Air
Land
Sea
Space
Cyberspace

Innovation. In all domains.

Everything You Wanted to Know About CMMI® and Six Sigma but Did Not Know Who to Ask
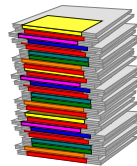
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November, 2009

Today's Mission

- **QUICK Introduction to Six Sigma**

- **Relationship of Six Sigma to the CMMI**

- **Applying Six Sigma**

- **Examples of Six Sigma Tool Usage to Improve**

BlackBelt training is 160 hrs   Intro to CMMI is 24 hrs   **I have 30 Minutes**

What Do You Think Six Sigma Is All About?

Benchmark?

Metric?

Method?

Philosophy?

Vision?

Pipe Dream?

Disease?

Stretch Goal?

What Is Six Sigma?

A customer-driven management methodology to significantly increase **customer** satisfaction through reducing and eliminating variation and thus defects.

A concept developed by Motorola to achieve a desired level of quality, virtually defect-free products and processes

With this definition, six sigma is applicable to any development or manufacturing process

The Many Facets of Sigma

Sigma is a letter in the Greek alphabet

"**Sigma**" is used to designate the distribution about the mean of any process or product characteristic (standard deviation)

"**Sigma value**" indicates how often defects are likely to occur
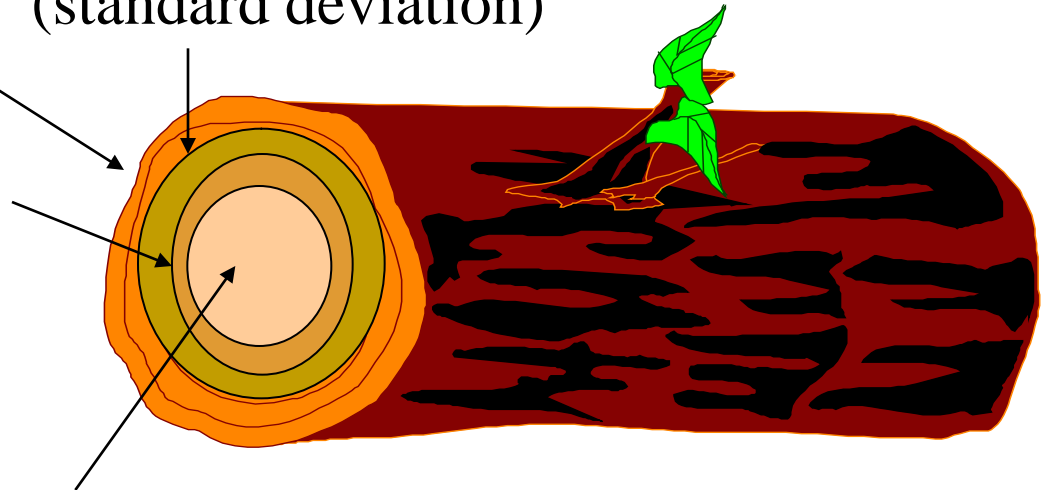
"**Sigma level**" is the number of standard deviations between the process center and the CLOSEST spec limit

Premise for Six Sigma

- Sources of **variation** can be
    - Identified
    - Quantified
    - Mitigated by control or prevention

- The elements of a process responsible for variation are called the "6 M's"
    - Man (people)
    - Machine
    - Material
    - Method
    - Measurement
    - Mother Nature
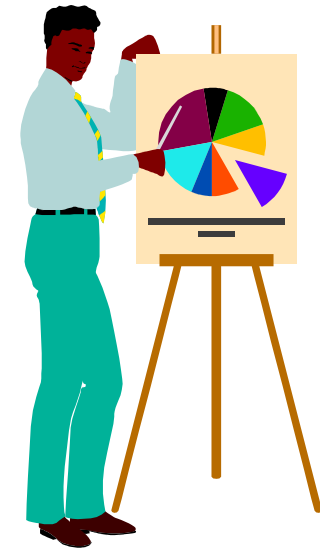
Variation is the Enemy

- Variation exists in everything

- If it is assumed that everything is a result of some process, then it is safe to conclude that the process introduces product variation

- Variation in the product is due to variation in the process

- Variation comes in two forms - **common** and **special cause**
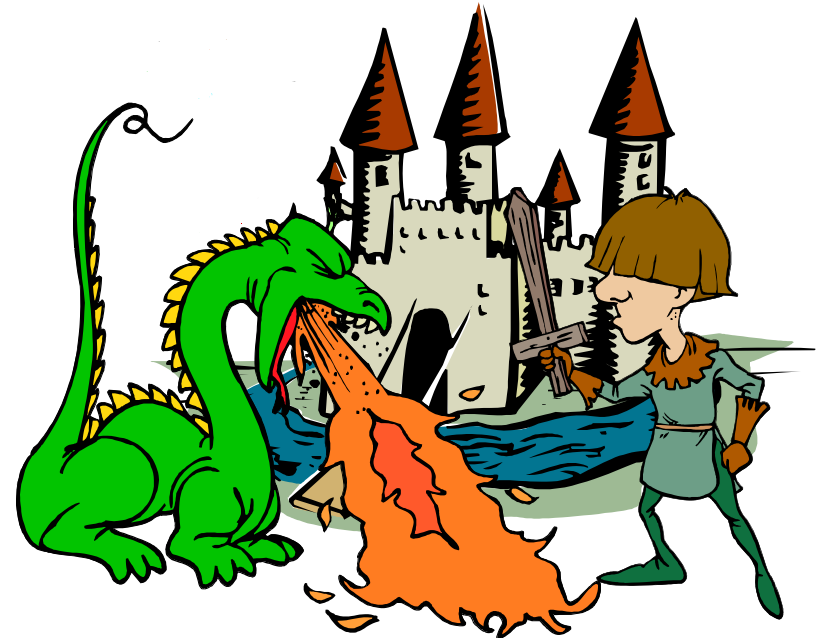
We Must Slay the Enemy
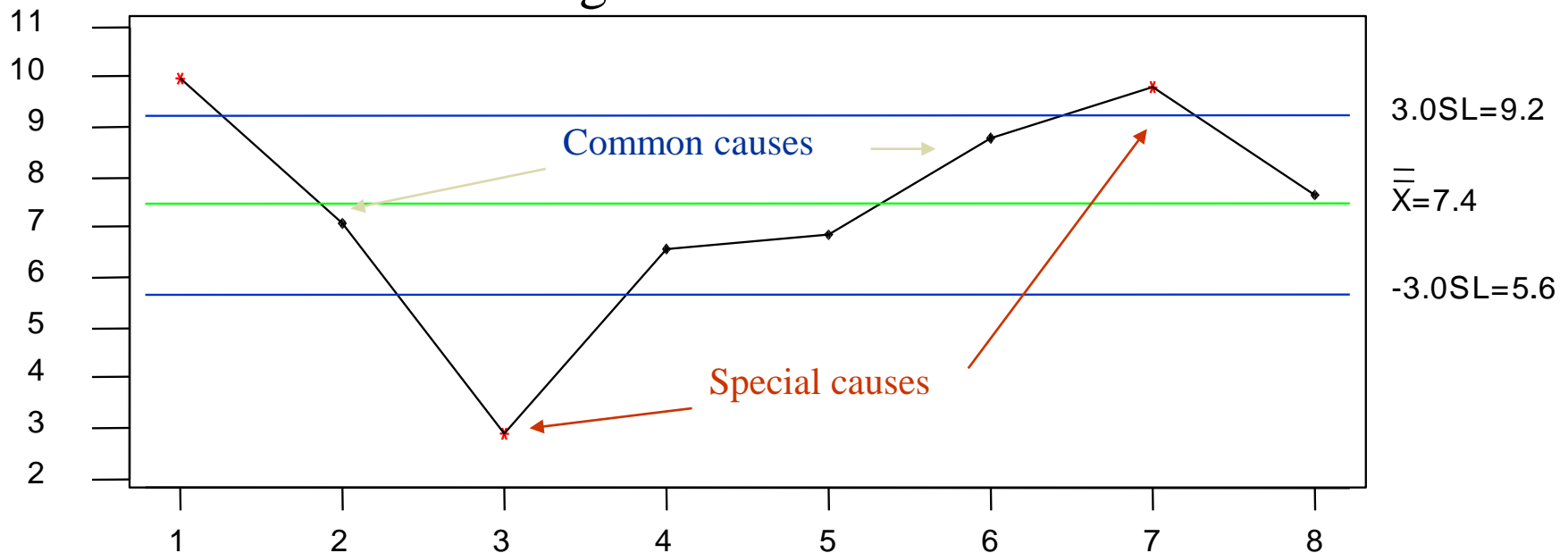
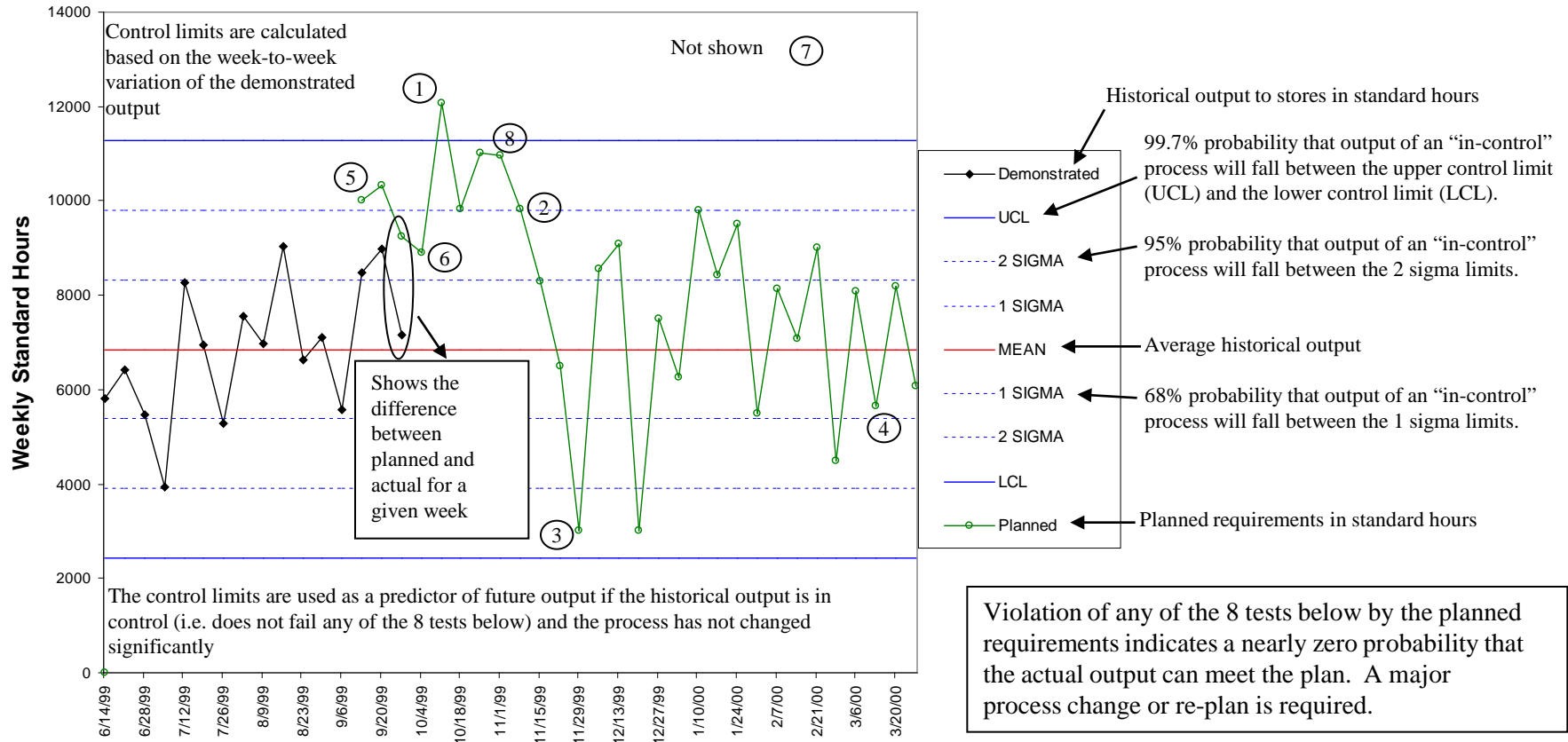# Common and Special Causes

Common Causes
- Continuously active in the process
- Predictable

Special Cause
- Extraordinary events
- Can assign a reason
- Can do something about it

Control limits reflect the predictions and process variation
Control limits lead to the decisions about a specific trade

Common causes

Special causes

3.0SL=9.2

$\bar{\bar{X}}$=7.4

-3.0SL=5.6

Reading a Control Chart

Weekly Standard Hours (y-axis: 0 to 14000)

Control limits are calculated based on the week-to-week variation of the demonstrated output

Not shown ⑦

① ⑧ ⑤ ② ⑥ ③ ④

Shows the difference between planned and actual for a given week

The control limits are used as a predictor of future output if the historical output is in control (i.e. does not fail any of the 8 tests below) and the process has not changed significantly

Legend:
- Demonstrated — Historical output to stores in standard hours
- UCL — 99.7% probability that output of an "in-control" process will fall between the upper control limit (UCL) and the lower control limit (LCL).
- 2 SIGMA — 95% probability that output of an "in-control" process will fall between the 2 sigma limits.
- 1 SIGMA
- MEAN — Average historical output
- 1 SIGMA — 68% probability that output of an "in-control" process will fall between the 1 sigma limits.
- 2 SIGMA
- LCL
- Planned — Planned requirements in standard hours

Violation of any of the 8 tests below by the planned requirements indicates a nearly zero probability that the actual output can meet the plan. A major process change or re-plan is required.

x-axis dates: 6/14/99, 6/28/99, 7/12/99, 7/26/99, 8/9/99, 8/23/99, 9/6/99, 9/20/99, 10/4/99, 10/18/99, 11/1/99, 11/15/99, 11/29/99, 12/13/99, 12/27/99, 1/10/00, 1/24/00, 2/7/00, 2/21/00, 3/6/00, 3/20/00
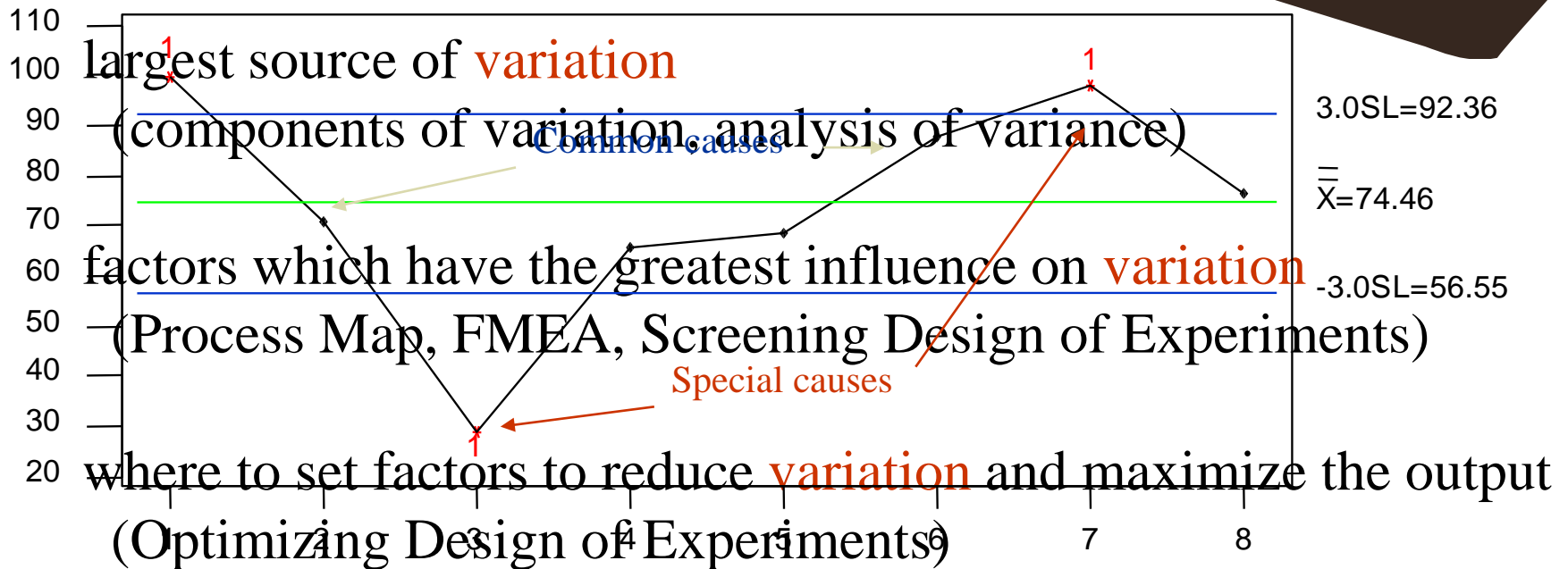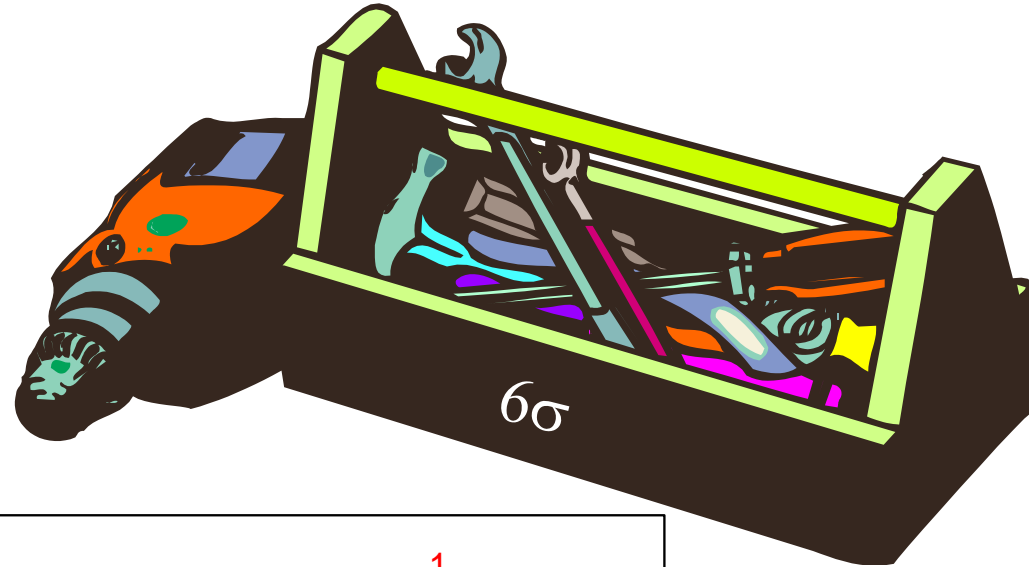
Tests for out-of-control conditions in a control chart

① One point more than three sigmas from the mean

② Nine points in a row on the same side of the mean

③ Six points in a row all increasing or decreasing

④ Fourteen points in a row, alternating up and down

⑤ Two out of three points more than 2 sigmas from the mean

⑥ Four out of five points more than 1 sigma from the mean

⑦ Fifteen points in a row within 1 sigma of the mean
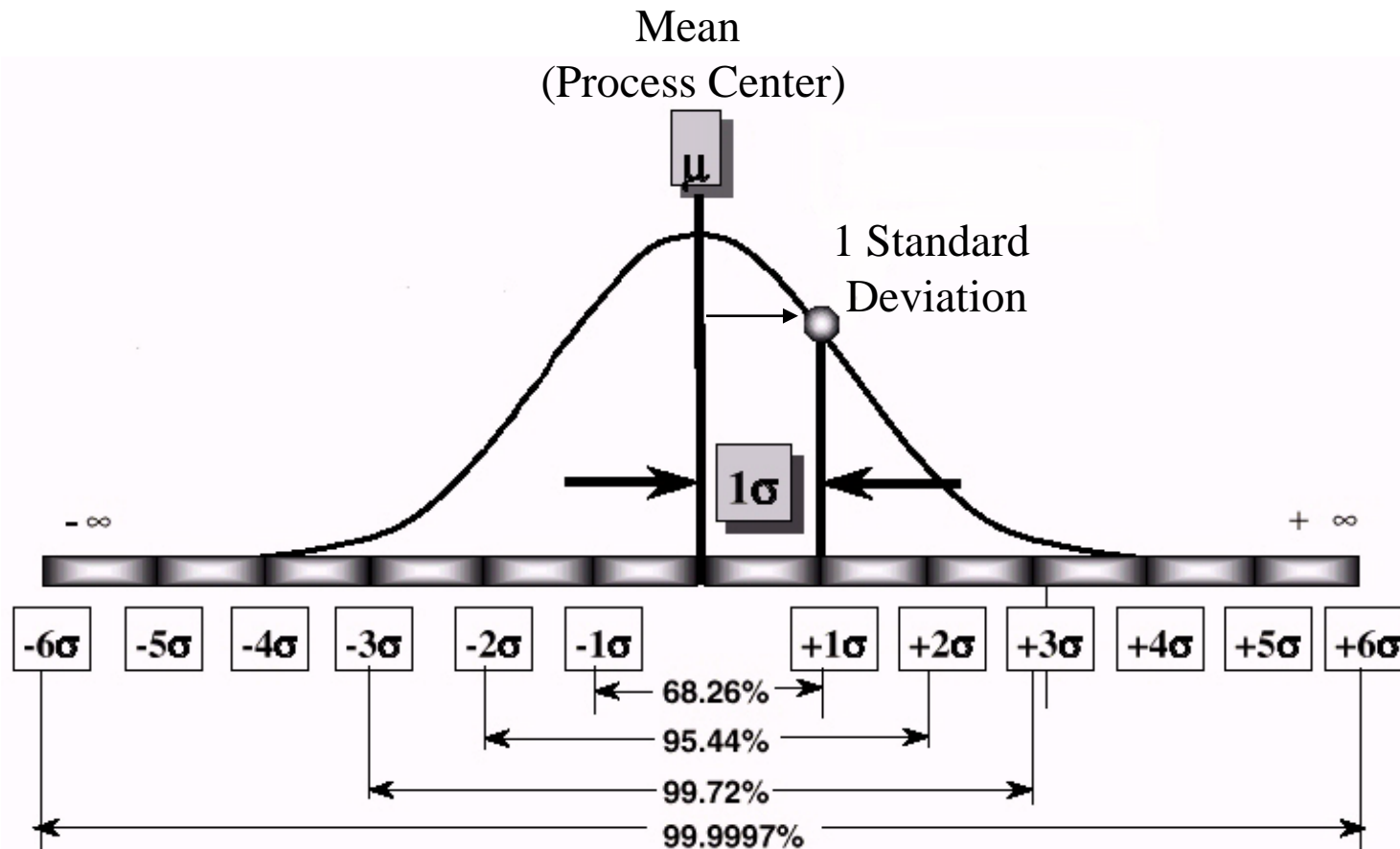
⑧ Eight points in a row more than 1 sigma from the mean

Six Sigma is All About Variation

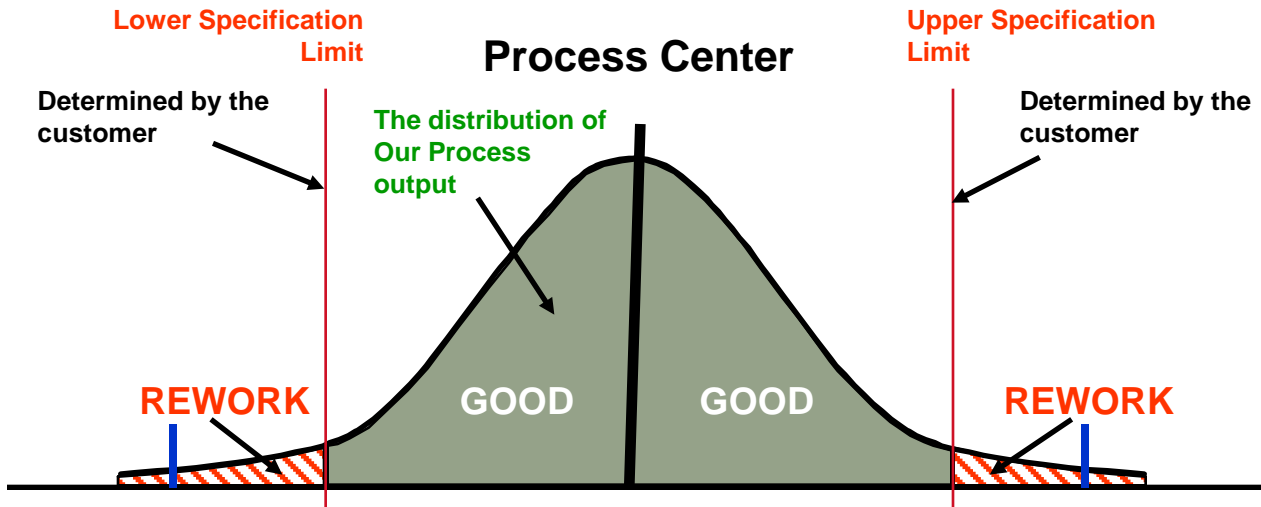Six Sigma tools help identify

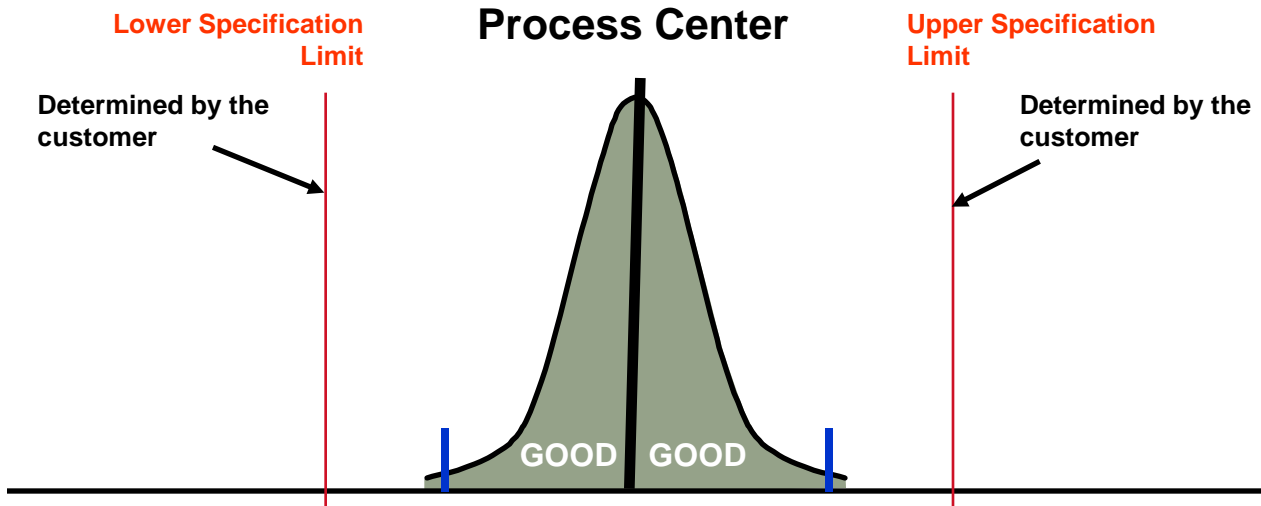types of variation
(control chart)

largest source of variation
(components of variation, analysis of variance)

factors which have the greatest influence on variation
(Process Map, FMEA, Screening Design of Experiments)

where to set factors to reduce variation and maximize the output
(Optimizing Design of Experiments)

6σ

3.0SL=92.36

$\overline{\overline{X}}$=74.46

-3.0SL=56.55

Common causes

Special causes

Six Sigma is Based on Statistics

Mean
(Process Center)

μ

1 Standard
Deviation

1σ

- ∞

+ ∞

| -6σ | -5σ | -4σ | -3σ | -2σ | -1σ | +1σ | +2σ | +3σ | +4σ | +5σ | +6σ |

68.26%

95.44%

99.72%

99.9997%

Remember - no statistics today

States of a Process

Lower Specification Limit

Upper Specification Limit

Process Center

Determined by the customer

The distribution of Our Process output

Determined by the customer

REWORK

GOOD

GOOD

REWORK

Incapable Process

- We have **REWORK** because some of what we make is waste

- Process is **WIDER** than the specification limits

Lower Specification Limit

Process Center

Upper Specification Limit

Determined by the customer

Determined by the customer

GOOD

GOOD

Capable Process

- We make as much as the customer needs and have very little waste

- Process **FITS** within the specification limits

X Bar What? Standard Who?

Raytheon

If you take the bell shaped curve and turn it on its side, you have a control chart
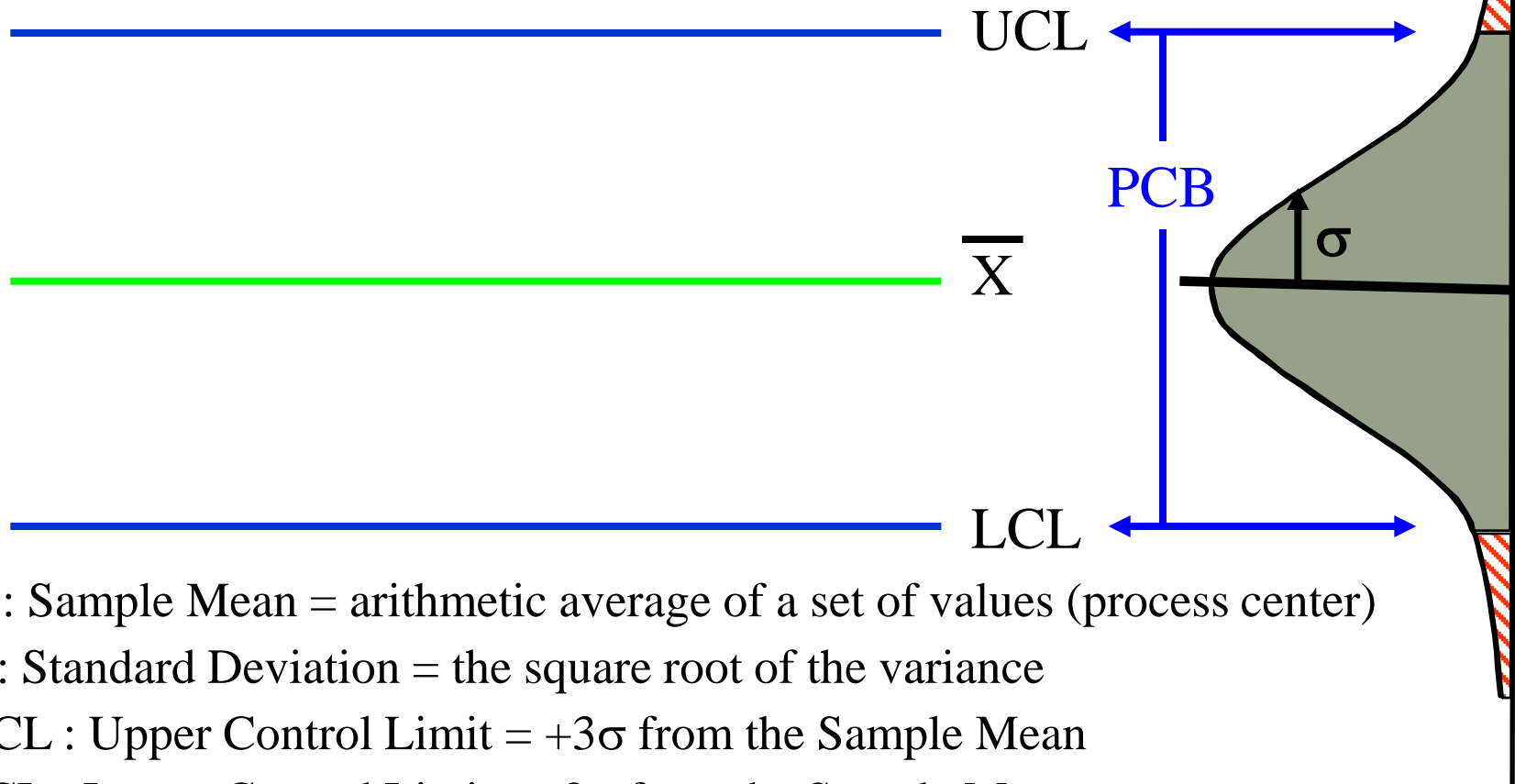
$\overline{X}$: Sample Mean = arithmetic average of a set of values (process center)

σ : Standard Deviation = the square root of the variance

UCL : Upper Control Limit = $+3\sigma$ from the Sample Mean

LCL : Lower Control Limit = -3σ from the Sample Mean

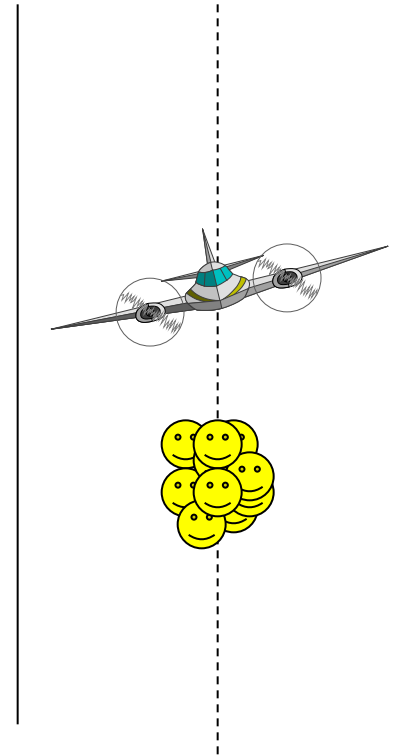PCB : Process Capability Baseline = "normal" variation for the sample

So Long As We Satisfy the Requirements, Right?
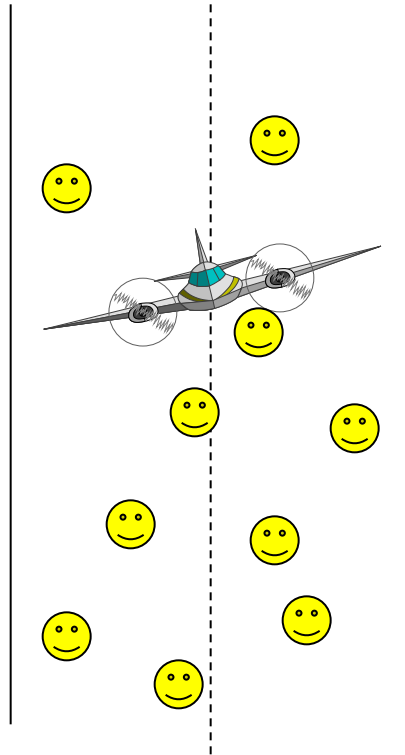
Pilot A

Pilot B

Both within spec,
same average landing

Which pilot would you want to fly with? Why?

Moving Towards Six Sigma

Pilot A's Distribution

Target

1 Standard Deviation

Lower Spec

Upper Spec

Process Center

σ σ σ σ

4σ
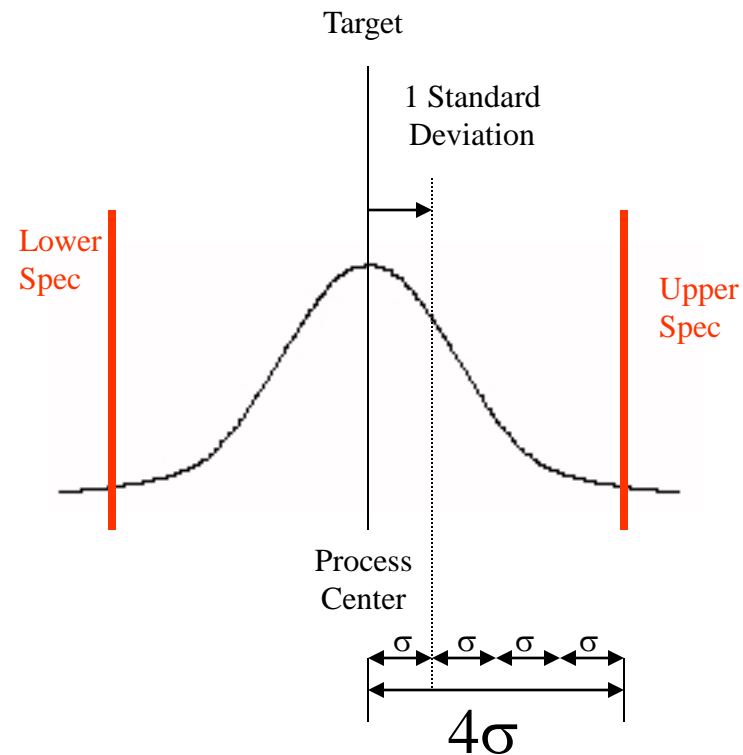
Pilot A is at 4 sigma

Pilot B's Distribution

Target

1 Standard Deviation

Lower Spec

Upper Spec

Process Center

σ σ σ σ σ σ

6σ
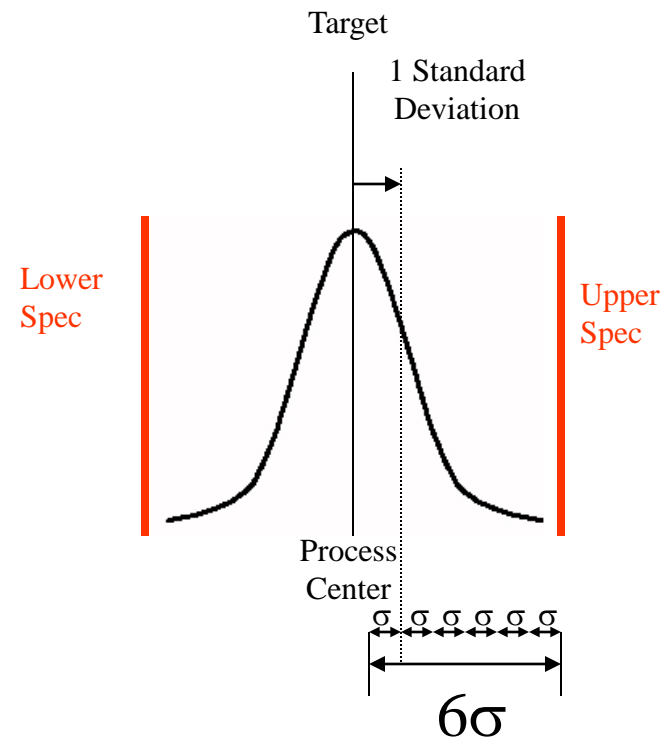
In order to be six sigma, like Pilot B, the variation in Pilot A's landings must be reduced

Pilot A and B at Sky Harbor Airport

Wouldn't stay in business too long...
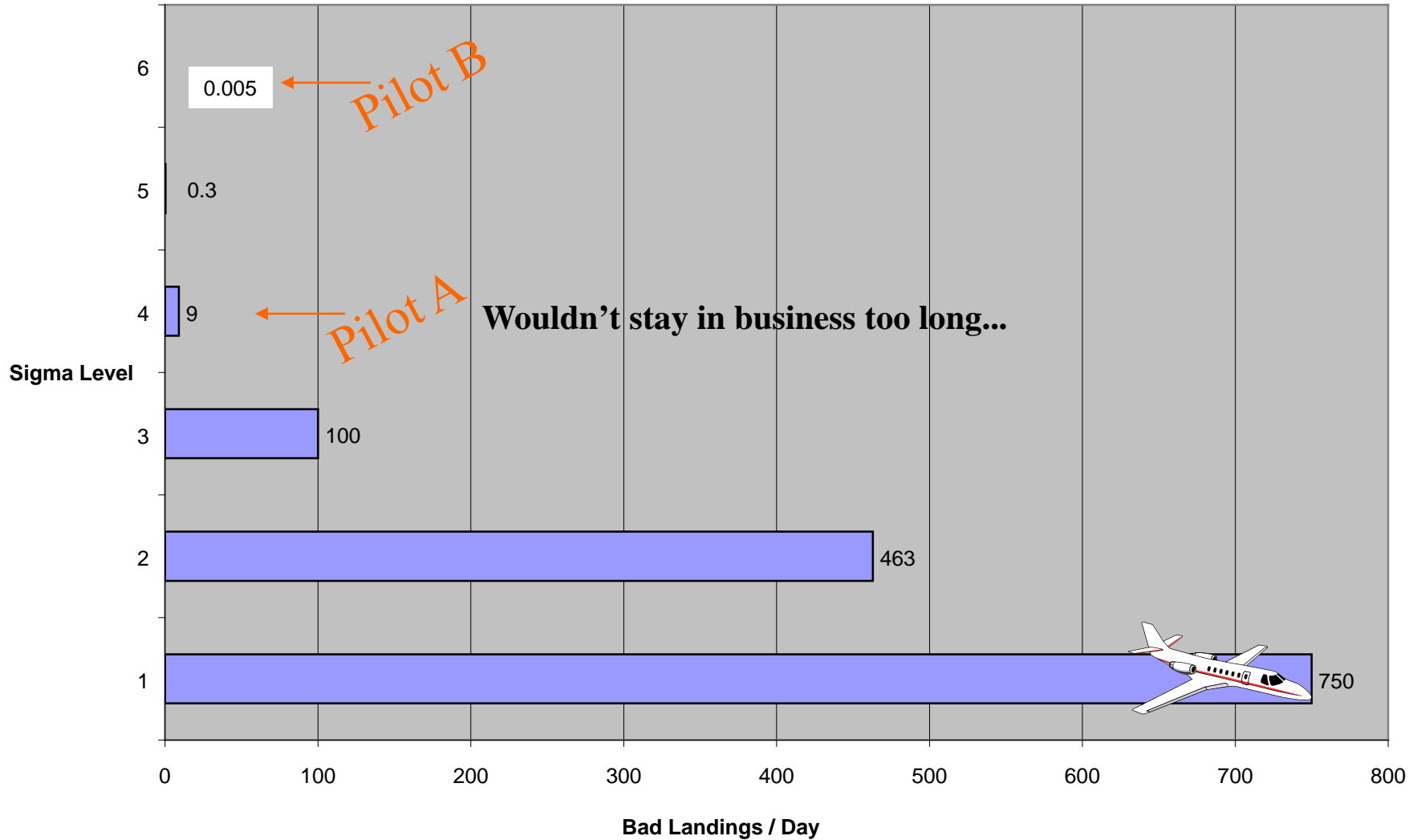
Higher Sigma Equates to Major Reduction in Defects

Raytheon
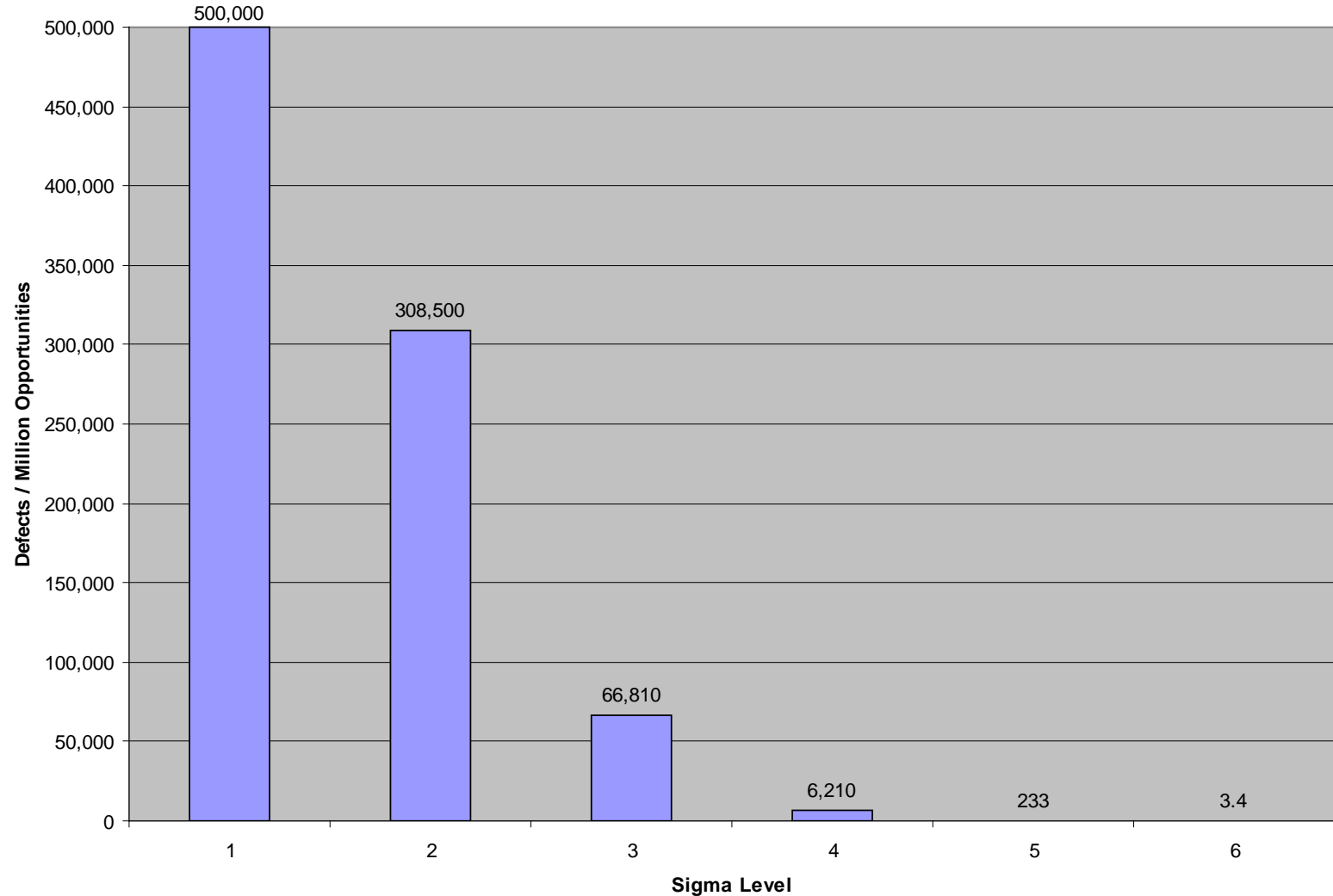
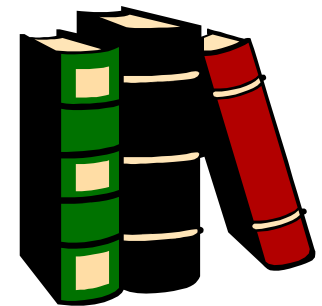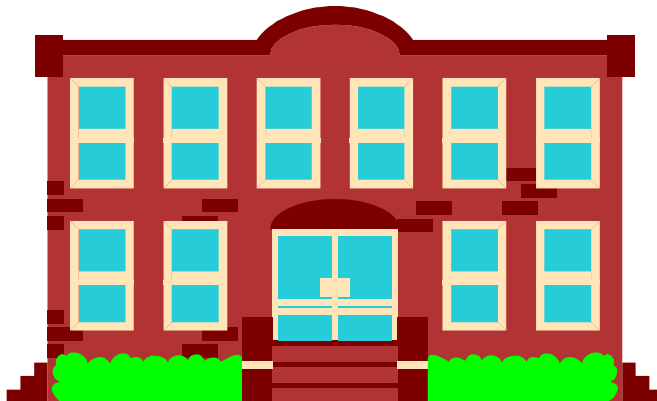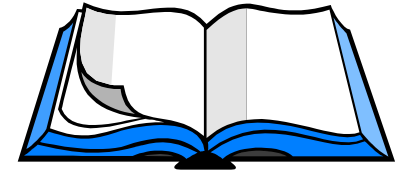1σ - 170 misspelled words per page in a book

2σ - 25 misspelled words per page

3σ - 1.5 misspelled words per page

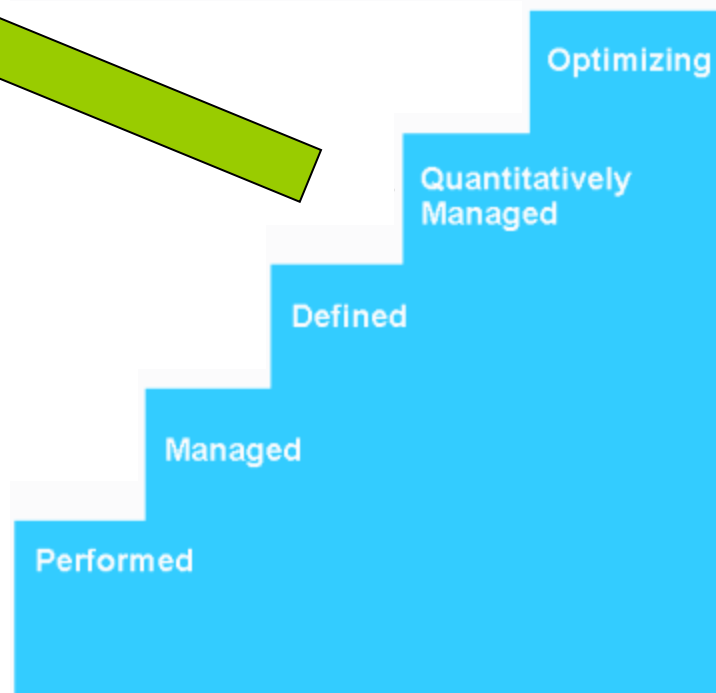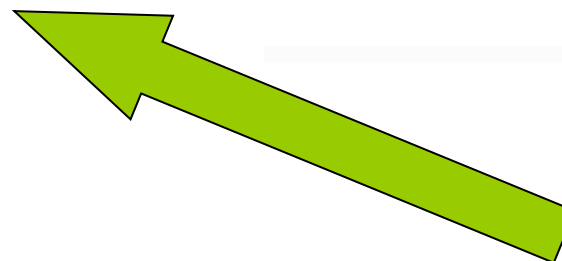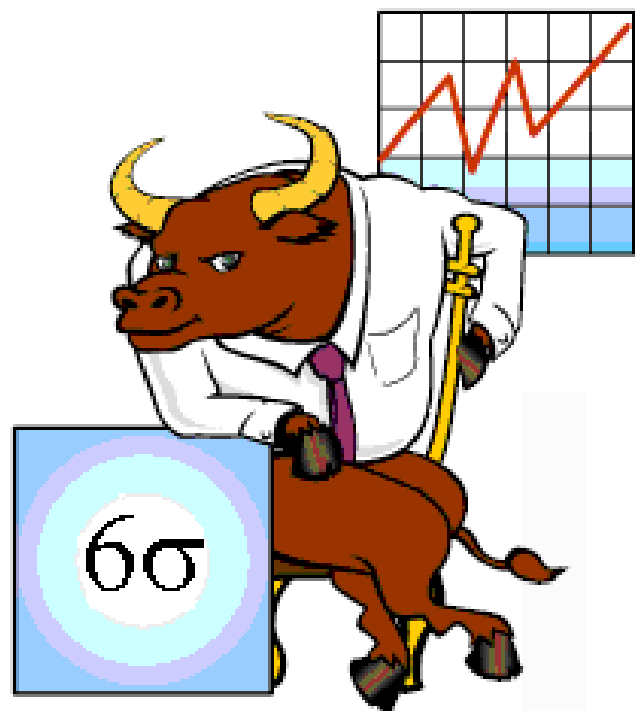4σ - 1 misspelled word per 30 pages

5σ - 1 misspelled word in a set of encyclopedias

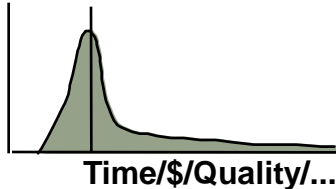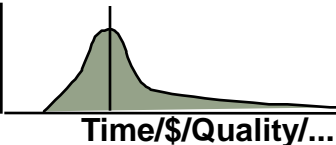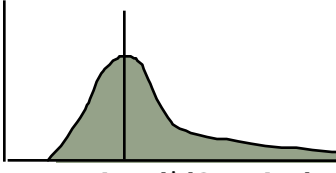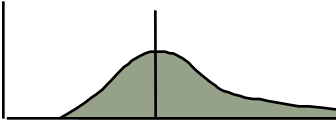6σ - 1 misspelled word in all the books in a library

Understand you customers' needs
And balance with cost

CMMI Meets Six Sigma

CMMI Reminder

Maturity Level		Predicted Performance
Optimizing 5	the organization concentrates on quantitatively improving the process to maximize the achievement of the organization's and projects' goals	Time/$/Quality/...
Quantitatively Managed 4	all the process assets accumulated from Level 2 and 3 are used to quantitatively understand the process performance	Time/$/Quality/...
Defined 3	the organization has a defined common process which includes the collection of common product and process metrics	Time/$/Quality/...
Managed 2	the best practices reside in the projects	Time/$/Quality/...

Level 2 - Measuring the Project

The initial focus for measurement activities is at the project level. As the organization moves toward Level 3, common measures are defined which prove useful for addressing organization and/or enterprise-wide information needs.

Level 3 – Understanding the Organizational Practices

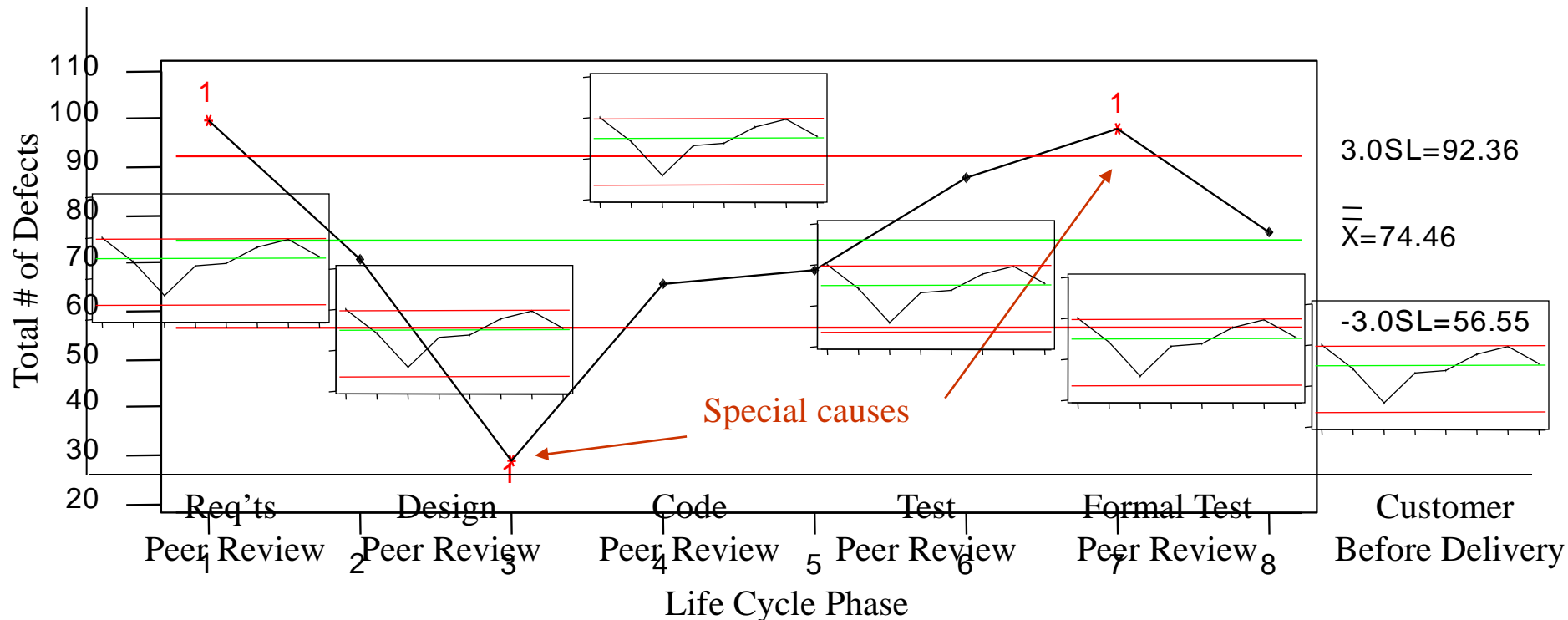At Level 3, project data is collected and analyzed across the organization. Thresholds may be set based on good engineering judgment which trigger corrective action

Level 2/3 set the stage for quantitative and statistical management
• Repeatable, Consistent Processes
• Adequate Resources
• Defined, Consistent Process Measures
• Data Collected From Above Process
• Assurance of Process Compliance

Level 4 – Characterizing and Stabilizing the Process

At maturity level 4, quantitative and statistical techniques are used to manage process performance and product quality. Quality and process performance is understood in statistical terms. Special causes of process variation are identified and, where appropriate, the sources of special causes are corrected to prevent future occurrences.

3.0SL=92.36

$\overline{\overline{X}}$=74.46

-3.0SL=56.55

Total # of Defects

Special causes

Req'ts Peer Review	Design Peer Review	Code Peer Review	Test Peer Review	Formal Test Peer Review	Customer Before Delivery
1	2	3	4	5	6	7	8

Life Cycle Phase

Level 4 – Characterizing and Stabilizing the Process

When performance falls outside normal range of process performance
- Identify the reason
    - Take corrective action when appropriate

A critical distinction between maturity level 3 and 4 is the predictability of process performance. At maturity level 4, the performance of processes is quantitatively predictable and controlled using statistical and other quantitative techniques

Level 5 - Optimizing the Process

At maturity level 5, an organization continually improves its processes based on a quantitative understanding of the common causes of variation inherent in processes to maximize the probability of achieving its goals

When performance is within normal range of process performance but unable to meet the established objectives
- Narrow the performance limits
- Shift the performance limits

Common causes

3.0SL=136.0

$\bar{\bar{X}}$=74.46

-3.0SL=12.91
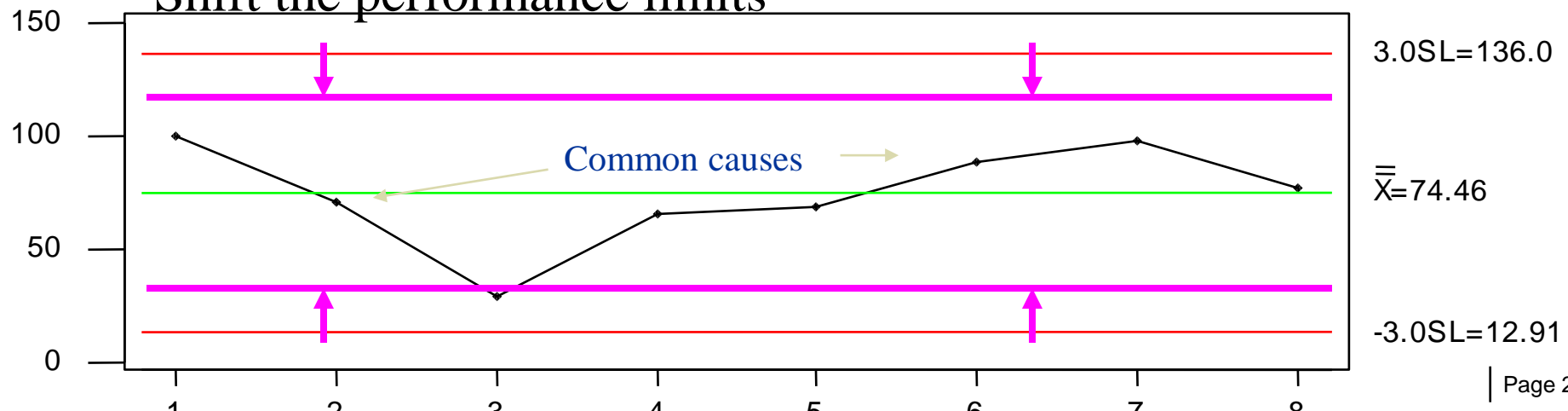
Am I Acting 4 or 5?

A critical distinction between levels 4 and 5 is the type of process variation addressed

• At maturity level 4, the organization is concerned with providing statistical predictability of the results. Although processes may produce predictable results, the results may be insufficient to achieve the established objectives

• At maturity level 5, the organization is concerned "bumping" the process (to shift the mean of the process performance or reduce the inherent process variation experienced) to improve process performance and to achieve the established quantitative process-improvement objectives
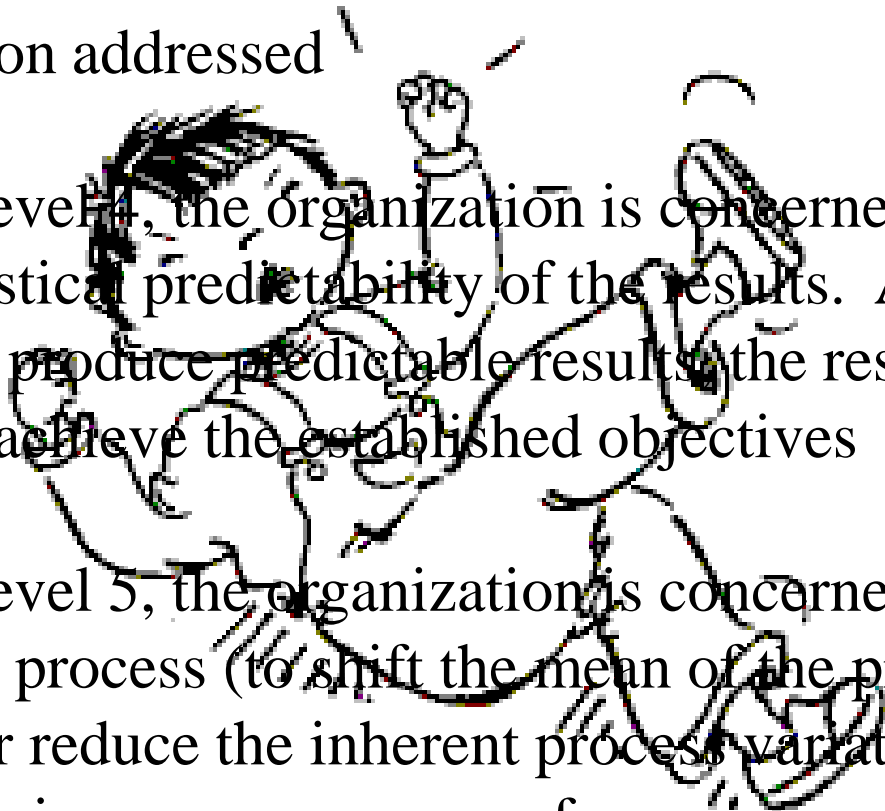
Six Sigma Tools Enable Levels 4 and 5

Six Sigma methodology provides the tools that enable high maturity
- **Quantitative Project Management,**
- **Organization Process Performance**
- **Causal Analysis and Resolution**
- **Organizational Innovation and Deployment**

CMMI provides a "process wrapper" to effectively and efficiently use the Six Sigma toolbox
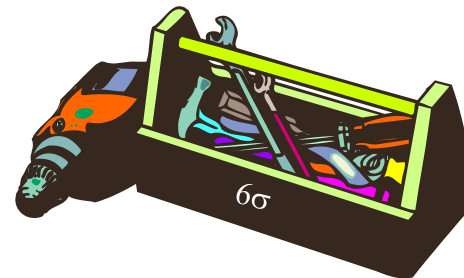
A Level 5 organization is one that has implemented, among other things, statistical management

Applying Six Sigma

Develop Infrastructure

Continuous Measurable Improvement

PROCESS

Quantitatively Understand Process Performance
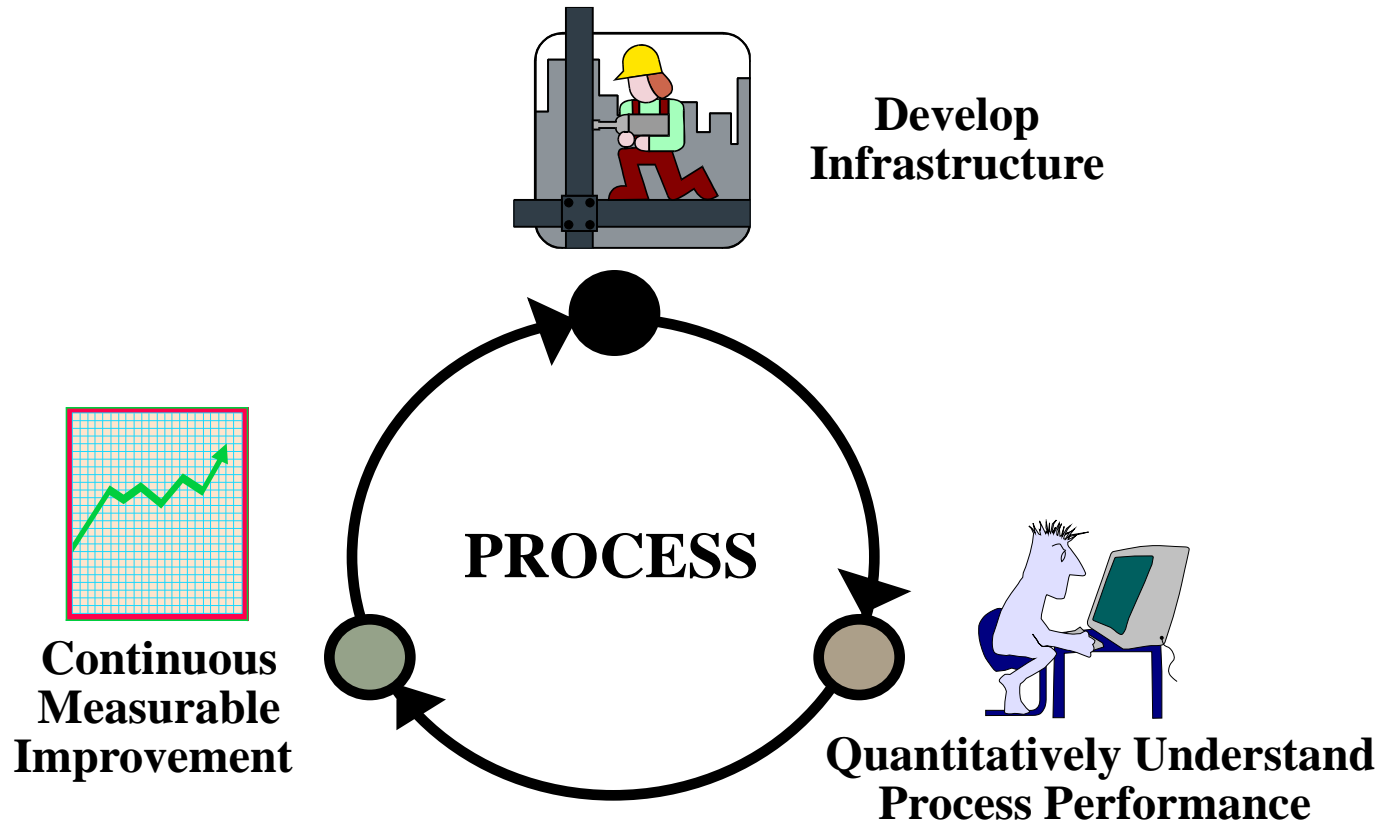
Develop Infrastructure

- ## Commitment to Process Improvement
  - Repeatable, Consistent Process
  - Adequate Resources
  - Defined, Consistent Process Measures
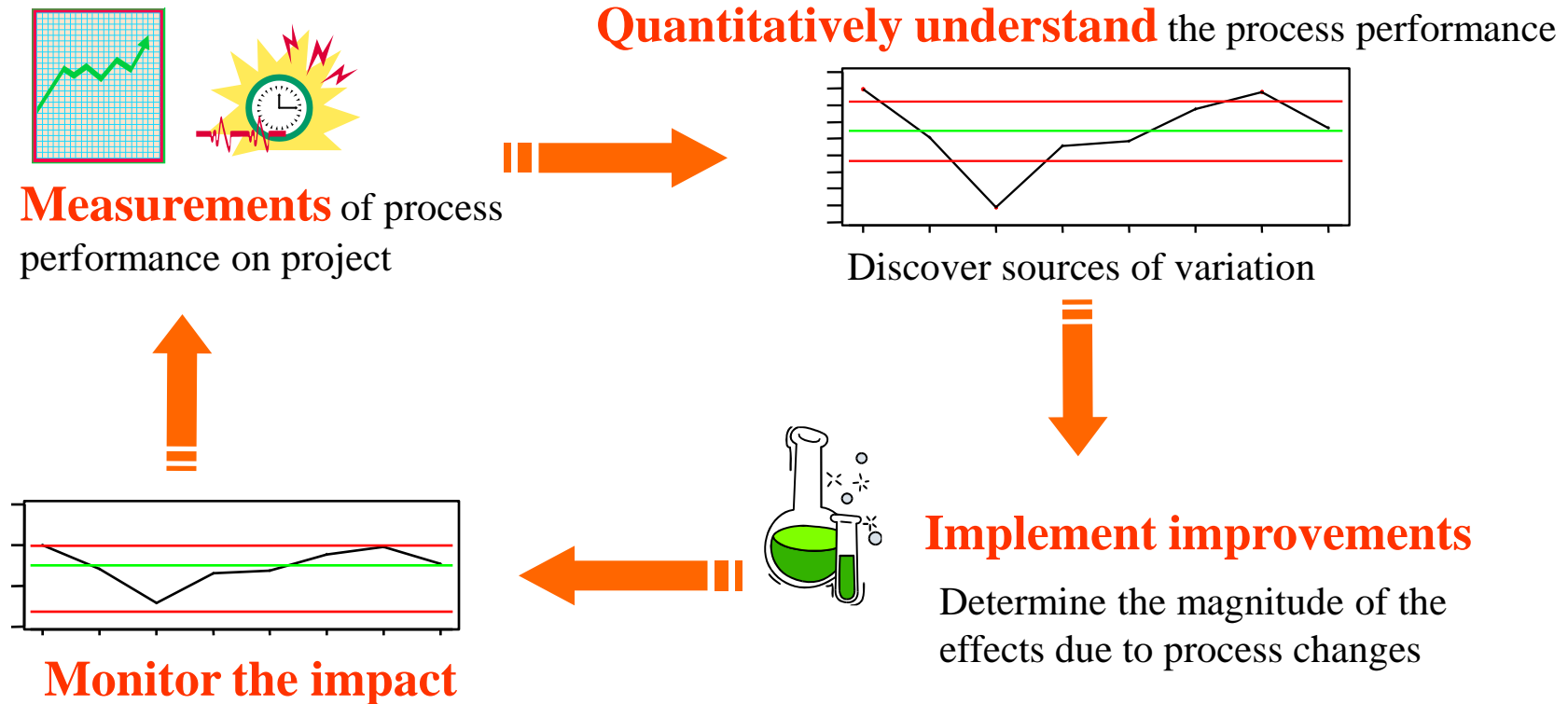 - Data Collected From Above Process
  - Assurance of Process Compliance

Only required for the window you are looking through

Quantitatively Understand Process Performance

Use Six Sigma tools to identify sources of variation (quantitatively understand process performance) and then act to eliminate or reduce those sources

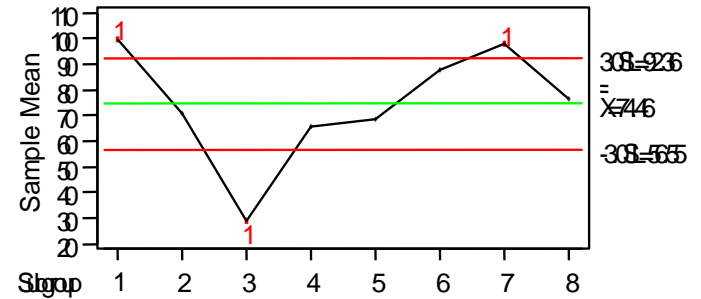**Quantitatively understand** the process performance
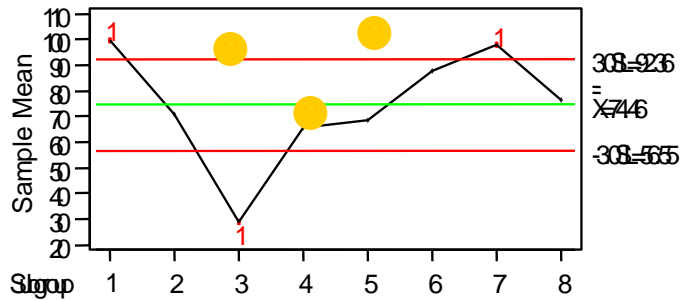
Measurements of process performance on project

Discover sources of variation

Implement improvements

Determine the magnitude of the effects due to process changes

Monitor the impact

Six Sigma – Real Life Example

Measurements

	Planning	Customer	Rqmts Analysis	Design	Implementation	Test	Formal Test	Customer Before	TOTAL	Leaked
Planning	2.03	0	0	0	0	0	0	0	2.03	0
Customer	0	1.8	1.4	0	4.06	0	16.15	0	23.41	21.61
Rqmts Analysis	0	0	7.32	12.04	32.77	41.6	56.09	0.79	150.61	143.29
Design	0	0	0.13	41.99	8.2	23.2	118.94	5.28	197.74	155.75
Implementation	0	0	0.17	0.5	154	90.3	88.88	23.3	357.15	203.15
Test	0	0	0	0.16	0.03	19.92	4.5	0	24.61	4.69
Formal Test	0	0	0	0	0	2.34	149.25	0	151.59	2.34
Customer Before	0	0	0	0	0	0	2.7	13.6	16.3	13.6
TOTAL	2.03	1.8	9.02	54.69	199.06	177.36	436.51	42.97	923.44	544.43

Statistically understand

$+3\sigma = 92.36$

$\overline{\overline{X}} = 74.46$

$-3\sigma = 56.55$

Subgroup 1 2 3 4 5 6 7 8

Sample Mean

Determine the magnitude

Interaction Plot (data means) for % Match

Program
Experience
Training
Criteria
Num People

Monitor the impact

$+3\sigma = 92.36$

$\overline{\overline{X}} = 74.46$

$-3\sigma = 56.55$

Subgroup 1 2 3 4 5 6 7 8

Sample Mean

Continuous Measurable Improvement

Measurements of process performance of project

Statistically understand the process capability

Discover sources of variation

Determine the magnitude of the effects due to process changes

Monitor the impact

Implement improvements

Measurements of process performance of project

Statistically understand the process capability

Discover sources of variation

Determine the magnitude of the effects due to process changes

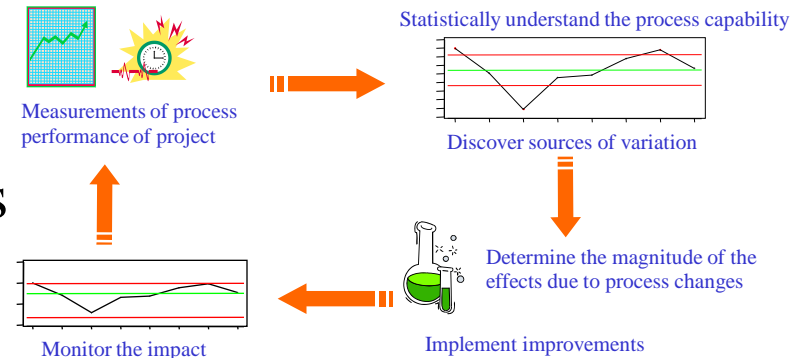Monitor the impact

Implement improvements

- Can be next biggest hitter
- Can be next quickest
- Can be next logical problem
- Can be anything the org. determines

Questions

That's All Folks

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