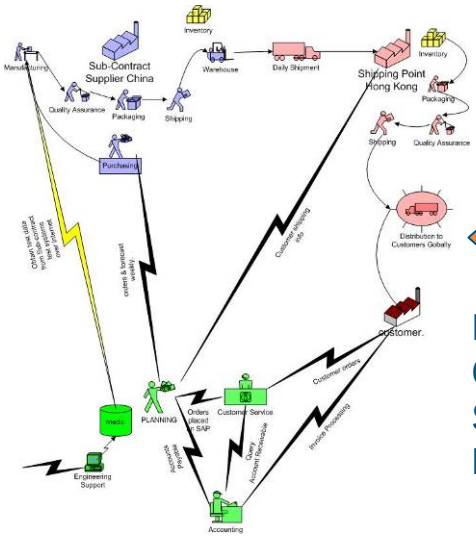


Detail expanded



Future State Value Stream Map

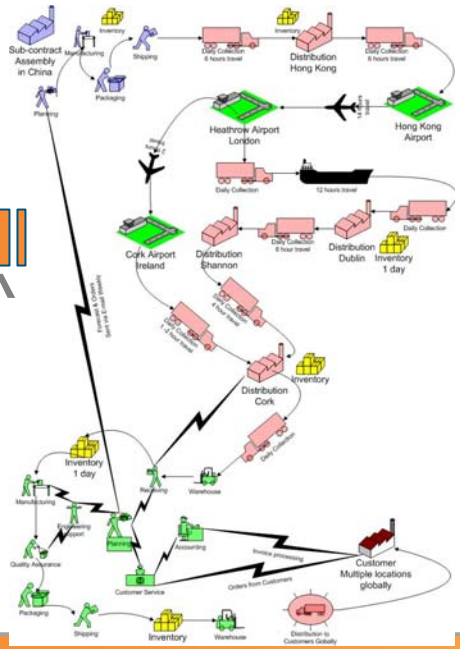
What We **Want**



Moving from Current State to Future state

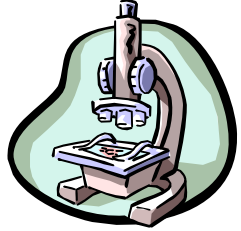
Current State Value Stream Map

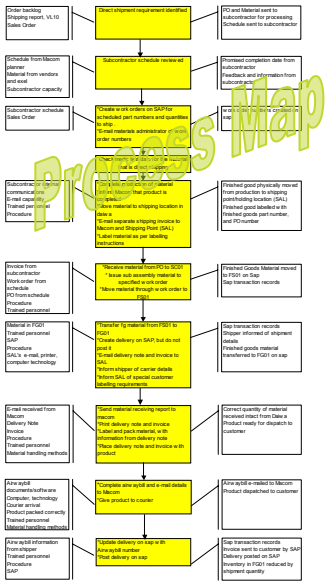
What We **have**



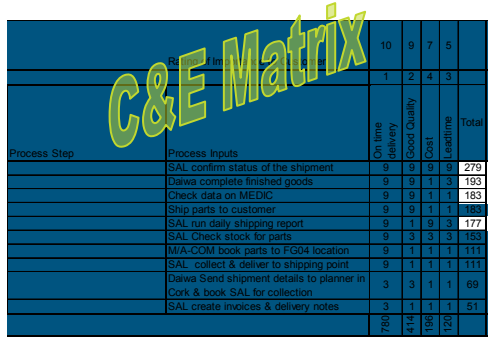
- Map flow of **Material, Information** & **Company Activity.**
- Colour coded icons simplified identification of **product & cost ownership.**
- The visual nature of this **LEAN** tool is very conducive to analysis.

Analyze Phase

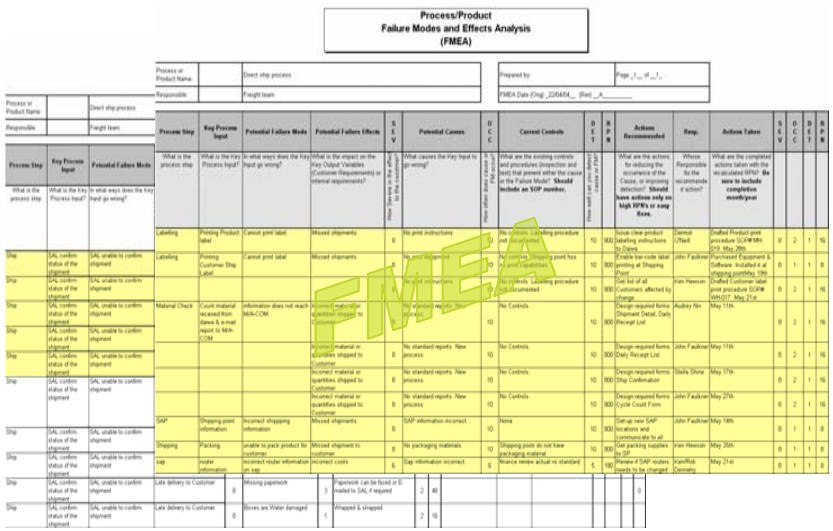




- **Translated** the Future State Value Stream map into a Traditional Process map.
- **Key Input & Output variables** were identified & these populated a Cause & Effects Matrix.
- Scoring resulted in an array of process steps & operations feeding **several FMEA's**.



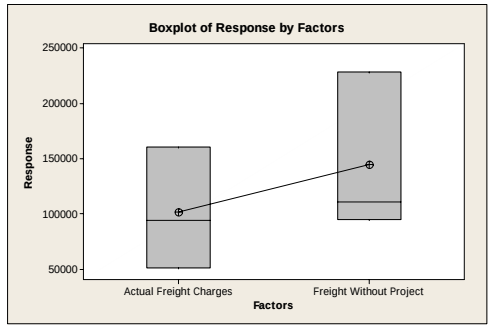
Process Step	Process Inputs	On time delivery	Good Quality	Cost	Leadtime	Total
	Rating	10	9	7	5	
		1	2	4	3	
	SAL confirm status of the shipment	9	9	9	9	279
	Daiwa complete finished goods	9	9	1	3	193
	Check data on MEDIC	9	9	1	1	183
	Ship parts to customer	9	9	1	1	183
	SAL run daily shipping report	9	1	9	3	177
	SAL Check stock for parts	9	3	3	3	153
	M/A-COM book parts to FG04 location	9	1	1	1	111
	SAL collect & deliver to shipping point	9	1	1	1	111
	Daiwa Send shipment details to planner in Cork & book SAL for collection	3	3	1	1	69
	SAL create invoices & delivery notes	3	1	1	1	51
		780	414	198	120	

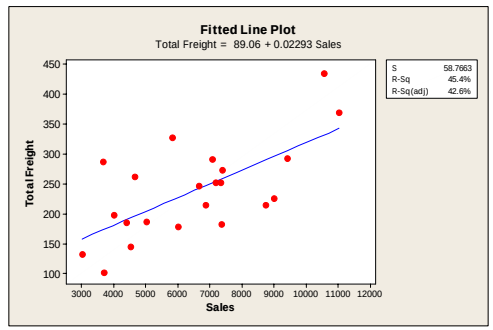


- The key **gaps** identified were:
  - **Product & Customer labelling capabilities at Subcontract & Shipping point.**
  - **Accuracy of SAP (routers etc.)**
  - **Reports & material checks.**
  - **Packaging materials.**

Improve Phase

- Obtained **Customer approval** for new process.
- **Eliminated** the need for 17 Part numbers ship to M/A-COM. Now **Ship direct to customer** from **Asia Region**
- **Transferred** product labelling process to **Asia Region** sub-contractor.
- Established **new shipping point** in **Asia Region**
- Transferred **Customer labelling** process to Shipping point.
- **Reduced the lead-time** for these products by 2-4 days (depending on customer location)
- **Transferred operators** to new products at M/A-Com Facility Facility & freed up floor space for new business.
- **Regression analysis** indicates other factors influence freight as a % of Sales. **New projects proposed** as a result of this one.





Control Phase

- **Control Plan** drafted
- **Focus** area “Shipping Process”
- Primarily physical check of product to paperwork
- **Reaction plan** for out of control situation.

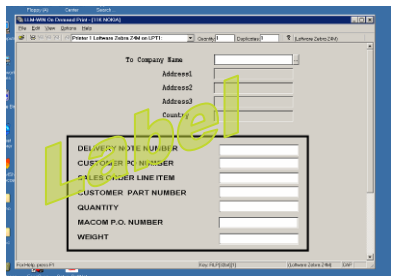
Control Plan

		Attribute/ Variable Name							
Process	Process Step	Output	Input	Process Specification	Cp, Cpk / Date	Measurement Technique	%R&R P/T	Sample Size	Sample Frequency	Control Method
Shipping	Process Material	Material process to invoice	Invoice, Product for shipping							
Shipping	Label & Pack		Customer Label, Printer, software		N/A	Visual Inspection	N/A	2	Each Shipment	Procedure

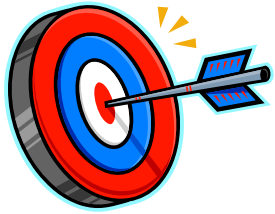
Control Plan

- MEDIC Database.Web based Oracle database that allows M/A-COM to remotely view & retrieve test data, results, Cpk etc, of product tested at subcontractor.
- E-mail alert to M/A-COM if out of control condition is reached.

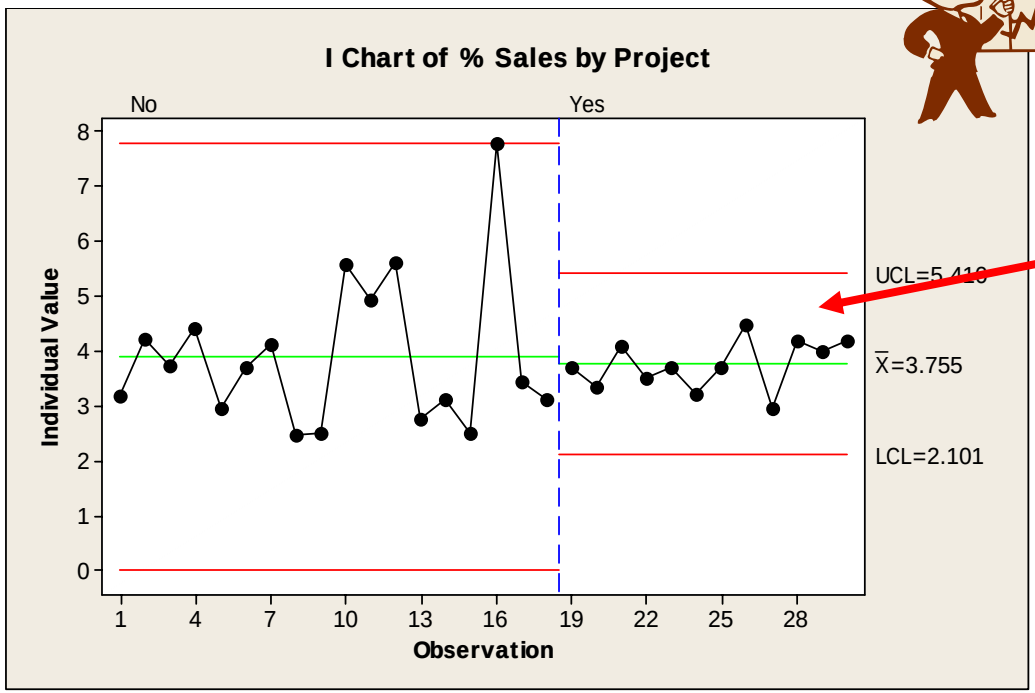
- Poka-Yoke Label system for Customer Labels
- Ensures the correct label format for our customers is selected. (different customers have different label Configurations)
- Database is pre-programmed, Human error is minimised.
- System installed at Shipping Point in New Asia Region.



Results



- Big Y - Savings



Stabilized the variation &

improved **predictability.**

Operational

Driving to the Critical “X” Wire Bonding

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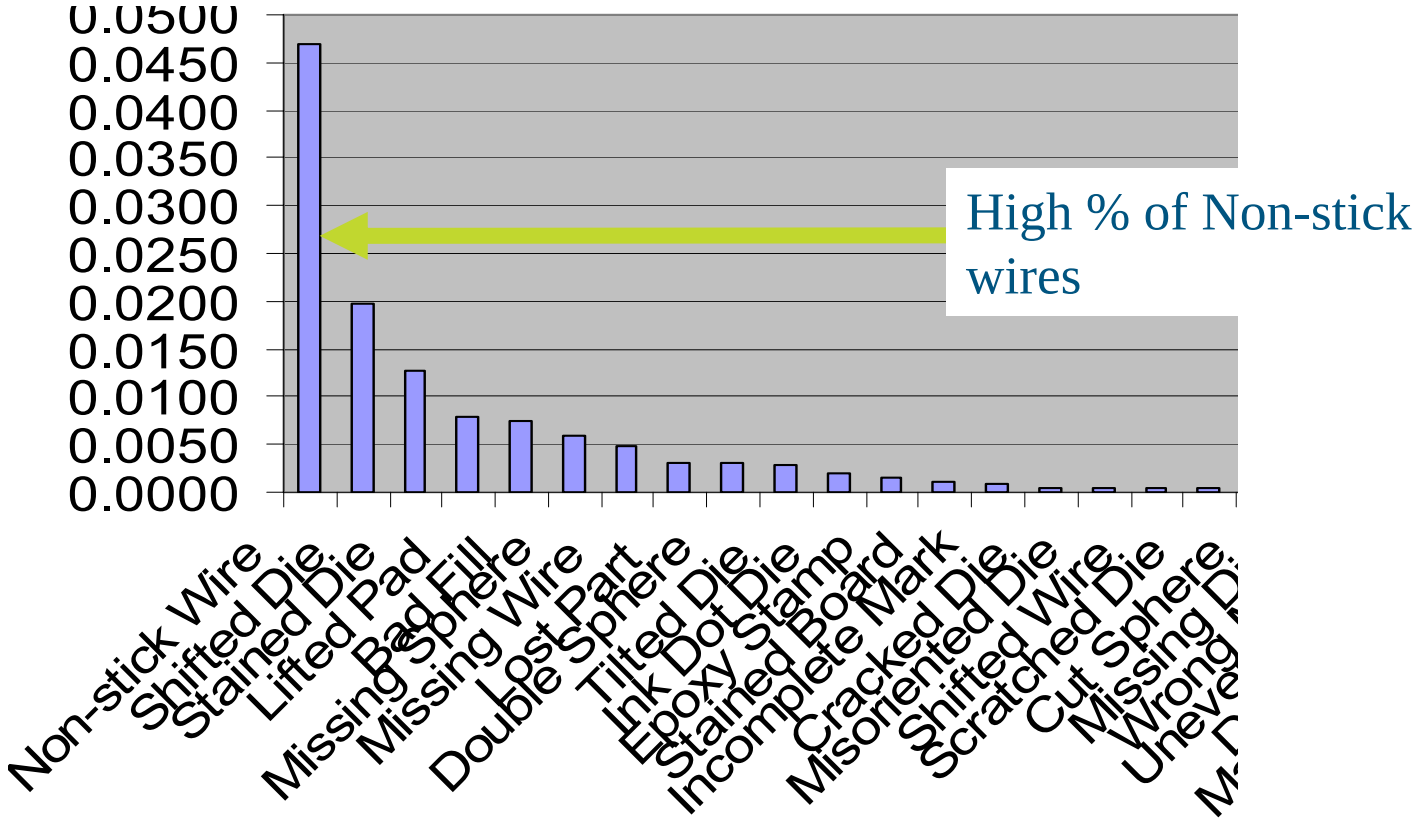
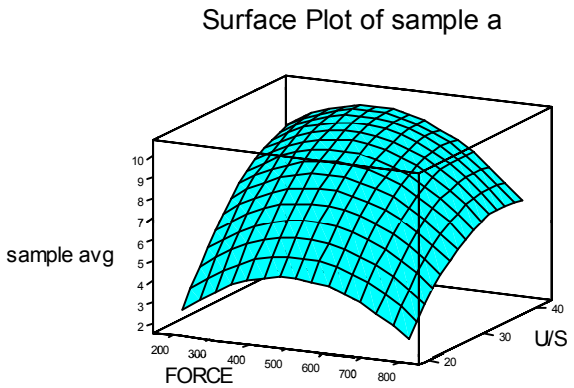
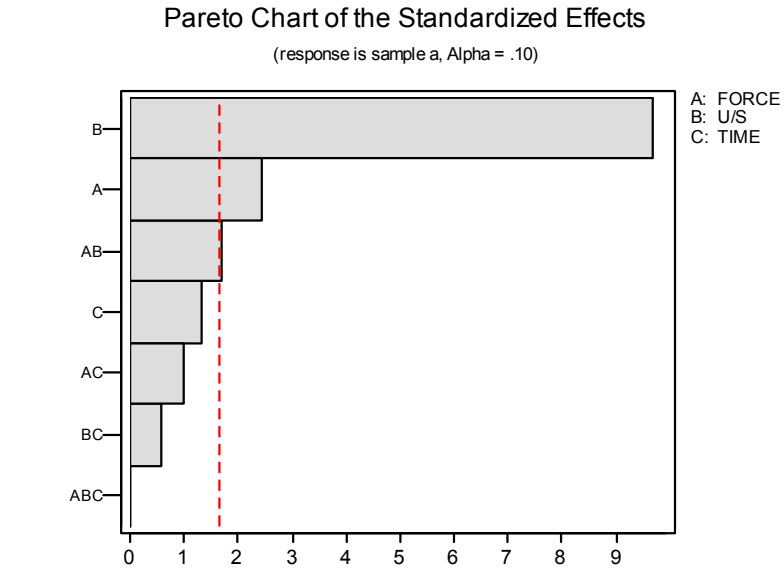
Tyco Electronics

Paretos for Assembly Defects

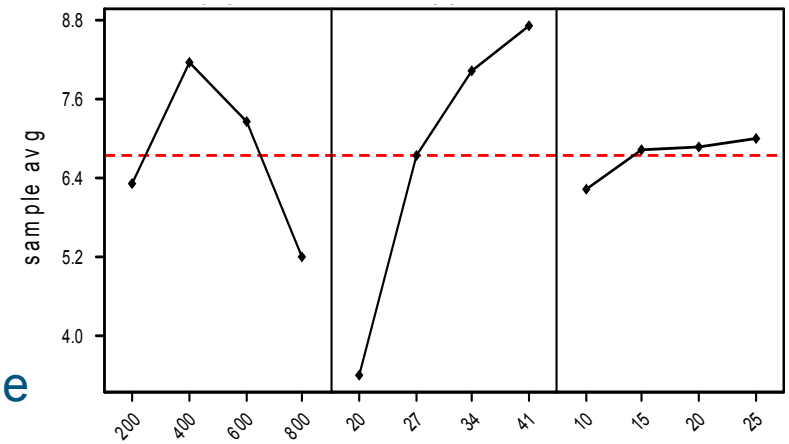


Wire Bond DOE

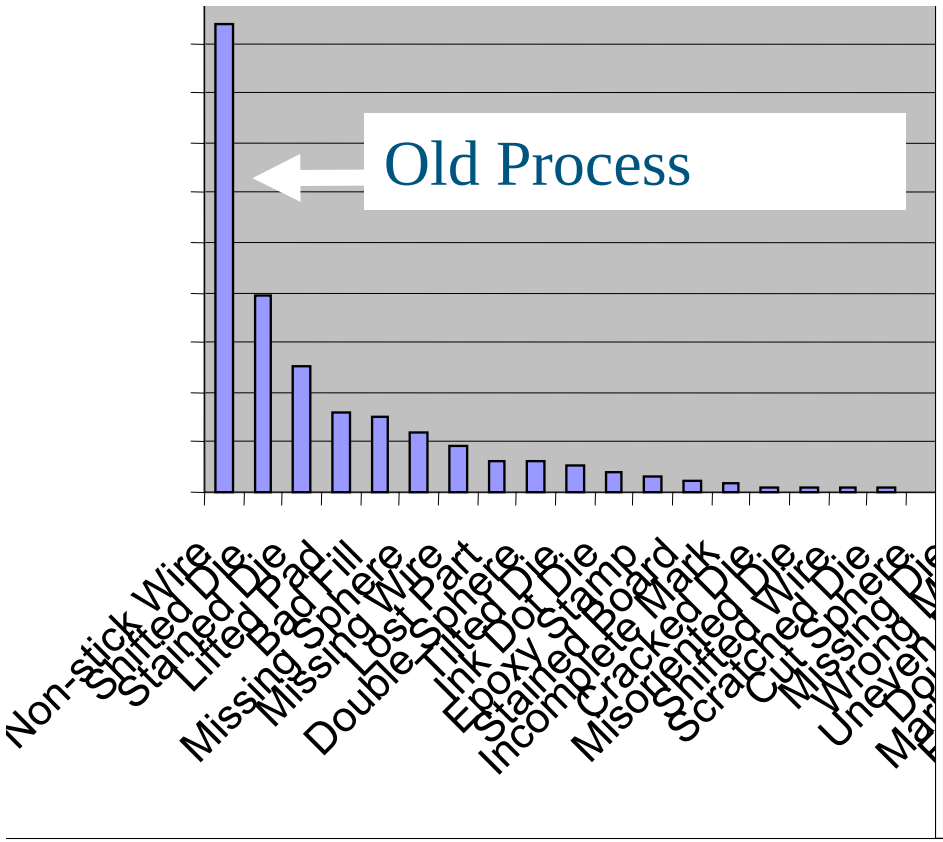


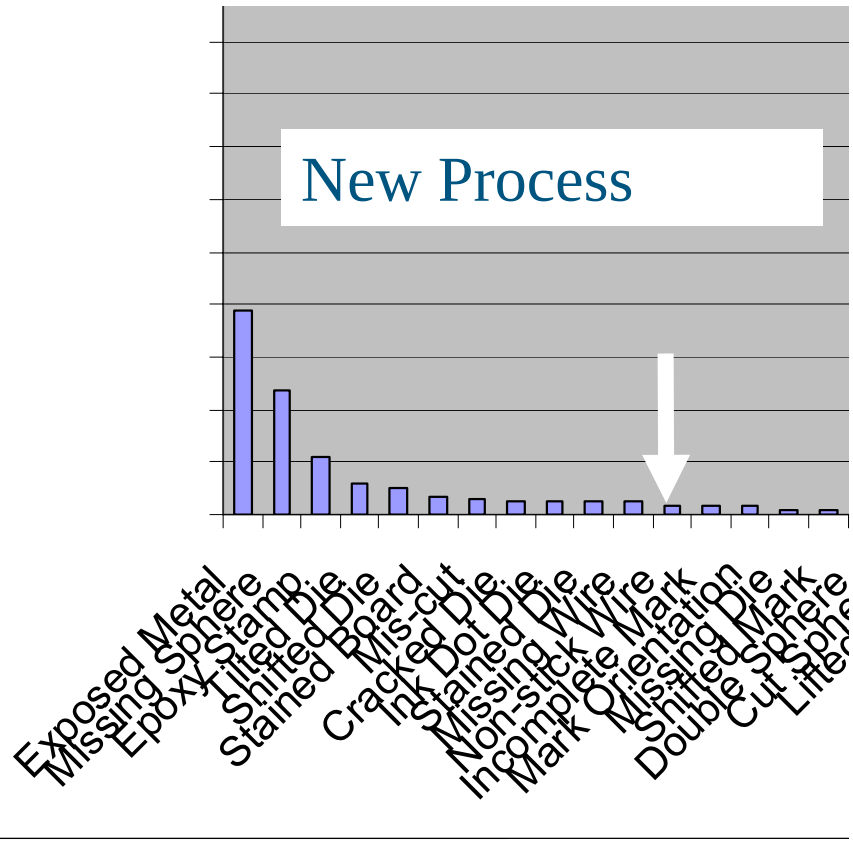


- Full Factorial DOE Design
  - 3 factors (Force, Ultrasonic Power, Time)
  - 4 levels
  - 2 replications
  - Focus on wedge bond parameters only
  - Random
  - 128 samples - 10 wires per sample
- Record destructive pull value and failure mode



Paretos for Assembly Defects





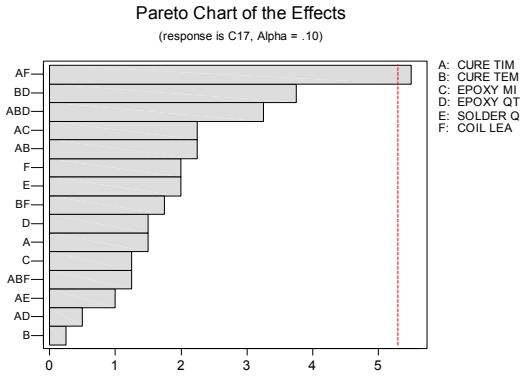
Operational

Fixing Customer Issue
DOE
Design of Experiments

Define Problem

- Tested Parts were passing at final
- Customer was seeing Very High fail rate
- Parts returned failed Freq test
- After reflow at customer freq had shifted to out of spec
- Needed immediate solution to support Customer

Screening DOE



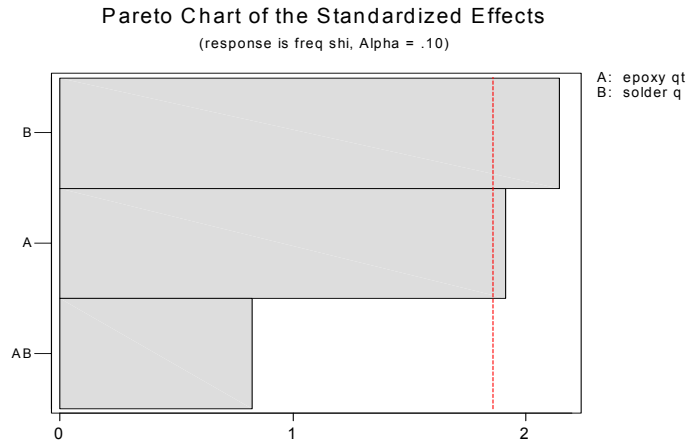
- I + CURE*CURE*EPOXY*SOLDER + CURE*EPOXY*SOLDER*COIL + CURE*EPOXY*EPOXY*COIL
- CURE + CURE*EPOXY*SOLDER + EPOXY*SOLDER*COIL + CURE*CURE*EPOXY*EPOXY*COIL
- CURE + CURE*EPOXY*SOLDER + EPOXY*EPOXY*COIL + CURE*CURE*EPOXY*SOLDER*COIL
- EPOXY + CURE*CURE*SOLDER + CURE*EPOXY*COIL + CURE*EPOXY*EPOXY*SOLDER*COIL
- EPOXY + CURE*SOLDER*COIL + CURE*EPOXY*COIL + CURE*CURE*EPOXY*EPOXY*SOLDER
- SOLDER + CURE*CURE*EPOXY + CURE*EPOXY*COIL + CURE*EPOXY*EPOXY*SOLDER*COIL
- COIL + CURE*EPOXY*SOLDER + CURE*EPOXY*EPOXY + CURE*CURE*EPOXY*SOLDER*COIL
- CURE*CURE + EPOXY*SOLDER + CURE*EPOXY*EPOXY*COIL + CURE*EPOXY*SOLDER*COIL
- CURE*EPOXY + CURE*SOLDER + CURE*CURE*EPOXY*COIL + EPOXY*EPOXY*SOLDER*COIL
- CURE*EPOXY + SOLDER*COIL + CURE*CURE*EPOXY*COIL + CURE*EPOXY*EPOXY*SOLDER
- CURE*SOLDER + CURE*EPOXY + EPOXY*COIL + CURE*CURE*EPOXY*EPOXY*SOLDER*COIL
- CURE*COIL + EPOXY*SOLDER + CURE*CURE*EPOXY*EPOXY + CURE*EPOXY*SOLDER*COIL
- CURE*EPOXY + EPOXY*COIL + CURE*CURE*SOLDER*COIL + CURE*EPOXY*EPOXY*SOLDER
- CURE*COIL + EPOXY*EPOXY + CURE*CURE*EPOXY*SOLDER + CURE*EPOXY*SOLDER*COIL
- CURE*CURE*EPOXY + CURE*EPOXY*COIL + CURE*SOLDER*COIL + EPOXY*EPOXY*SOLDER
- CURE*CURE*COIL + CURE*EPOXY*EPOXY + CURE*EPOXY*SOLDER + EPOXY*SOLDER*COIL

This is the alias structure, this tells us that factor AF is either Coil Length *Cure Temp combination or it also could be Epoxy Qty*Solder Qty combination.

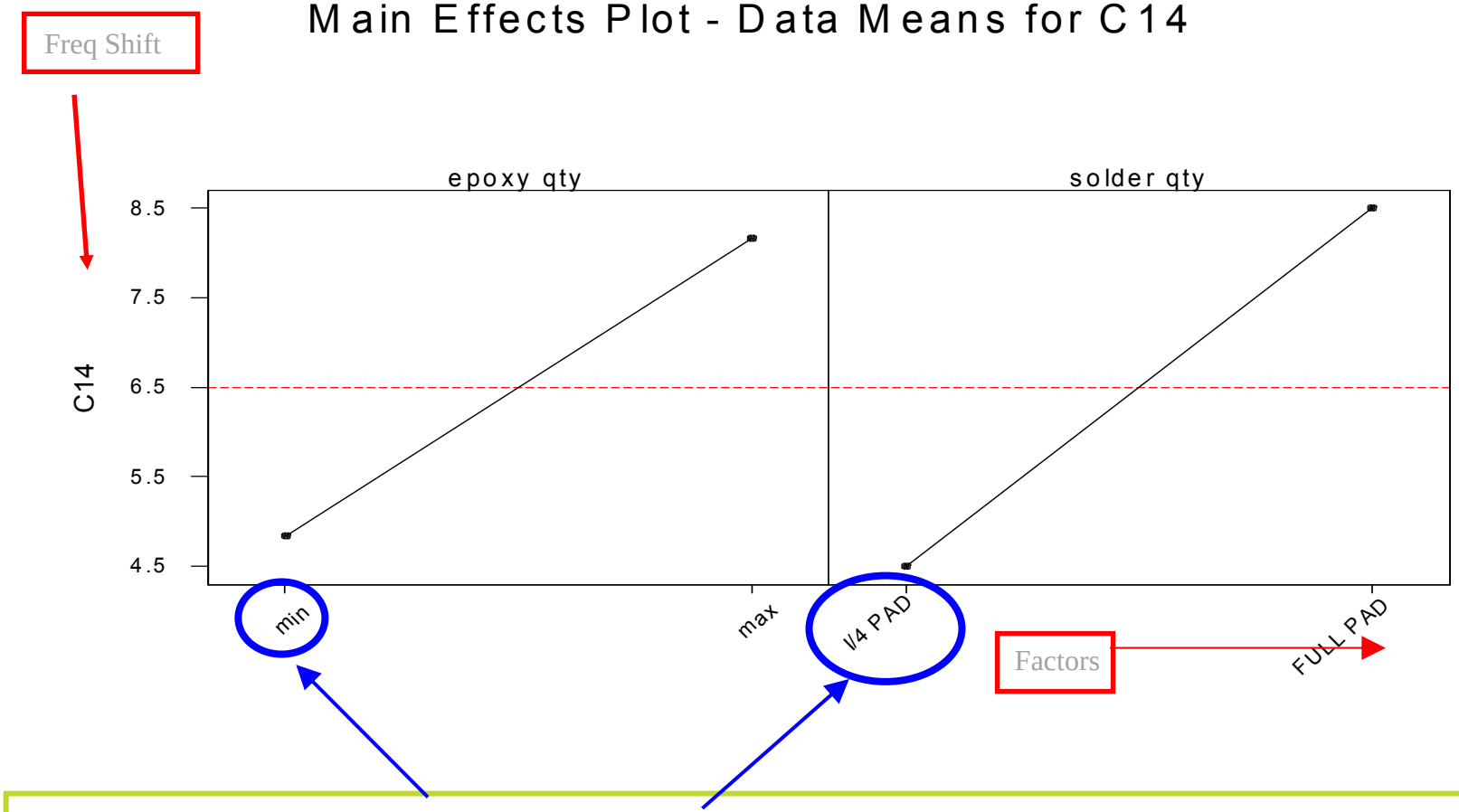
Second DOE

- Second DOE. performed on Two Factors
  - Epoxy Qty
  - Solder Qty
  - Full Factorial
  - 3 Replicates “Experiment is repeated 3 times”
  - No aliasing “All factors are independent”

Thou shalt confirm,
Thou shalt confirm



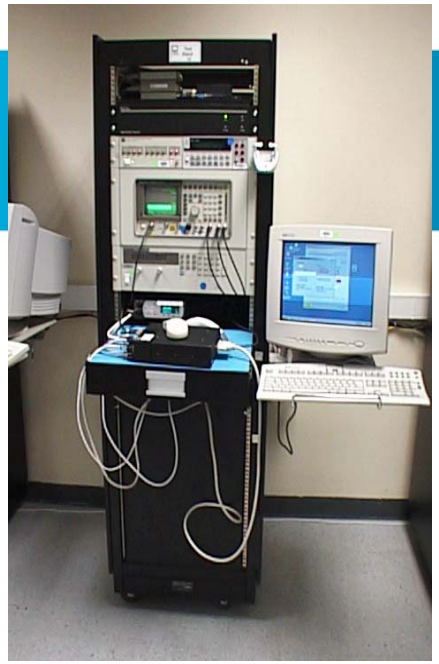
Main Effects Plot



This graph indicates which measure of Solder qty and Epoxy qty will achieve the least freq shift. As shown the least freq shift occurs with Minimum Epoxy and Minimum Solder applied.

Results

- Customer has reported no failures
  - Shipping thousands per month and growing
  - Changed 20 years of
    - ***I think***
    - ***I feel***



Measurement Systems Analysis

Source of Variation

February 23, 2007

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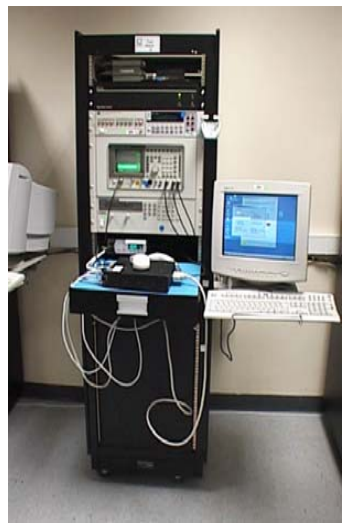
The Problem

- Common story:
  - The Unit fails test on an electrical parameter.
    - Operator then takes the unit & retests it on an alternative test stand. Unit passes!
- Why is it better? All stands should be the same.
- What is different? Do we have a problem?



Define The Problem

- This problem occurred in Manufacturing
- There were three test stands involved.
- The parameter of interest (known as the “Y”) Current.
- The factors (“X’s”) are the components of the test stand.

$$Y = f(x_1 \ x_2 \ x_3 \ldots\ldots x_n)$$

Measure The Problem

- Gathered some data.
- Conducted an ANOVA
- Established test stand B was statistically different to stand A & C.

One-way ANOVA: tx_current versus test_stand

Analysis of Variance for tx_current

Source	DF	SS	MS	F	P
test_sta	2	1.579	0.789	4.88	0.028
Error	12	1.942	0.162		
Total	14	3.521			

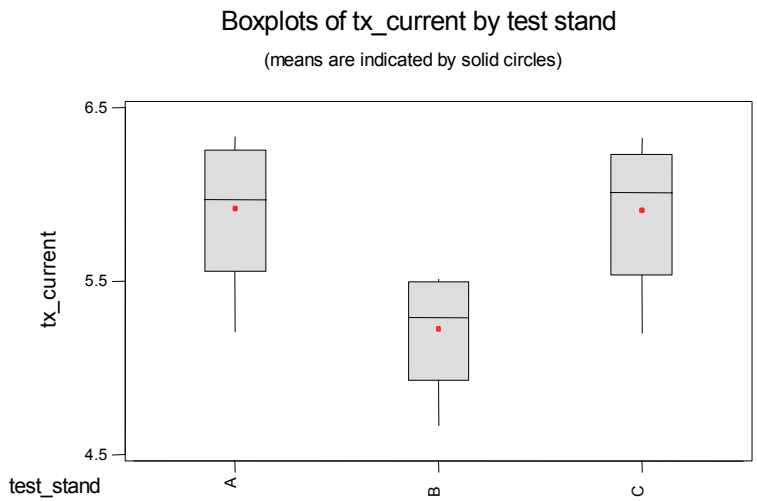
Individual 95% CIs For Mean

Based on Pooled StDev

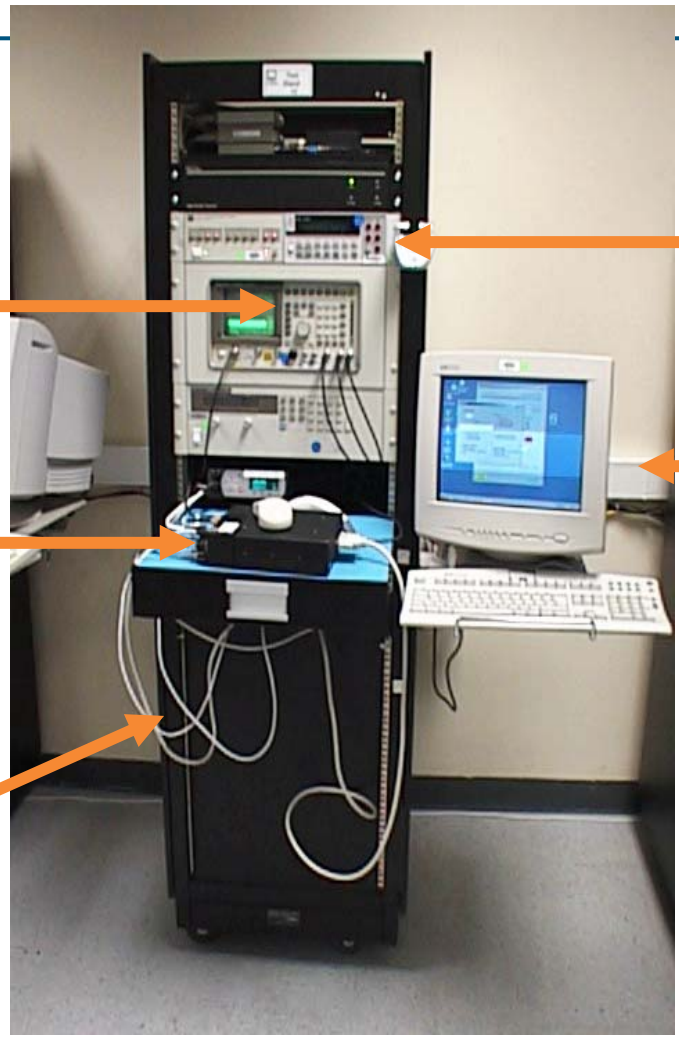
Level	N	Mean	StDev	----------+---------+---------+------
A	5	5.9184	0.4314	(---------*---------)
B	5	5.2260	0.3394	(---------*--------)
C	5	5.9100	0.4292	(---------*---------)

----------+---------+---------+------

Pooled StDev = 0.4023 5.20 5.60 6.00

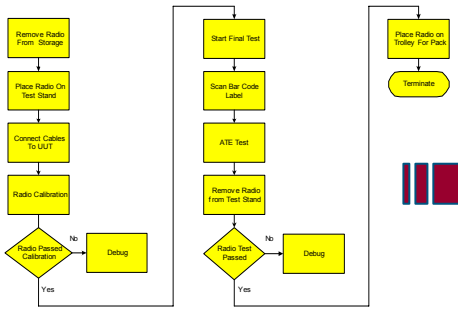


The Test Stand



Identify the X's

Basic Process Map



Use C&E to identify key operations

	Process Step	Process Input	Electrical Fail	Visual Fails	Test Yields	Test Software	Application Sc	Total
7	M03 Final Test	ATE Test	9	0	9	3	3	195
4	M03 Final Test	Radio Calibration	9	0	9	3	3	195
3	M03 Final Test	Connect Cables To UUT	3	0	3	0	0	60
1	M03 Final Test	Remove Radio From Storage	0	1	0	0	0	5
9	M03 Final Test	Place Radio On Trolley for Rack	0	0	0	0	0	0
8	M03 Final Test	Remove Radio From Test Stand	0	0	0	0	0	0
6	M03 Final Test	Scan Bar Code Label	0	0	0	0	0	0
5	M03 Final Test	Start Final Test	0	0	0	0	0	0
2	M03 Final Test	Place Radio On Test Stand	0	0	0	0	0	0

Add KPIV & KPOV

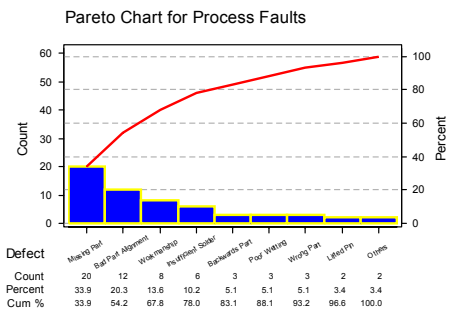
PK (Processing Kernel) PCB	C
HPA (High Power Amplifier) PCB	C
XCVR (Transceiver) PCB	C
Trained operator	C
PC Mouse	U
Radio Final Test Procedure	C
Test Software	U
Mains Power	U
PC	U
PC Monitor	U
Printer	U
DC Power Supply	C
20dB 50W Attenuator	C
20dB 1W Attenuator	C
Hybrid combiner	C
Voltage Variable Attenuator 0-11dB	C
Voltage Variable Attenuator 0-110dB	C
HP11713A Attenuator/Switch Driver	C
Duplexer	C
Power Divider (PD032) X 2	C
40dB Pad	C
ATE Silver Box	C
Internal Test Stand Cabling	C
DUT Cabling	U
Application S/W	C

Radio Calibration → Calibrated Radio Results logged to database

Use C&E to identify key X's

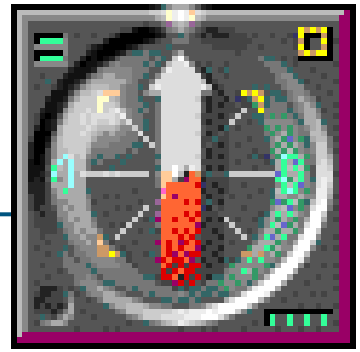
	Process Step	Process Input	Electrical Fail	Visual Fails	Test Yields	Test Software	Application Sc	Total
7	M03 Final Test	ATE Test	9	0	9	3	3	195
4	M03 Final Test	Radio Calibration	9	0	9	3	3	195
3	M03 Final Test	Connect Cables To UUT	3	0	3	0	0	60
1	M03 Final Test	Remove Radio From Storage	0	1	0	0	0	5
9	M03 Final Test	Place Radio On Trolley for Rack	0	0	0	0	0	0
8	M03 Final Test	Remove Radio From Test Stand	0	0	0	0	0	0
6	M03 Final Test	Scan Bar Code Label	0	0	0	0	0	0
5	M03 Final Test	Start Final Test	0	0	0	0	0	0
2	M03 Final Test	Place Radio On Test Stand	0	0	0	0	0	0

Pareto the X's



Some Direction!!

The Direction



- The direction the data lead the Belt was to the connectors. The interface between the cables & the unit under test.
- Upon investigation, test stand B used a push on connector, test stand A & C did not.
- The Belt had the connector changed to match the two other stands.
- The tests conducted initially were run once again & the data collected.

Measure The Problem

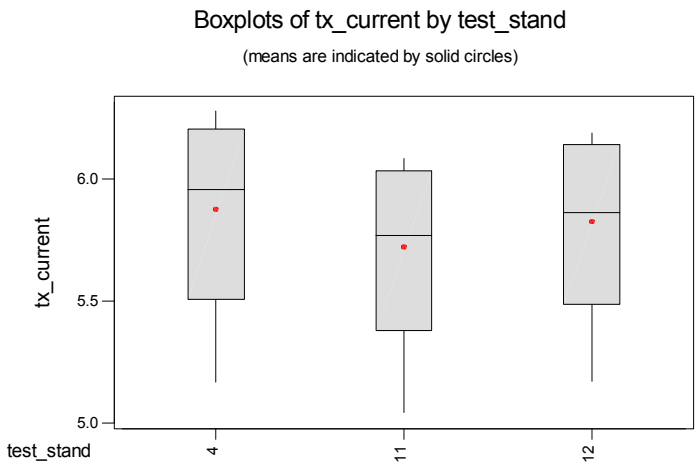
- Conducted an ANOVA on data
- Result. Statistically all three test stands are the same.
- Problem solved

One-way ANOVA: tx_current versus test_stand

```
Analysis of Variance for tx_curre

Source     DF        SS        MS        F        P
test_sta    2     0.062     0.031     0.18    0.834
Error      12     2.030     0.169
Total      14     2.092

                                  Individual 95% CIs For Mean
                                  Based on Pooled StDev
Level       N      Mean     StDev  ---+---------+---------+---------+---
 A          5    5.8740    0.4281       (-------------*------------)
 B          5    5.7190    0.4070  (-------------*------------)
 C          5    5.8230    0.3981      (------------*------------)
                                  ---+---------+---------+---------+---
Pooled StDev =   0.4113            5.40      5.70      6.00      6.30
```



Six Sigma in our Daily Lives

Pinewood Derby

Resolving Conflict with Data

February 23, 2007

tyco Electronics MACOM

Tyco Electronics

Back Ground

Cars, Kids, Track, Parents

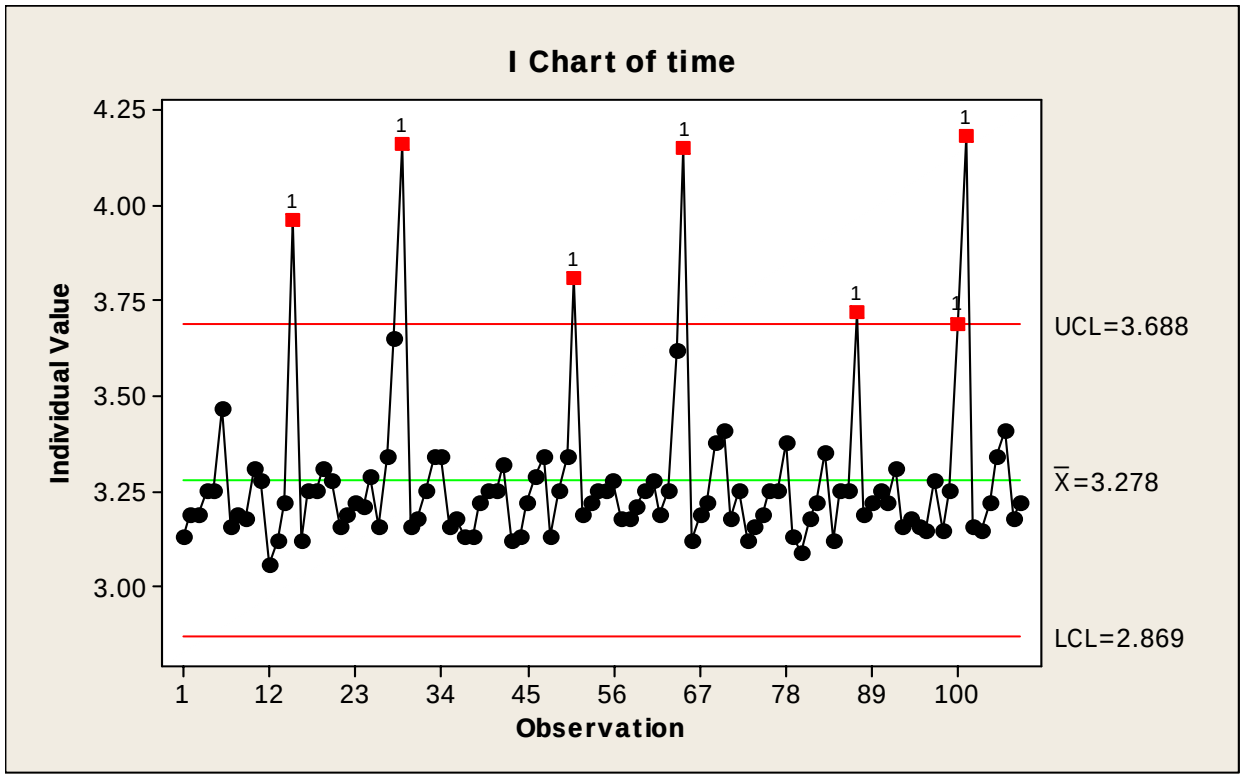
Vs

Data

Problem

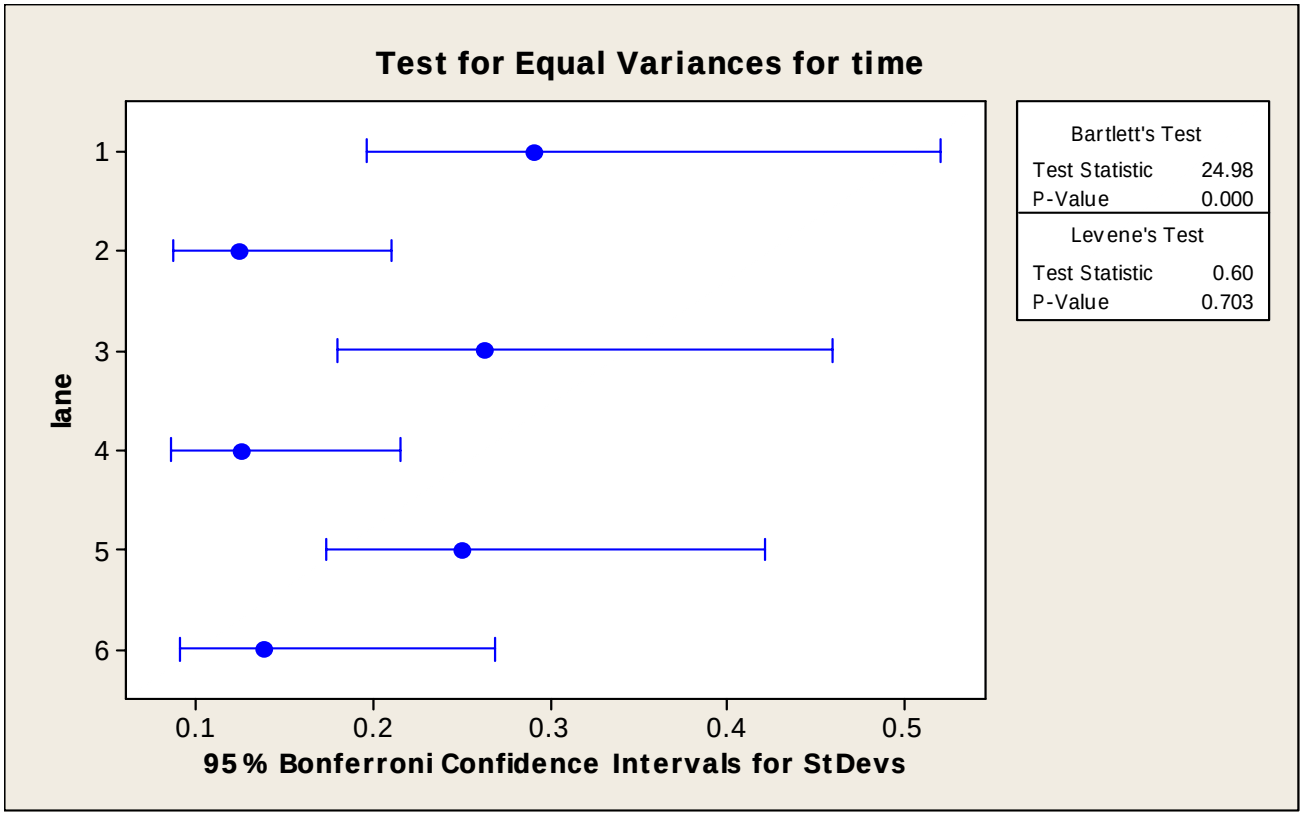
- Ho = The Scout's Cars are not affected by lane run on
- Ha = The lane the Scout's Cars is run on affects the time

First Look



All lanes are non-normal

How are the cars placed



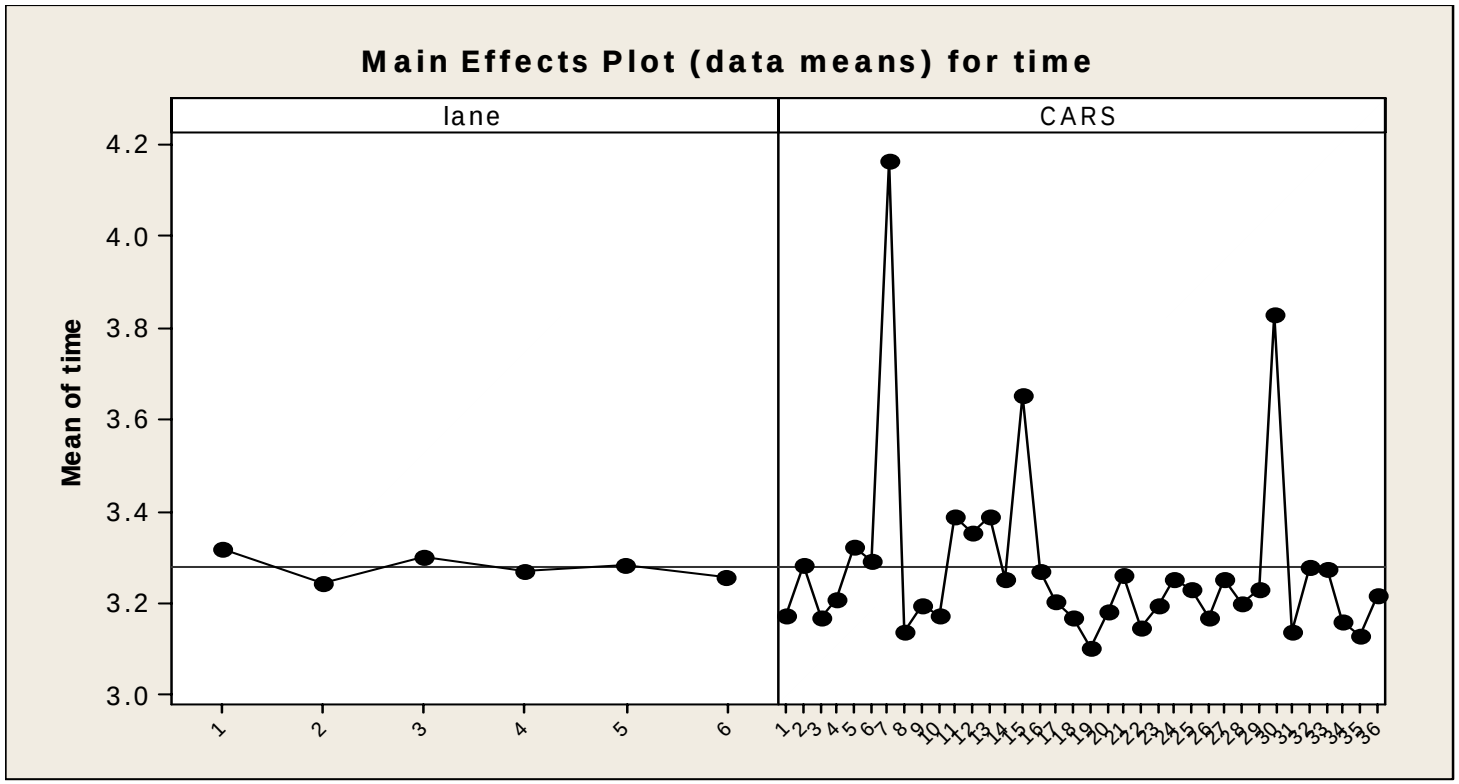
Very Clear No Lane Bias

- **One-way ANOVA: time versus lane**

- Source DF SS MS F P
- lane 5 0.0699 0.0140 0.31 0.903
- Error 102 4.5324 0.0444
- Total 107 4.6022

- S = 0.2108 R-Sq = 1.52% R-Sq(adj) = 0.00%

Car's are Driving the Time



Median Test Confirmed No lane Bias

Mood Median Test: time versus lane

Mood median test for time

Chi-Square = 1.11 DF = 5 P = 0.953

Question on Normality
Double Check

lane	N<=	N>	Median	Q3-Q1	Individual 95.0% CIs
1	9	8	3.220	0.165	(----------*----------)
2	11	9	3.220	0.085	(-------*-----)
3	10	8	3.220	0.150	(---------*----------)
4	8	11	3.250	0.150	(------*--------)
5	11	9	3.190	0.115	(-*----------)
6	8	6	3.220	0.085	(-----*------)

3.200 3.250 3.300

Driving for Excellence in Every Thing We Do

- Optimizing Processes to their fullest Advantage
  - Leveraging Lean for Cycle Time and Inventory
  - Removing Opportunities with Six Sigma
  - Designing it On Time, at the Right Price, and Right the First Time with DFSS

- Making Continuous Improvement

Just the way we do our jobs each day!

QUESTIONS

Thank You

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