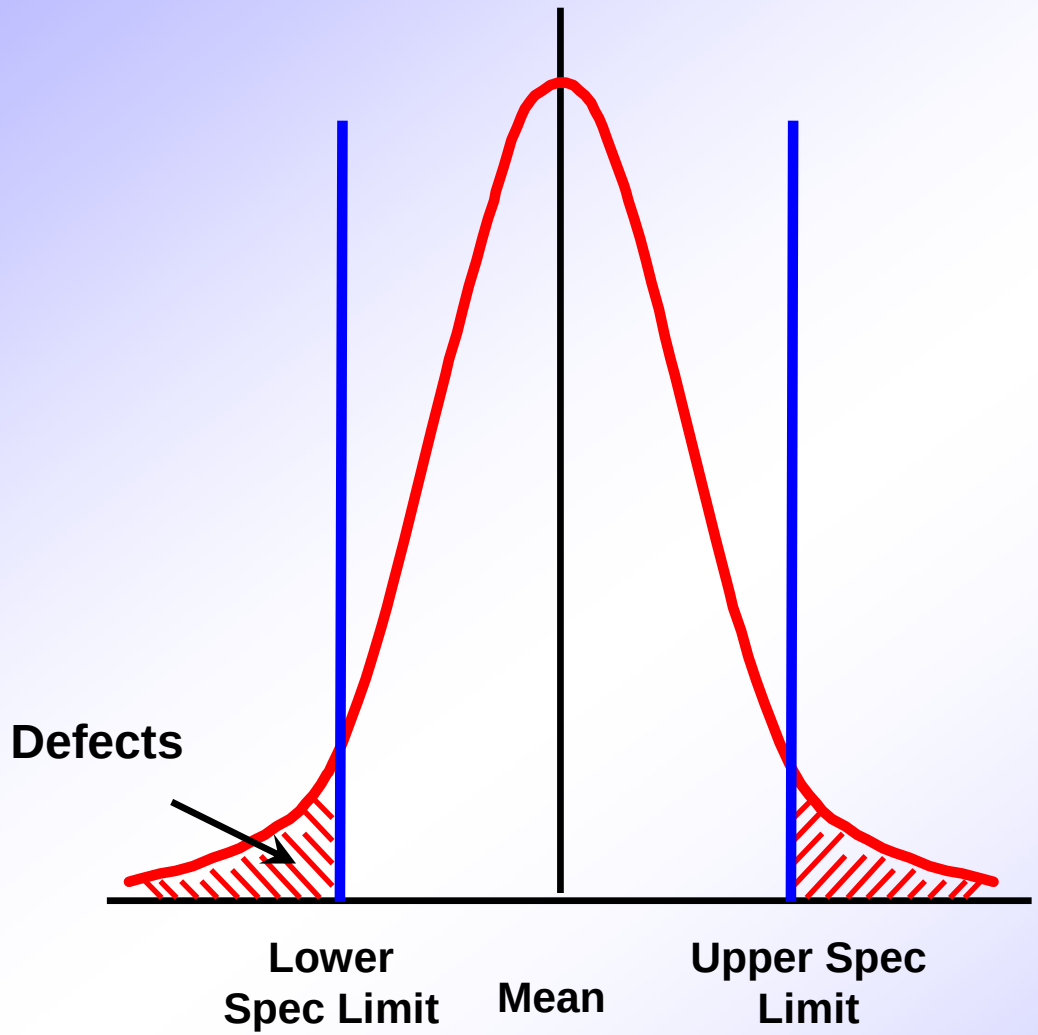
Six Sigma Optimization - MAIC -

Objectives

- Review definition of Defect and Sigma Level
- Describe generic MAIC Process flow
- Highlight the MAIC Process via example
- Explain “What’s different about MAIC” from traditional Engineering Design approach?

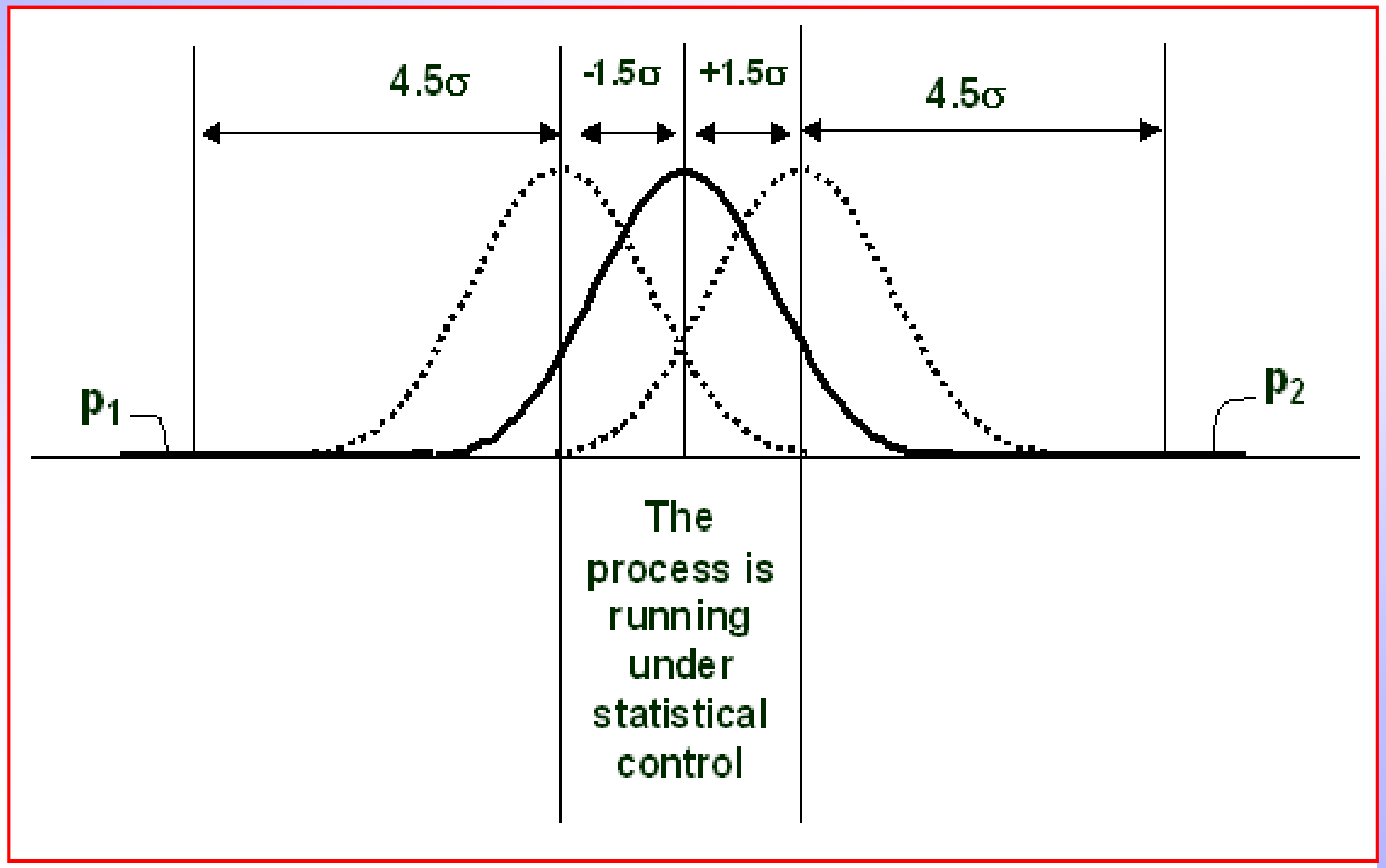
Refresher from Six Sigma Overview . . .



Sigma Level	% Out of Spec
6	0.00034
5	0.02327
4	0.62097
3	6.68072
2	30.85375
1	69.1462

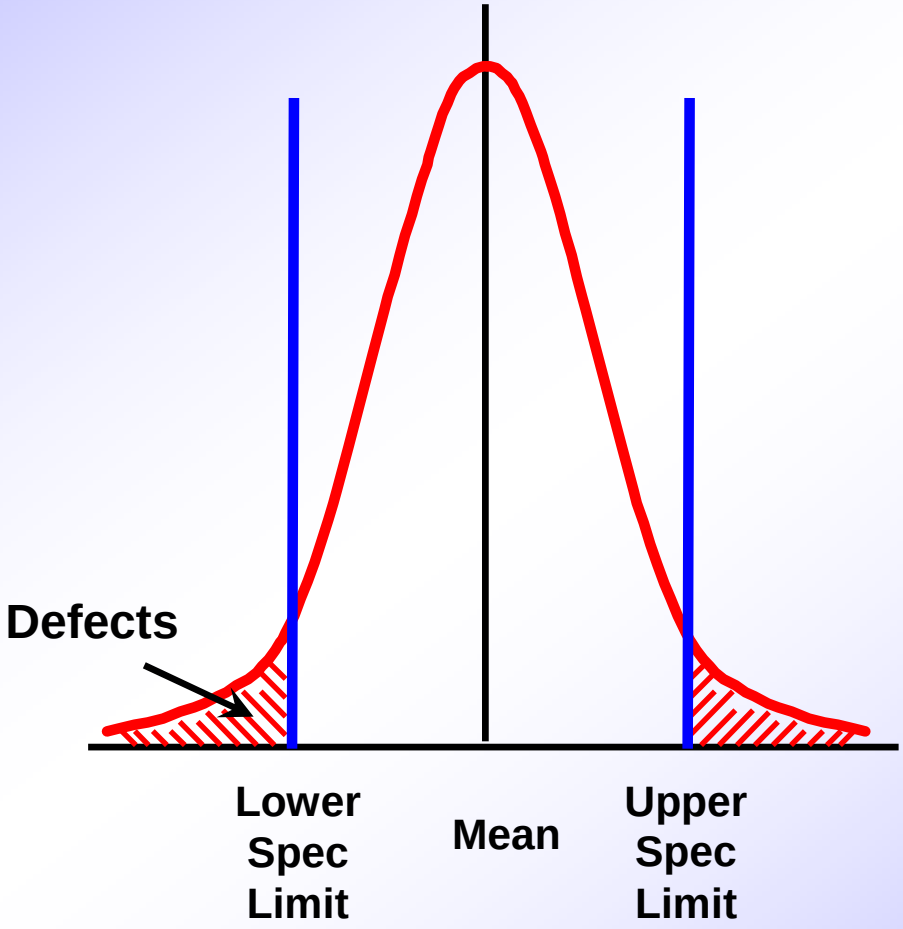
Assuming a Long Term 1.5 Sigma Shift

Long Term there can be a +/- 1.5 Sigma Shift



MAIC Has Two Goals:

1) Shift Mean to new Target Specification
2) Reduce Variability – narrow distribution to achieve desired Sigma Performance



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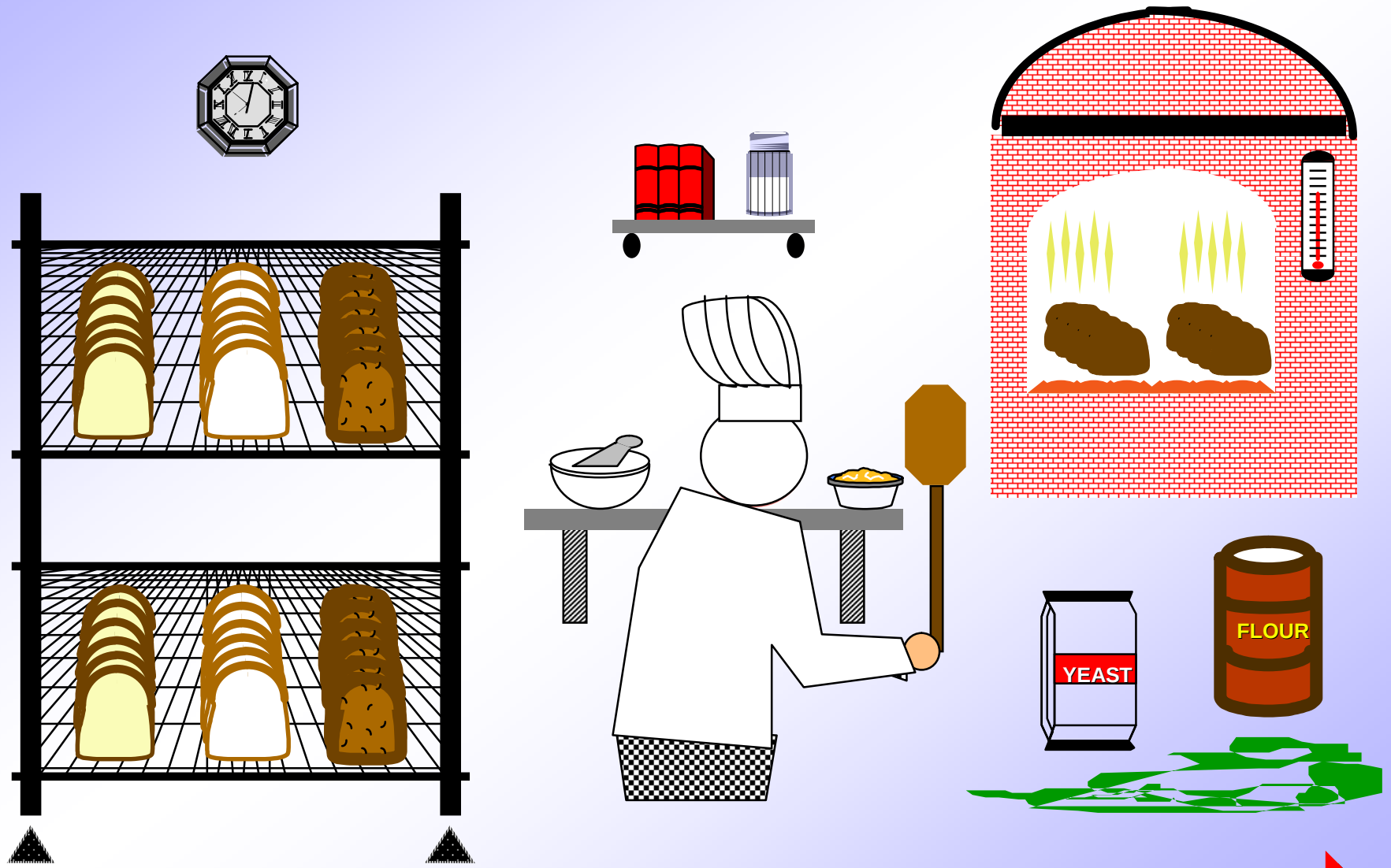
Assuming a Long Term 1.5 Sigma Shift

Example: Better Bread Company

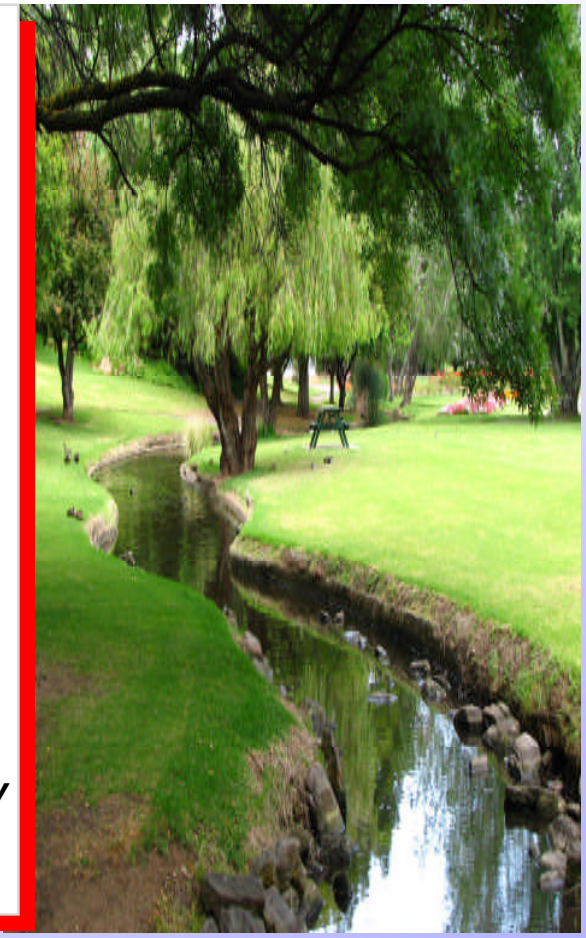
The “Better Bread” Company



Using a 12 Step “Cookbook” Process

Six Sigma Breakthrough Strategy
Product…..Process…..Service

"Strategy"	*"Cookbook"*	
***M**easure*	→	*1 Identify Critical Variables* *2 Define Measurement System* *3 Validate Measurement System*
		Characterize
***A**nalyze*	→	*4 Establish Current Sigma Capability* *5 Define Performance Objectives* *6 Identify Sources of Variation*
***I**mprove*	→	*7 Screen Potential Root Causes* *8 Discover Variable Relationships* *9 Establish Operating Tolerances*
		Optimize
***C**ontrol*	→	*10 Validate Measurement System* *11 Determine Improved Sigma Capability* *12 Implement Control Plan*



Step 1 ..... Identify Critical Variables (CTQs or Y)

What is Important to the Customer?

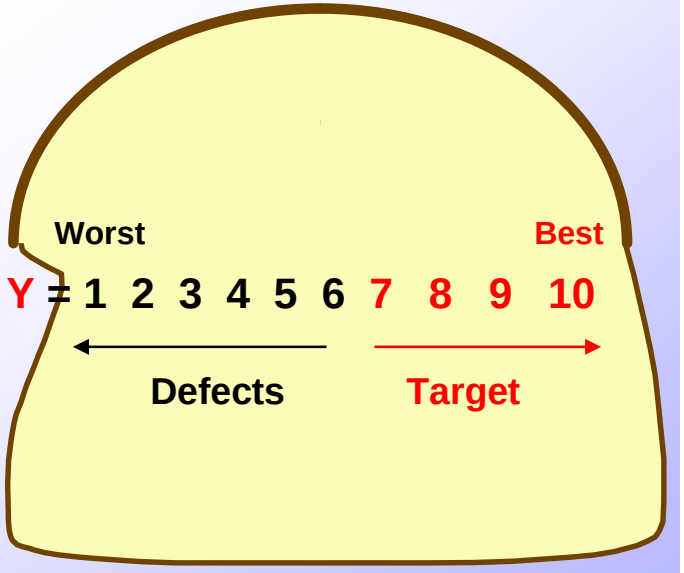
- Rise
- Texture
- Smell
- Freshness
- Taste

Y = Taste!!

Step 2 ..... Define Measurement System for CTQs, or Y

How could we measure Taste?

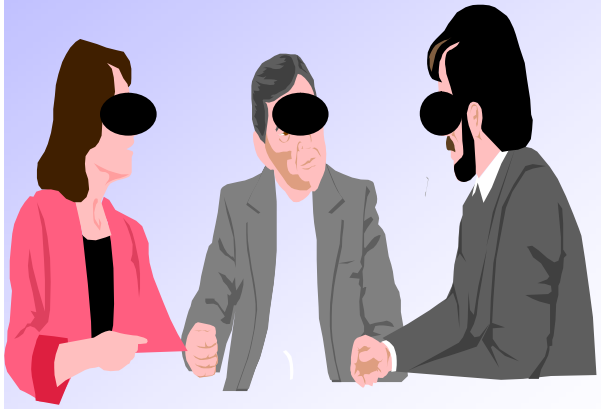
- Panel of Tasters
- Rating System of 1 to 10
- Target: Average Rating at 8
- Desired: No Individual Ratings ("defects") Below 7

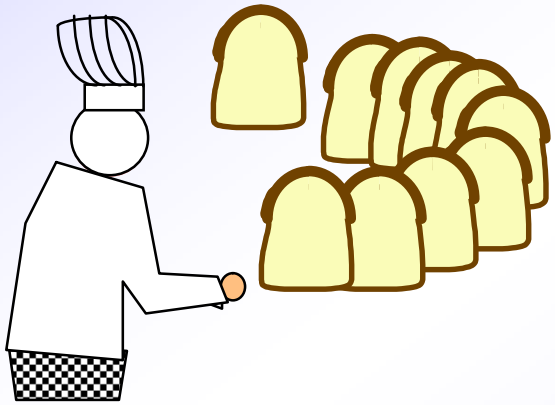


But ..... Is this the Right System?

Step 3 ..... Validate the Measurement System for Y

How Could We Approach This?





- Blindfolded Panel Rates Several Loaf Samples
- Put "Repeat" Pieces from Same Loaf in Different Samples
- Consistent Ratings* on Pieces from Same Loaf = "Repeatability"
- Consistent Ratings* on Samples Across the Panel = "Reproducibility

Panel Member	Loaf 1	Loaf 2	Loaf 3
A	5	8	9
B	4	9	1
C	4	9	2
D	8	9	8
E	4	8	2
F	5	9	1
G	8	9	2

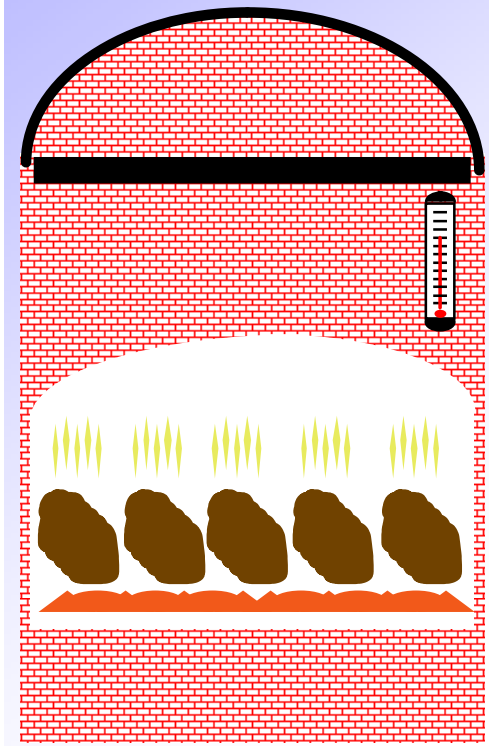
* Within ± One Taste Unit

"Repeatability" &"Reproducibility" Suggest Valid Measurement Approach

Analyze

Step 4 ..... Establish Current Sigma Capability for Y (Taste)

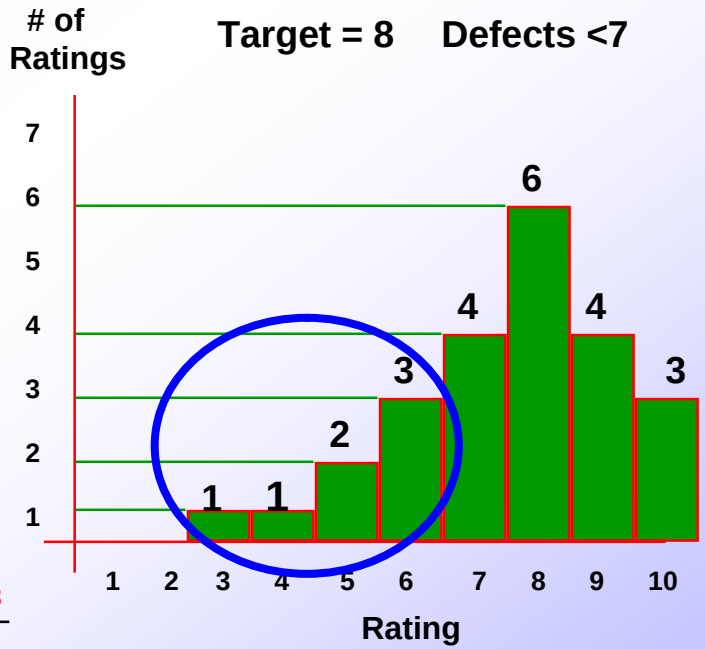
How Do We Approach This?



- Bake Several Loaves Under "Normal" Conditions
- Have Taster Panel Again Do the Rating
- Average Rating is 7.4

$$\frac{3 \times 10 + 4 \times 9 + 6 \times 8 + 4 \times 7 + 3 \times 6 + 2 \times 5 + 1 \times 4 + 1 \times 3}{1 + 1 + 2 + 3 + 4 + 6 + 4 + 3}$$

- But Variation is too Great for a 6σ Process



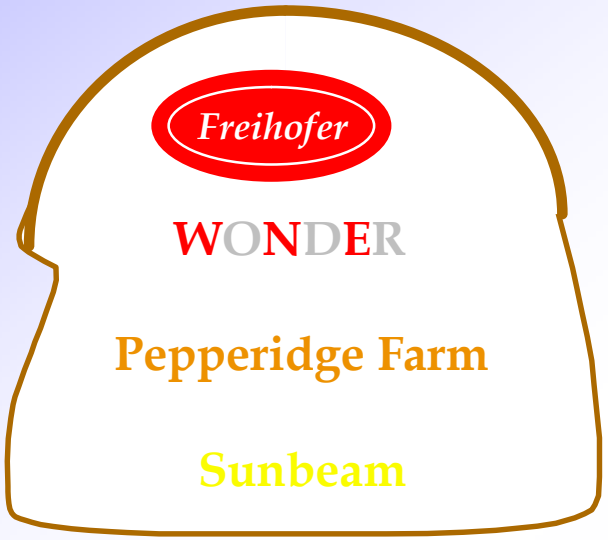
$$\frac{\text{7 Defects (}\textit{ratings below 7}\text{)}}{\text{24 Ratings (}\textit{from our panel}\text{)}} = .292$$

OR 292,000 Defects per 1,000,000 Loaves

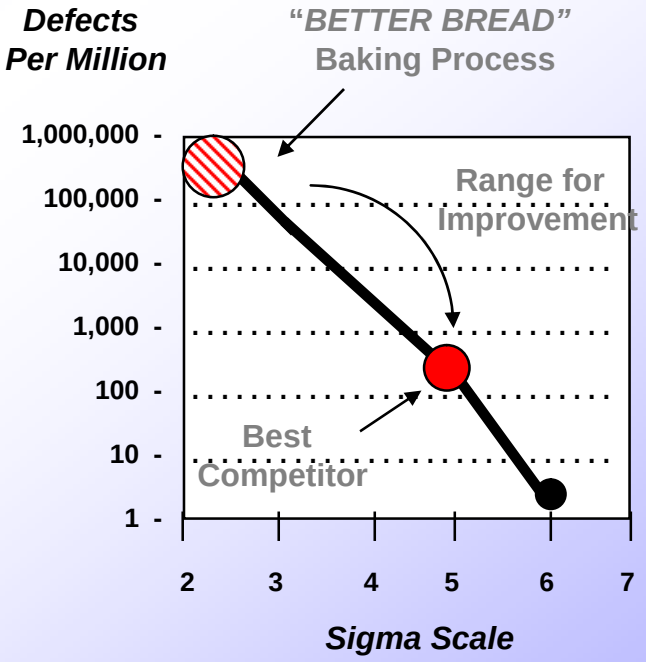
This is only a 2σ Process!

Step 5 ..... Define Performance Objectives for Y (Taste)

How do we Define Improvement?



- Benchmark the Competition
- Focus on Defects (i.e. taste rating < 7)
- Determine What is an "Acceptable Sigma Level"
- Set Improvement Objectives Accordingly

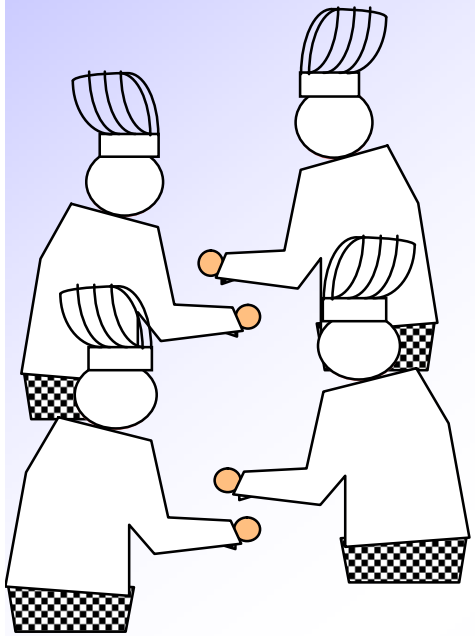


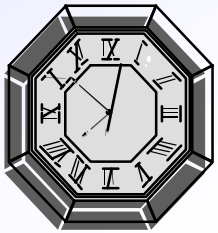
Maybe a 5σ Process Will Suffice!

Step 6 ..... Identify Sources of Variation in Y (Taste)

How do we Determine Potential Sources of Variation (Xs)?

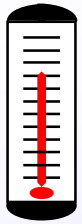
Have the Chefs Brainstorm



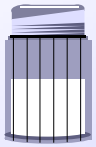


Bake Time

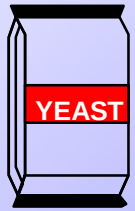
Flour Brand



Bake Temp.



Amount of Salt



Yeast Brand

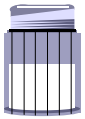
Multiple Sources: Chefs, Suppliers, Controls

Step 7 ..... Screen Potential Root Causes of Variation (Xs)

Improve

How do we Screen for Causes of Variation (Xs)?

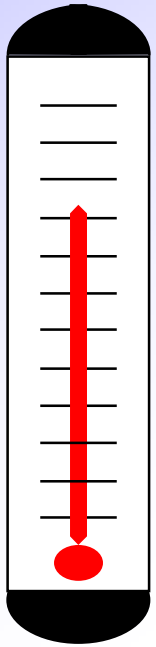
- Perform Designed Experiment
- Use Different Sources of Potential Variation
- Have Panel Rate the Bread from the Experiment
- Results Lead to the "Vital Few" Root Causes

Source	Conclusion
	Negligible
	Major Cause
	Negligible
	Major Cause
	Negligible

Focus on The "Vital Few" Variables

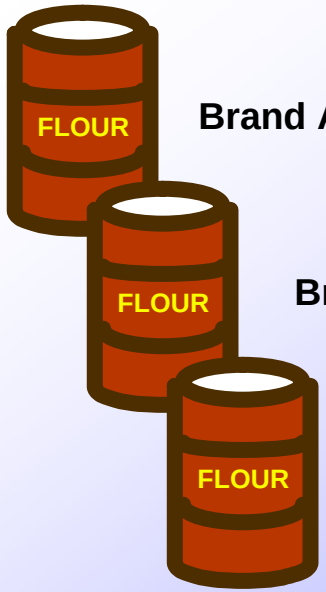
Step 8 ..... Discover Relationships Between "Vital Few" (Xs) and Y

How do we Find the Relationship Between the "Vital Few" (Xs) and Taste (Y)?



- Conduct a More Detailed Experiment
- Focus: Oven Temperature from 325 ° to 375 ° and 3 Brands of Flour
- RUN# TEMP BRAND

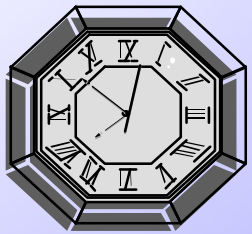
RUN#	TEMP	BRAND
1	325	A
2	325	B
3	325	C
4	350	A
5	350	B
6	350	C
7	375	A
8	375	B
9	375	C



Brand A ✓

Brand B

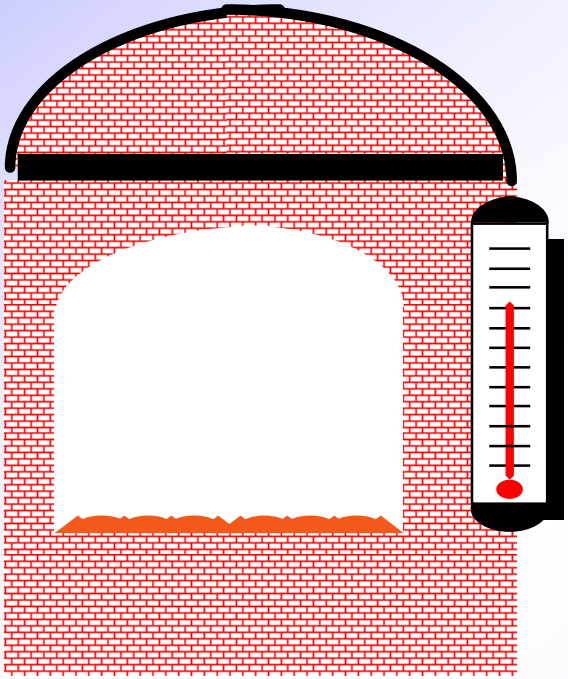
Brand C



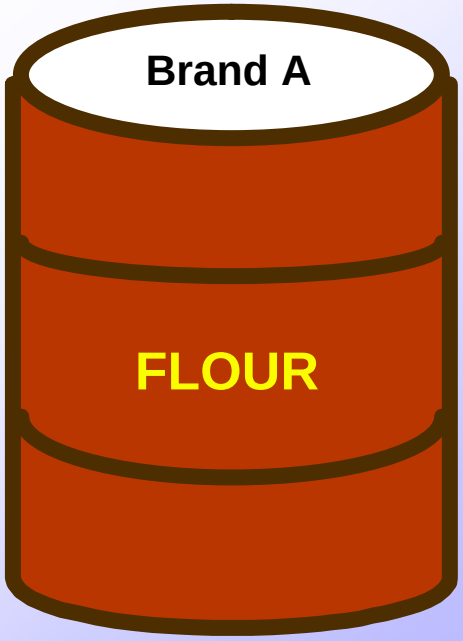
Note: Time is a Factor Only if Temperature Changes Significantly

Results: 350° & Brand A is Best Combination of Temperature & Flour

Step 9 ..... Establish Tolerances on "Vital Few" (Xs)

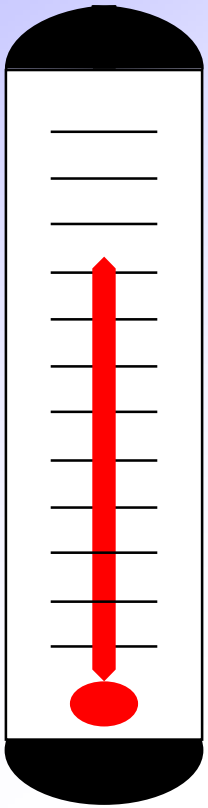


- Data Suggests 350° (± 2°) is best Temperature to Reduce Taste Variation
- Brand A Flour to be Used Except in Case of Emergency
- *"BETTER BREAD"* to Search for Better Alternative Supplier of Flour Just in Case

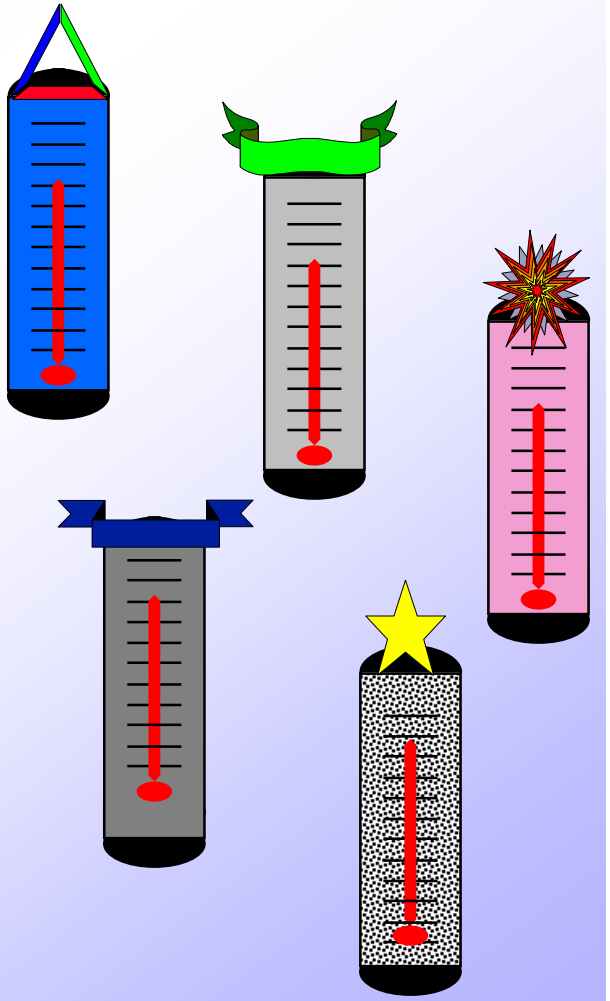


But ..... Is Our Measurement System Correct?

Step 10 ..... Validate the Measurement System for Xs



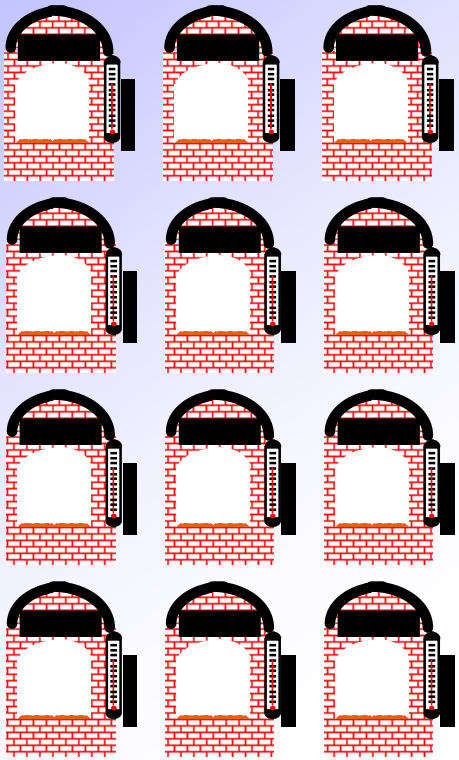
- Need to Verify the Accuracy of Our Temperature Gauges
- Need for "Benchmark" Instrumentation for Comparison
- Rent Some Other "High End" Gauges
- Compare the Results



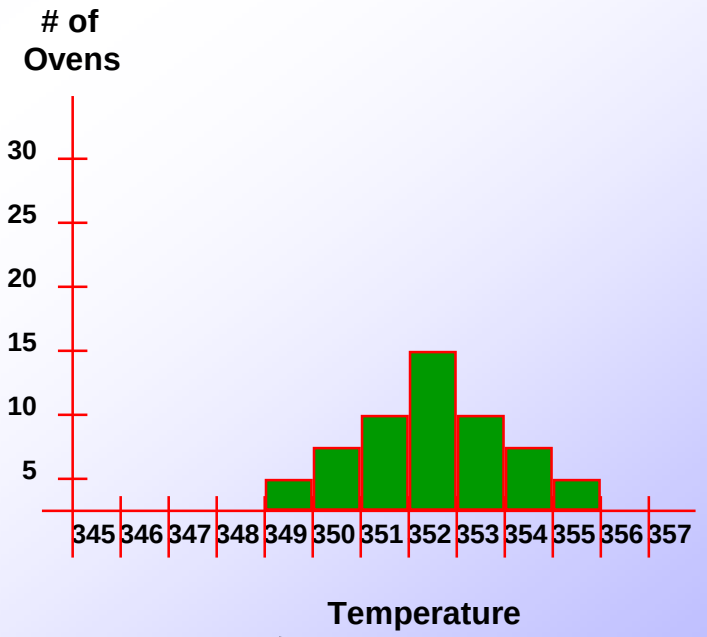
Verify that our Instruments are Accurate

Step 11 ..... Determine Improved Sigma for Vital Few Xs

How Could We Approach This?



- Check all of Better Bread Ovens
- Monitor Temperatures Over Time
- Focus on the Process Capability
- Look for Degree of Variation



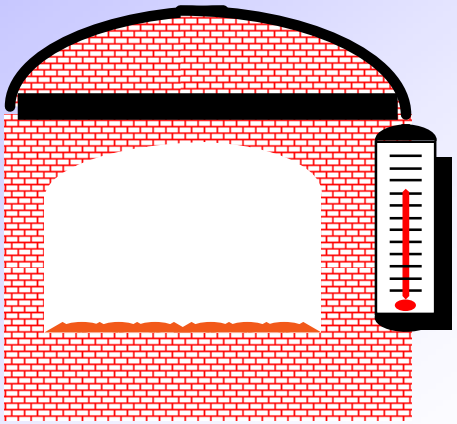
Variation OK, But .....

Mean is High (and the algorithm should be checked)

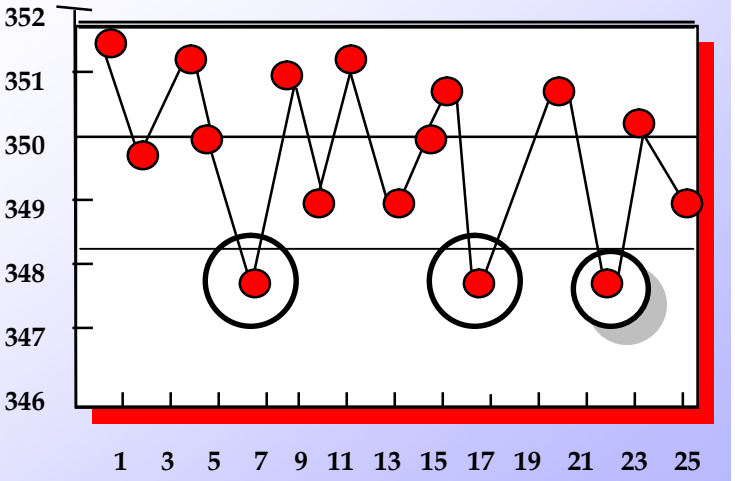
Control

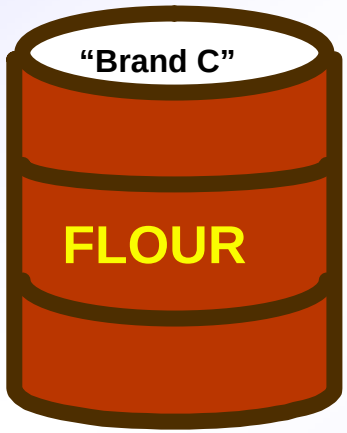
Step 12 ..... Implement Process Control Plan on Xs

What do we do Going Forward?



- Check Ovens Daily for Temperature Levels
- Audit Usage Frequency of Alternative Flour Supplier (e.g., Brand C)
- Periodically Reassemble the Panel to Test Taste
- Chart the Results





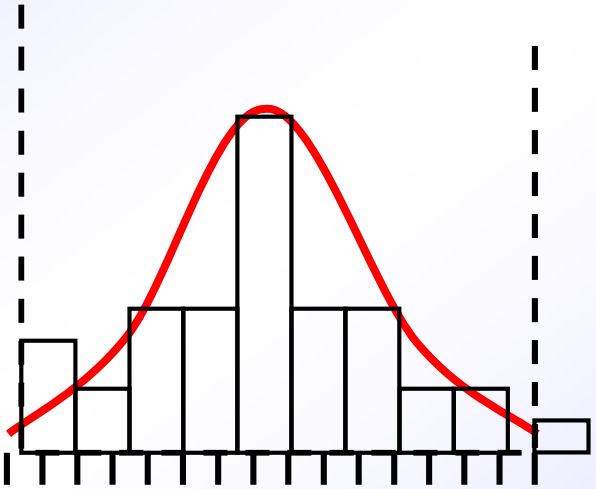
And.....Plot the Data Over Time

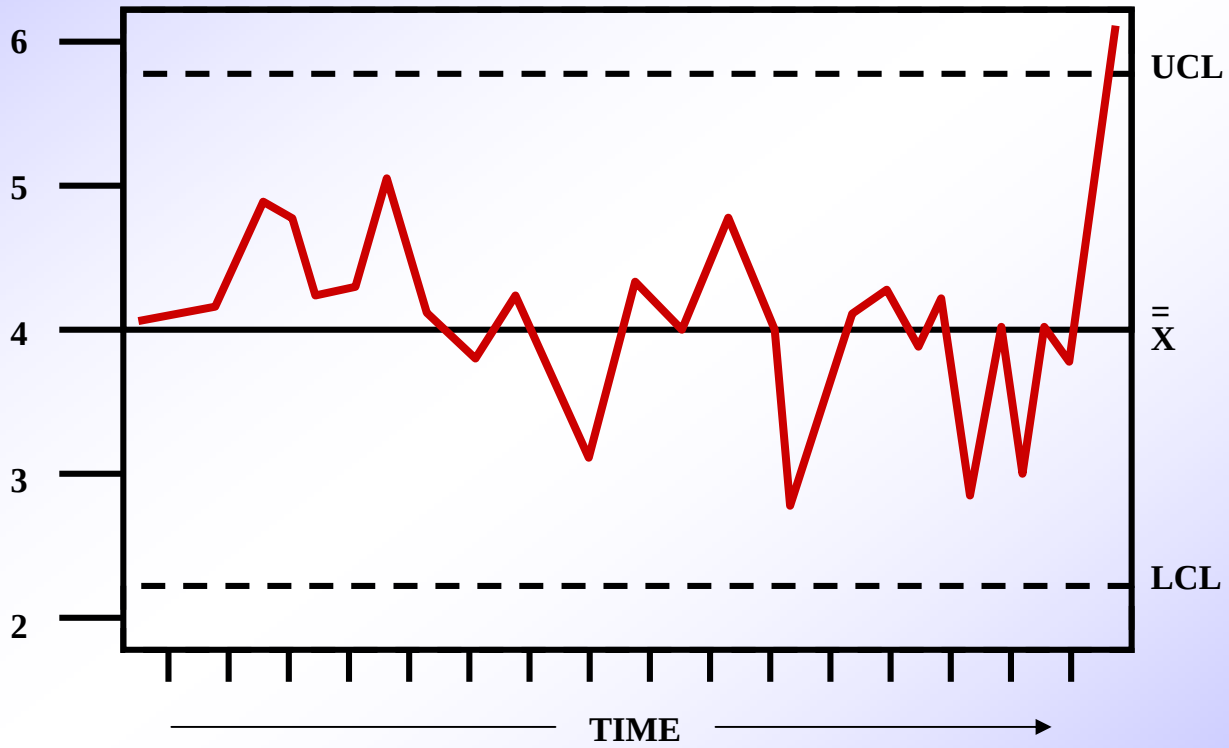
Statistical Control

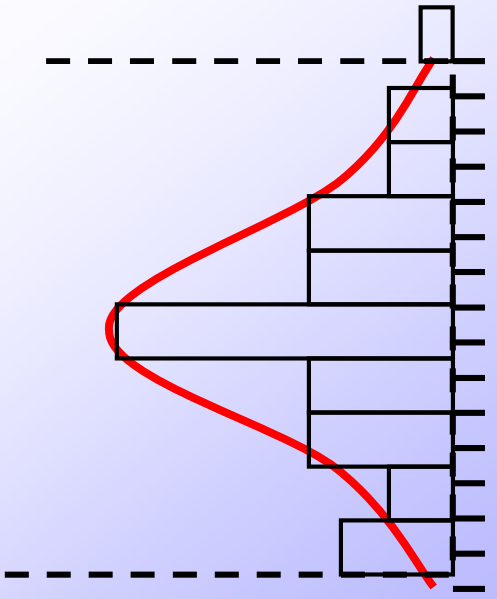
"A phenomenon will be said to be controlled when, through the use of past experience, we can *predict*, at least within limits, how the phenomenon may be expected to vary in the future."

W.A. Shewhart

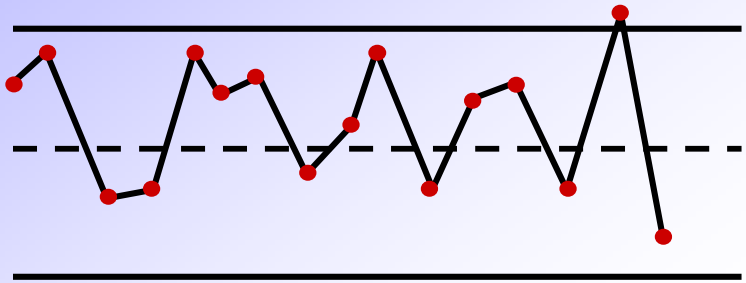
Relationship Between Histogram and Control Chart



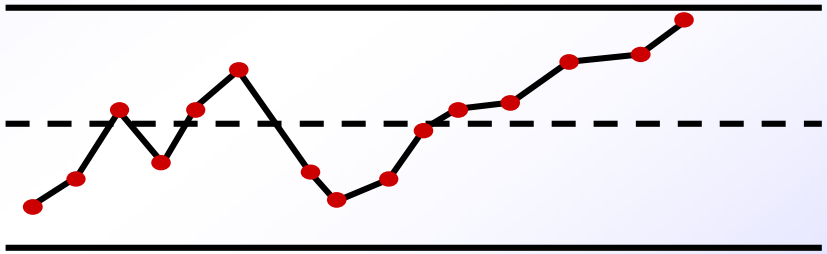




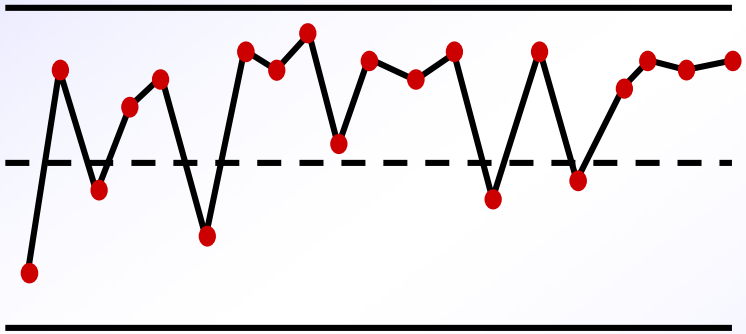
Control Chart Rules of Seven



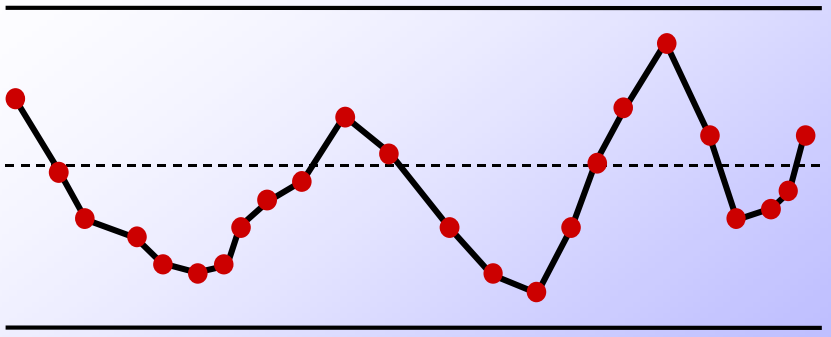
One Point Outside Control Limits



Trend of Seven in a Row



Seven in a Row
Above/Below Centerline



Nonrandom Pattern

What's Different About MAIC?

- **Very similar to good Engineering Design practices**
- **Disciplined, comprehensive "cookbook" process applicable to all types of Engineering – process, product, or service**
- **Data driven decision making**
- **Statistical design to understand and reduce Variation**
- **Dedicated Team can develop a Breakthrough Design in a few months**

But, does not replace need for sound Engineering Judgment

MAIC Optimization Summary

- Much more “Cookbook” than DFSS
- Illustrated via Bread Example
- Requires a lot of Regression and Modeling to UNDERSTAND variable relationships
- Many MAIC Tools are used in DFSS Projects
- Requires good Engineering Judgment

Questions