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# Integrating CMMI® and Six Sigma in Software and Systems Engineering

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# Outline

Objectives
Fundamentals
Implementation
The “Black Belt” Project
Case Study
Summary

Addendum
- Reading list
- Additional analytical tools
- Additional illustration
- Change agent references
- CMMI Process Areas

# Objectives

Review Six Sigma fundamental concepts and benefits.

Share tips on Six Sigma implementation and training in a systems and software environment.

Offer perspectives on the synergy between software/systems-specific initiatives and Six Sigma.

Illustrate several analytical tools for potential application in systems engineering and software development.

Share a “real story”: Details of Lockheed Martin Management & Data Systems technology change management project.

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# Brief History

1979 - Motorola quality imperative “roots of Six Sigma”

1981 - Motorola challenge to improve 10 fold in 5 years

1988 - Motorola wins Malcolm Baldrige Quality Award

1991 - Motorola Six Sigma Research Institute established

1992 - Motorola, Texas Instruments, IBM, Kodak, and others initiated efforts to develop the 6$\sigma$ Black Belt program

1995 - GE mandates Six Sigma rollout; estimates current performance at 3.5 Sigma

1997 - GE invests $250M to train 4,000 Black Belts and 60,000 Green Belts out of workforce of 222,000; recoups $300M same year

1998 - GE calculates Six Sigma payoff at $1.25B

[Stoddard 00]

# Who Uses Six Sigma?

Lockheed Martin
Boeing
General Electric
Hewlett Packard
Honeywell
Motorola
Northrop Grumman
Raytheon
Rohr
TRW

compiled from variety of news articles, web references and conference presentations

# Who Else Uses Six Sigma?

3M
Amazon.com
American Express
Bank of America
Black & Decker
Bombardier
Citigroup
DuPont
Eastman Kodak
Ford
General Motors
JP Morgan
Lantech
Pella Windows
Polaroid
Porsche
Sony Electronics
Toshiba
Toyota
Volkswagen
Wire Mole

compiled from variety of news articles, web references and conference presentations



# What Is Six Sigma?

- a philosophy
- a performance measurement
- an improvement framework
- a set of improvement tools
- a structured approach for business improvement (a business strategy)

# Six Sigma Philosophy

**Improve customer satisfaction by reducing and eliminating defects**

**Greater Profits**



# Six Sigma Metrics

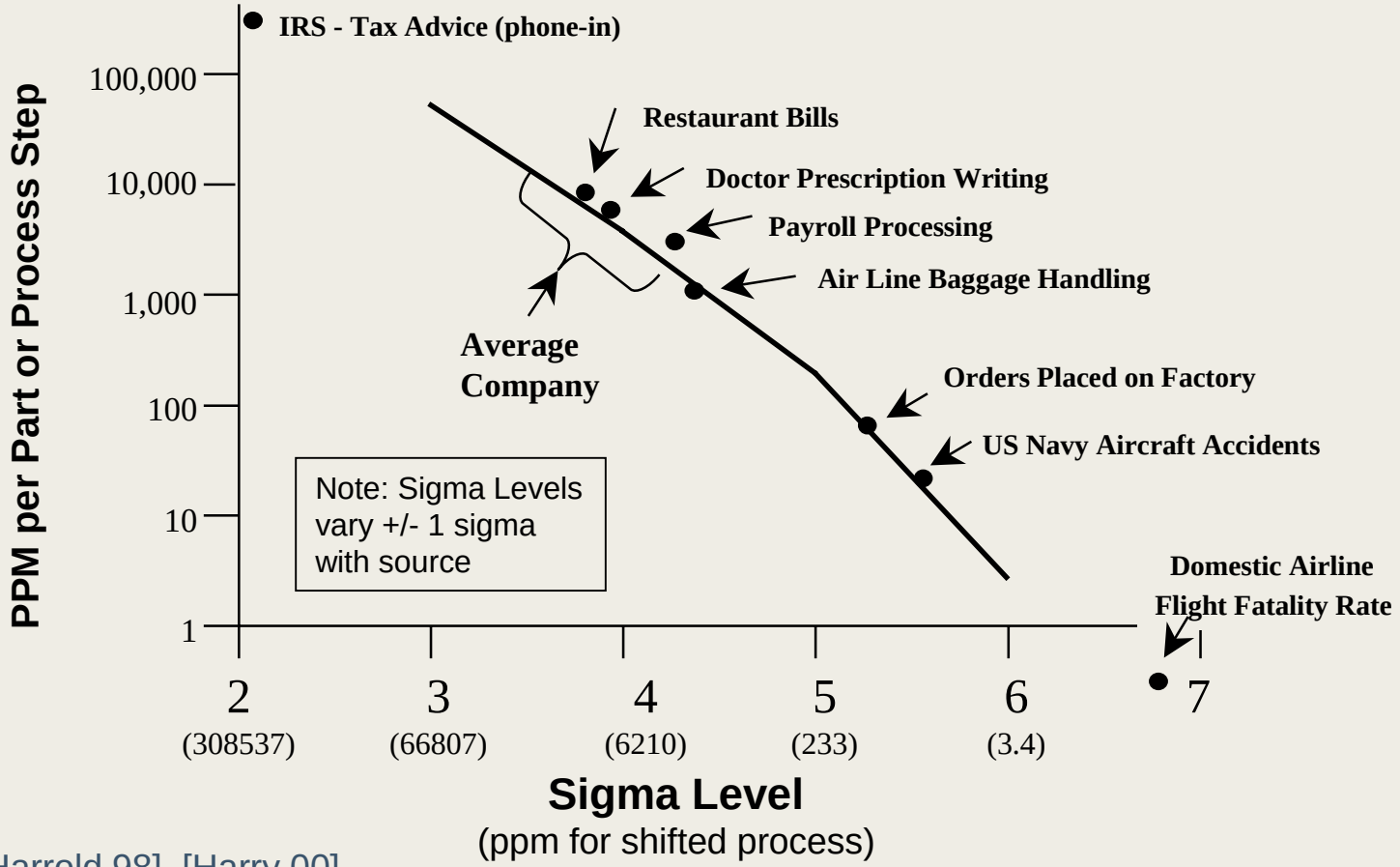
Defect Measures

- Defect Rate, parts per million (ppm)
  - "3.4 ppm" – most-cited metric
- Sigma Level
- Defects per Unit (dpu)
- Defects per Million Opportunities (dpmo)
- Yield

Practitioner Project Measures

- Defect measures
- Cycle time, cost, product performance, variability….
- Bottom-line savings

# Example Sigma Levels




[Harrold 98], [Harry 00]



# 4 Sigma in Everyday Terms

4 Sigma = "99.9% sure"

- 9 hours/year unsafe drinking water
- 107 incorrect medical procedures a day
- 200,000 incorrect drug prescriptions per year
- 18,322 pieces of mishandled mail an hour
- 2,000,000 documents lost by IRS a year
- Two short or long landings at any major airport each day

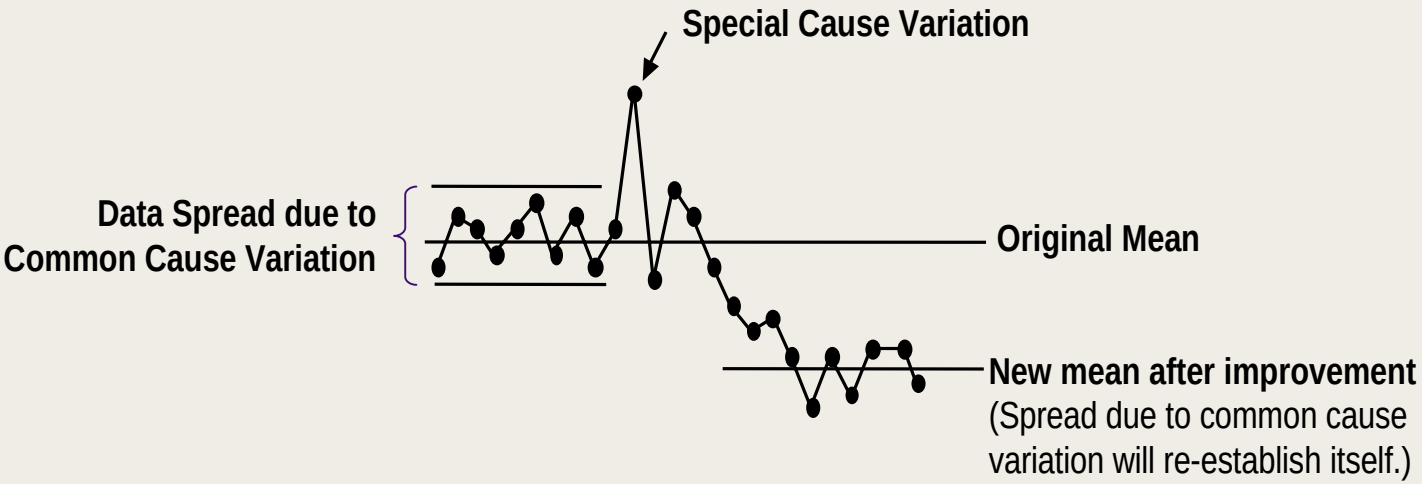
[Harrold 99], [LMC M&DS training]

# Statistical Thinking

Everything is a process.

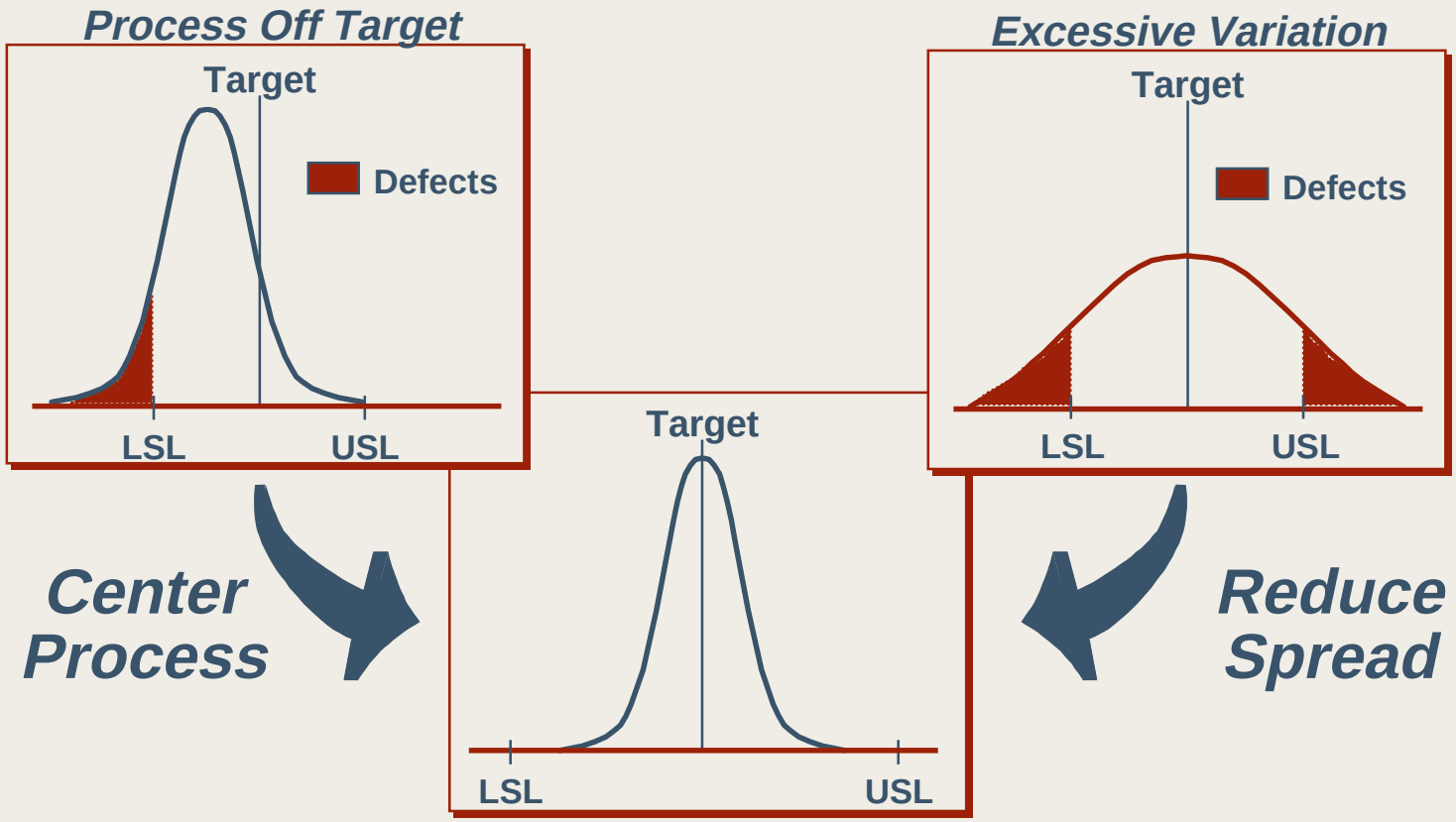
All processes have inherent variability.

Data is used to understand variation and to drive decisions to improve the processes.




[ASQ 00], [ASA 01]

# In Other Words…



# Operating at Six Sigma Implies

Data-driven decision making

Meeting customers' requirements

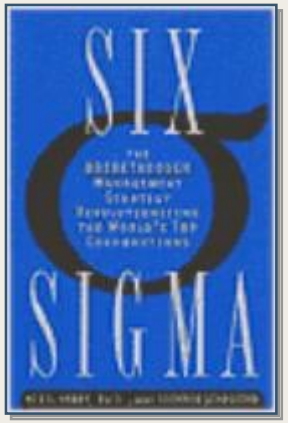
Measurable processes

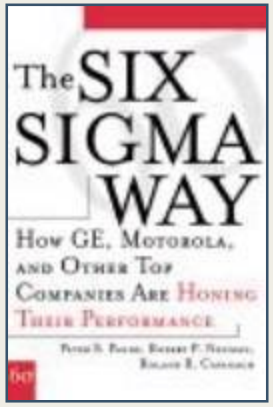
Processes Under Control

Variation has been reduced

Future performance can be predicted

Results of actions can be assessed




**Show me the Data!**

# Six Sigma Improvement Frameworks

DMAIC
- Define – Measure – Analyze – Improve – Control
- used to improve existing processes and products

DMADV
- Define – Measure – Analyze – Design – Verify
- a process of “Design for Six Sigma” (DFSS)
  - there is not unified approach to DFSS across industry
- used to design new products and processes
- used to redesign an existing process which has been optimized but still does not meet specifications

**Both emphasize customer satisfaction and business benefit.**
**Both focus on critical to quality characteristics.**

# Toolkit

| Define | Measure | Analyze | Improve | Control |
|---|---|---|---|---|
| Benchmark<br>**Baseline**<br>Contract/Charter<br>Kano Model<br>**Voice of the Customer**<br>Voice of the Business<br>Quality Function Deployment<br>**Process Flow Map**<br>Project Management<br>**"Management by Fact"** | Defect Metrics<br>Data Collection Methods<br>Sampling Techniques<br>Measurement Sys. Evaluation | **7 Basic Tools**<br>Cause & Effect Diagrams, Matrix<br>Failure Modes & Effects Analysis<br>Statistical Inference<br>Reliability Analysis<br>**Root Cause Analysis**<br>**5 Whys**<br>Hypothesis Test<br>ANOVA | Design of Experiments<br>Modeling<br>Tolerancing<br>Robust Design<br>Systems Thinking<br>Decision & Risk Analysis | Statistical Controls:<br>• Control Charts<br>• Time Series methods<br><br>Non-Statistical Controls:<br>• Procedural adherence<br>• Performance Mgmt<br>• Preventive activities |

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# Roles

Executive Management
- support of top management is **required**

Champions
- identify projects, select “belt” candidates, remove barriers

Master Black Belts
- train and mentor Black Belts
- typically work with Black Belts and process owners in a functional area or business unit

Black Belts – the “heart and soul” of Six Sigma initiatives
- lead improvement projects

Greenbelts
- support black belt projects or lead smaller projects
- typically part-time



# Training and Certification

Green Belt

- typical training: 1 week to 2 weeks

Black Belt

- DMAIC training: 4 to 5 weeks over 6 months with project
- DFSS training: 2 to 3 weeks over 6 months with project
- certification:
  - completion of certification project
  - completion of training
  - often rated on demonstration of skills

Master Black Belt

- role earned by experience and demonstrated project successes

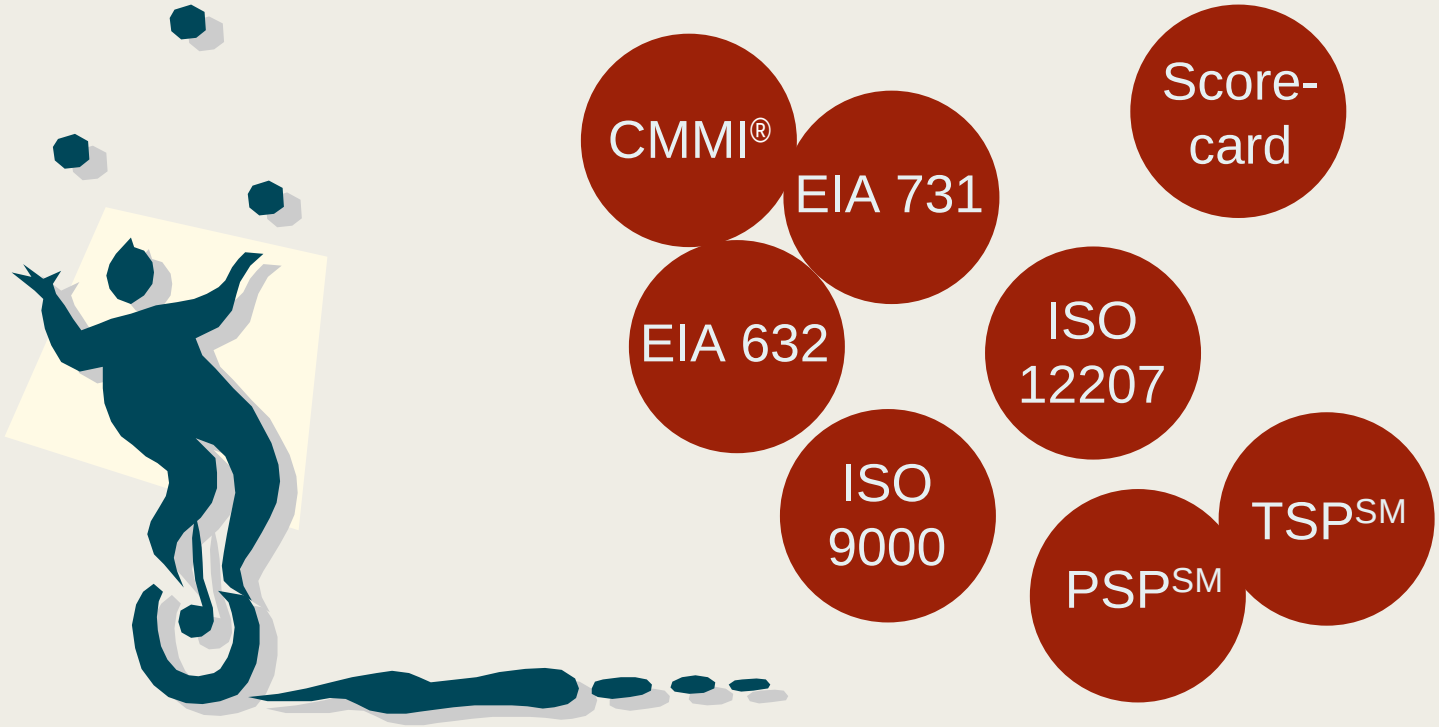
# The “Black Belt” Practitioner

Expectations:

- Influence change
- Provide leadership in applying quantitative methods
- Facilitate teamwork
- Consult with management
- Transfer knowledge and skills to others
- Discover new leveraging opportunities
- Continuously improve their skills
- Participate in the Black Belt network

[kodak.com]

# Juggling Multiple Initiatives?

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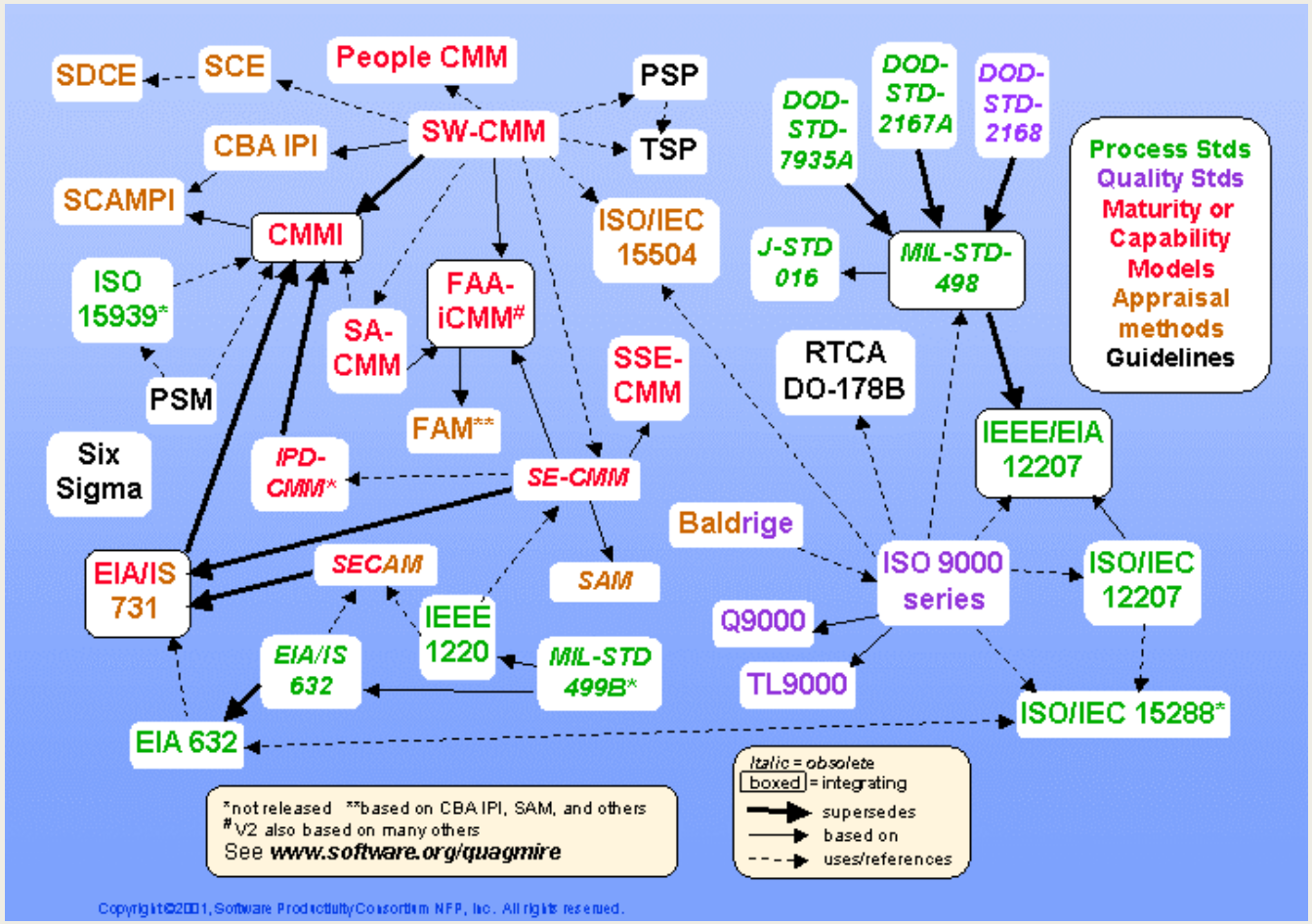
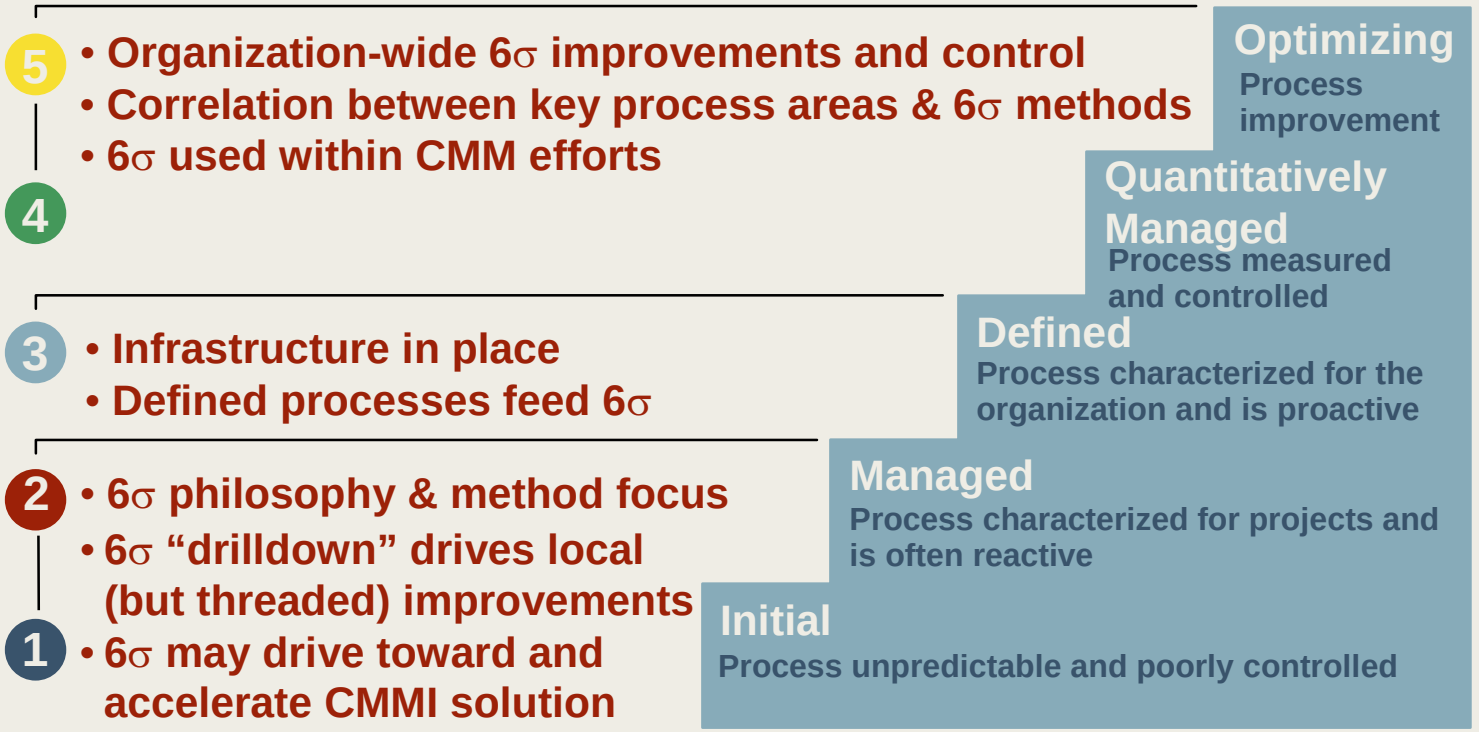
# SPC's Frameworks Quagmire



# CMMI Staged and Six Sigma



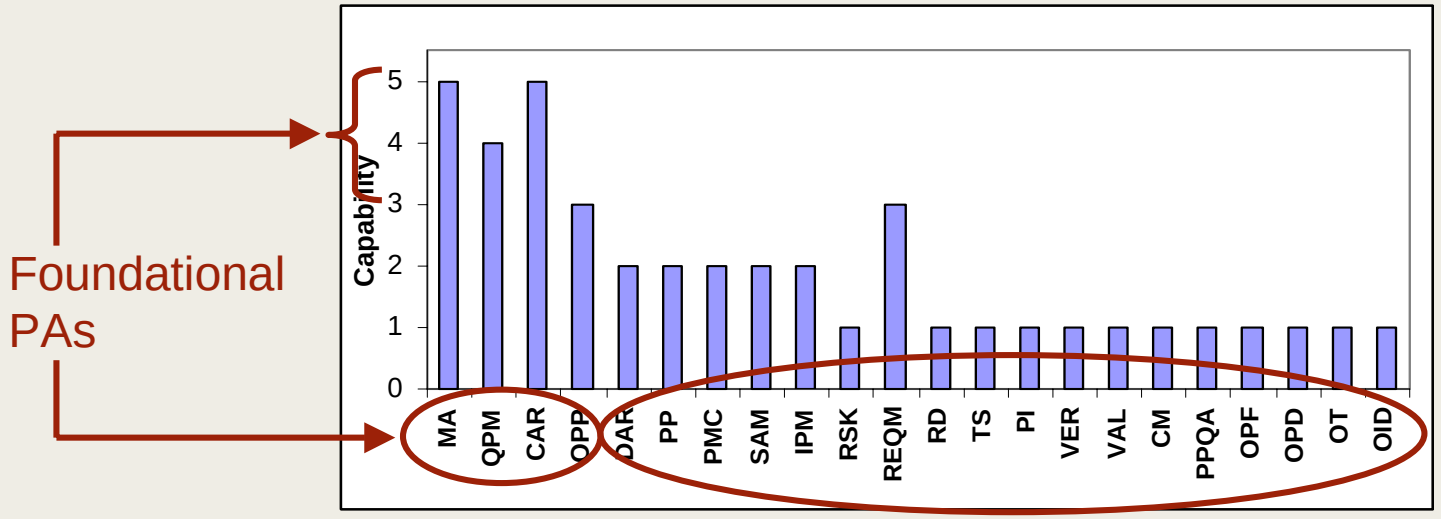

**Six Sigma is enterprise wide.**
**Six Sigma addresses product and process.**
**Six Sigma focuses on "critical to quality" factors.**

# CMMI Continuous and Six Sigma

Achieve high capability in PAs that build Six Sigma skills.

- MA, QPM, CAR, OPP

Use capability to prioritize order of remaining PAs




Remaining PAs ordered by business factors, improvement opportunity, etc.
(understood using foundational capabilities)

[vickroy 03]



# CMMI and Six Sigma: Additional Considerations

Six Sigma applications “around” CMMI

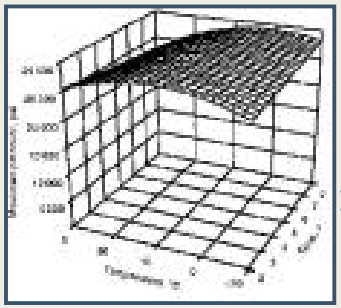
- SEPG process improvement rollout
- Appraisal methods

Organization certifications

- CMMI:  appraisals
- Six Sigma: performance is evidenced by bottom line results

# A Mathematical View

$$y_1, y_2 = f(x_1, x_2, \ldots, x_k)$$



not actual data

$y_1$ = customer satisfaction
$y_2$ = profitability
- note that profitability has a dependence on customer satisfaction

$x_1$ = standards, engineering practices/processes
- what to do, what is done
- as characterized and measured by capability models

$x_k$'s = product innovation, organization policies, marketplace factors and so on

In this view, cost, quality, schedule, product features are "intermediate" responses: functions of standards & practices, factors for customer satisfaction and profitability.

**Six Sigma is a way**
**to define the axes,**
**to traverse the response surface and find the optimum.**

# Tailoring Training for SW/SE

Leverage software and systems-specific measurement training as part of the DMAIC curriculum

Use projects to build repository of examples of analytical methods in context of systems and software

Extend Six Sigma curriculum, for instance

- Bayesian modeling
- Rayleigh distributions
- reliability fault trees

Develop an in-class design project suitable for systems and software engineering

# Tailoring Implementation for SW/SE

Business objectives should drive the effort

Leverage existing roles

- Select engineering process group members as sponsors, possibly as Champions and Black Belts.

Mapping methods

- Integrate the practices of models, standards, and initiatives into a unified, holistic approach that is appropriate for **your** organization.

# LMC M&DS Training & Implementation 1

Executive Lean Training

- Top Executives - one week off site
- Must understand and promote

Green Belt Training

- One week course (corporate initiated/ unit led)
- Certification (completion of course, 1 event, Black Belt Mentor)
- Considering expanding Green Belt training to keep Black Belt training at three weeks

Black Belt Training

- Three week DFSS/Lean course (corporate initiated)
- Certification (completion of course, 3 events, mentored one greenbelt to certification)

# LMC M&DS Training & Implementation 2

Lean Event Training

- 2-hour training session opens each lean event
- covers tools and methodologies
- geared for those without previous experience

Organizational Training Goals

- green belts to be trained set annually
- black belts to be trained set annually

# LMC M&DS Process Standard

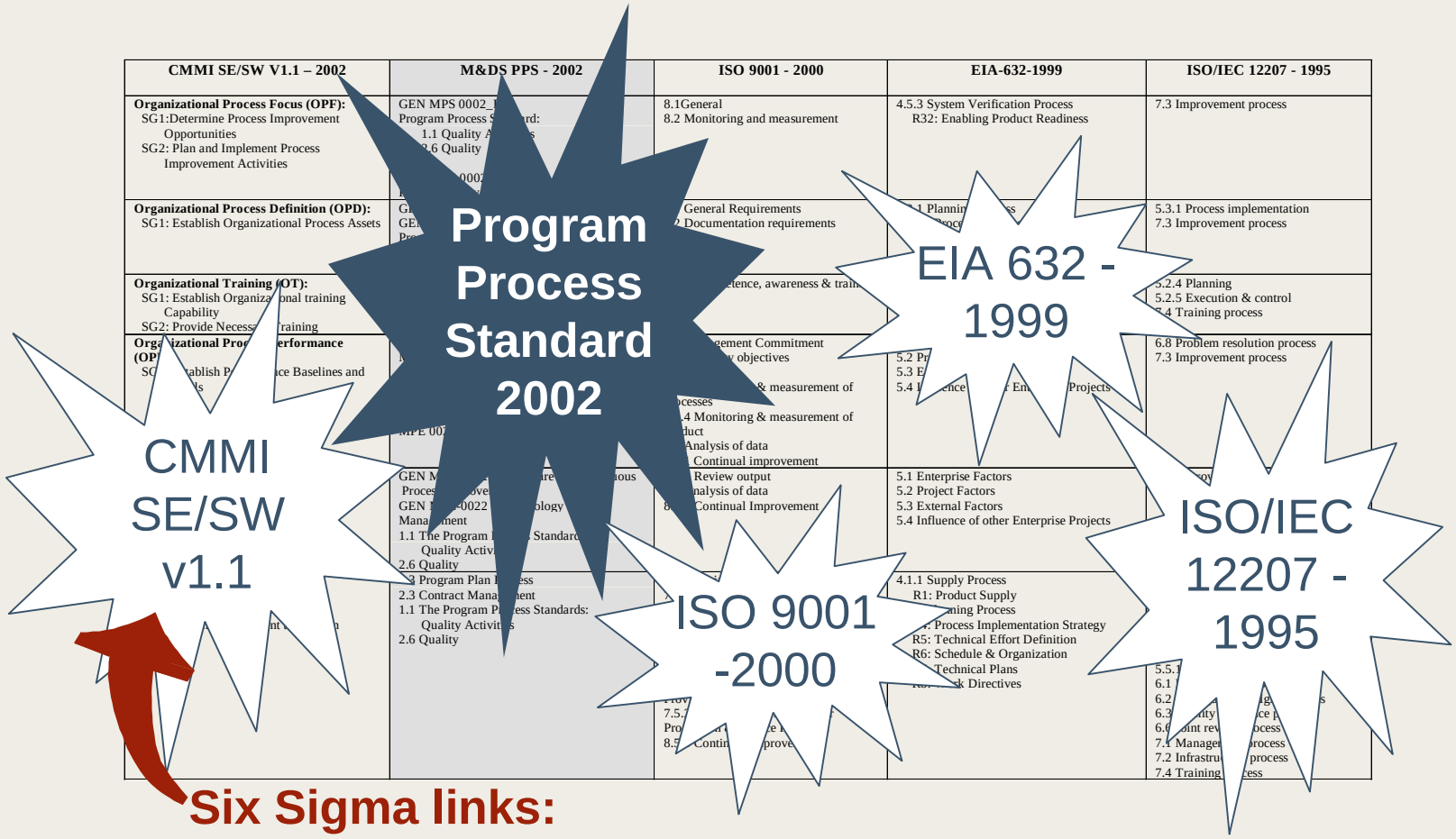
Program Process Standard (PPS)

- minimum mandatory set of development processes
- updated using industry standards in which certifications were desired

Example: Quantitative Management

- Key elements
  - program process standards
  - metrics program
- Map to CMMI Organizational Process Performance (OPP)
  - SG1: Establish performance baselines and models
- Map to ISO 9001 – 2001
  - 5.1 Management Commitment
  - 5.4.1 Quality Objectives….
- and so on

# LMC M&DS Process Standard Roadmap




| CMMI SE/SW V1.1 – 2002 | M&DS PPS - 2002 | ISO 9001 - 2000 | EIA-632-1999 | ISO/IEC 12207 - 1995 |
|---|---|---|---|---|
| **Organizational Process Focus (OPF):**<br>SG1:Determine Process Improvement Opportunities<br>SG2: Plan and Implement Process Improvement Activities | GEN MPS 0002_[illegible]<br>Program Process S[illegible]rd:<br>1.1 Quality A[illegible]s<br>2.6 Quality<br>[illegible]0007<br>[illegible] | 8.1General<br>8.2 Monitoring and measurement | 4.5.3 System Verification Process<br>R32: Enabling Product Readiness | 7.3 Improvement process |
| **Organizational Process Definition (OPD):**<br>SG1: Establish Organizational Process Assets | G[illegible]<br>GE[illegible]<br>Pr[illegible] | [illegible] General Requirements<br>[illegible]2 Documentation requirements | [illegible]1 Planni[illegible]s<br>[illegible]roce[illegible] | 5.3.1 Process implementation<br>7.3 Improvement process |
| **Organizational Training (OT):**<br>SG1: Establish Organizational training Capability<br>SG2: Provide Necessa[illegible]raining | | [illegible]etence, awareness & train[illegible] | | [illegible]5.2.4 Planning<br>5.2.5 Execution & control<br>[illegible]7.4 Training process |
| **Orga[illegible]izational Proc[illegible]erformance (OP[illegible]**<br>SG[illegible]tablish P[illegible]ce Baselines and [illegible]s | [illegible]<br>[illegible]<br>MPE 007[illegible] | [illegible]gement Commitment<br>[illegible]y objectives<br>[illegible]& measurement of [illegible]ocesses<br>[illegible].4 Monitoring & measurement of [illegible]duct<br>[illegible] Analysis of data<br>[illegible] Continual improvement | 5.2 Pr[illegible]<br>5.3 E[illegible]<br>5.4 I[illegible]nce [illegible]e En[illegible] Projects | 6.8 Problem resolution process<br>7.3 Improvement process |
| | GEN M[illegible]re[illegible]ious Proces[illegible]ove[illegible]<br>GEN [illegible]-0022[illegible]ology Manag[illegible]ment<br>1.1 The Program [illegible] Standard[illegible] Quality Activi[illegible]<br>2.6 Quality | [illegible] Review output<br>[illegible]nalysis of data<br>8.[illegible] Continual Improvement | 5.1 Enterprise Factors<br>5.2 Project Factors<br>5.3 External Factors<br>5.4 Influence of other Enterprise Projects | [illegible]oy<br>[illegible] |
| | [illegible]3 Program Plan [illegible]ess<br>2.3 Contract Manag[illegible]ment<br>1.1 The Program P[illegible]ess Standards: Quality Activit[illegible]s<br>2.6 Quality | [illegible]<br>7.5.[illegible]<br>Pro[illegible]ce [illegible]<br>8.5 Contin[illegible]prove[illegible] | 4.1.1 Supply Process<br>R1: Product Supply<br>[illegible]ning Process<br>[illegible]. Process Implementation Strategy<br>R5: Technical Effort Definition<br>R6: Schedule & Organization Technical Plans<br>[illegible]sk Directives | 5.5.1[illegible]<br>6.1[illegible]<br>6.2[illegible]g[illegible]s<br>6.3[illegible]ity[illegible]ce p[illegible]<br>6.6[illegible]oint rev[illegible]ocess<br>7.1 Manage[illegible]rocess<br>7.2 Infrastru[illegible] process<br>7.4 Training[illegible]cess |

**Six Sigma links:**

**Level 2 Measurement & Analysis PA, Level 4/5 PAs**



# Exercise: Important Concepts

Form groups of 4.

Each person takes a turn and shares

- the initiatives being juggled in his or her organization
- the most important or relevant concept from the first sections (fundamentals, implementation).

Total time for exercise:  12 minutes



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Objectives
Fundamentals
Implementation
**The “Black Belt” Project**
- **project basics**
- analytical tools

Case Study
Summary

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# What is a Defect?

**Six Sigma**: Any product, service, or process variation which prevents meeting the needs of the customer and/or which adds cost, whether or not it is detected.

**Personal Software Process$^{SM}$ (PSP$^{SM}$):** Defects or faults are the result of errors or mistakes. At a minimum, count a defect every time the program is changed during compile or test, where the change might be one character or multiple statements

**ISO 9000:2000:** Defects are the non-fulfillment of a requirement related to an intended or specified use.

**Software Reliability**: An error is a discrepancy between a computed, observed or measured value and the true value or a human action that results in software containing a fault. A failure is the inability to perform a required function with specified limits. A fault is a defect in the code that can be the cause of one or more failures.

[Humphrey 95], [DACS]

# Defect Consequences Worksheet

List the consequences of different types of defects.

| Event | Consequence |
|---|---|
| Customer complaints | |
| Escaping defects | |
| Test defects | |
| Inspection defects | |

Note: This worksheet is provided for your notes about the consequences of different types of defects in your organizational context. It may be completed after the tutorial.

# False Starts on SW Sigma Metrics

From Motorola:

Single, over-riding objective is **Customer Satisfaction:**

"the degree of confidence a customer has that his (or her) product … expectations will be met by the producer."

# incorrect orders

# airline bags lost

# late arrivals

# bad lines of code

[Stoddard 00], [Stoddard 02]



# The Customer's Vantage Point

32-step "workaround" to move info to new version of financial software

Wrong "Statement Ending Balance" when reconciling a mutual fund account using financial software

Bank ATM's debit accounts but don't give money

University students unable to enroll due to lingering problems in multi-million-dollar software system

New air traffic control system out of action more than 7 hours resulting in cancelled flights and extended delays

Carrier plane veers right without warning due to computer glitch (emergency landing was a result)

Money from payroll direct deposits missing from bank accounts

[NYT], [SM]

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# What "Sigma Level" is "Right"?

What is your customer telling you?

Plus, a general business perspective:

- A 4 sigma company spends >10% of revenues on internal & external repair
- A 6 sigma company spends <1% of revenues on internal & external repair

At LMC

- processes modeled using SWEEP* tool
  - allows tolerances to be set based on present performance
  - allows targets to be set based on future performance
- output of the modeling showed "six sigma" performance

*SWEEP = Software Error Estimation Program



# What Is a Black Belt Project?

Business importance

- Financial expectations: $100-150K (US) savings, at least
- Endorsed and approved by management

Duration: 3-6 months recommended

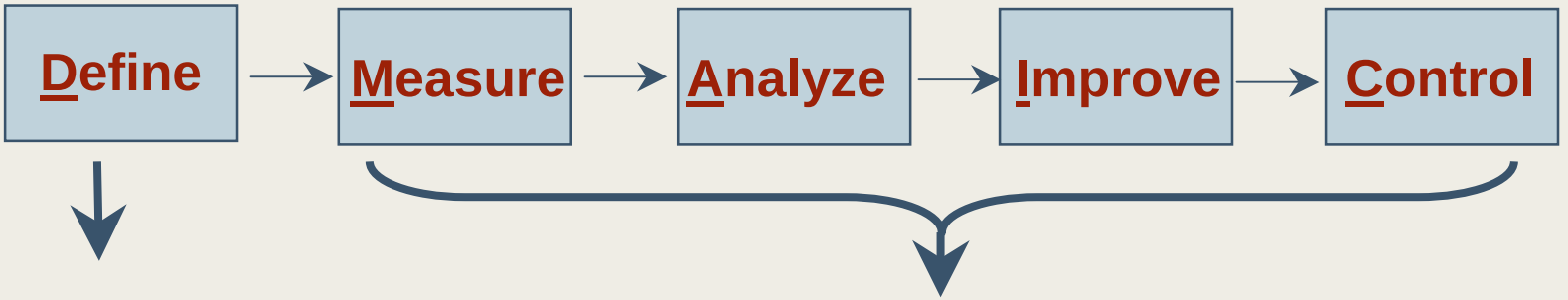
Objectives are quantitative and include at least one of the following:

- Improve customer satisfaction.
- Optimize the supply chain.
- Reduce defects.
- Reduce cycle time.
- Improve first-pass yield.
- Reduce variability.
- Optimize product performance.
- Optimize process performance.
- Reduce costs.
- Reduce the cost of quality.

[kodak.com], [Snee 01]

# Composite Project Illustration

**Problem and goal statement (Y):**
- maximum latent defects released
- minimum mean time between failure in the field
- time to market improvement (as function of test time, defect density)

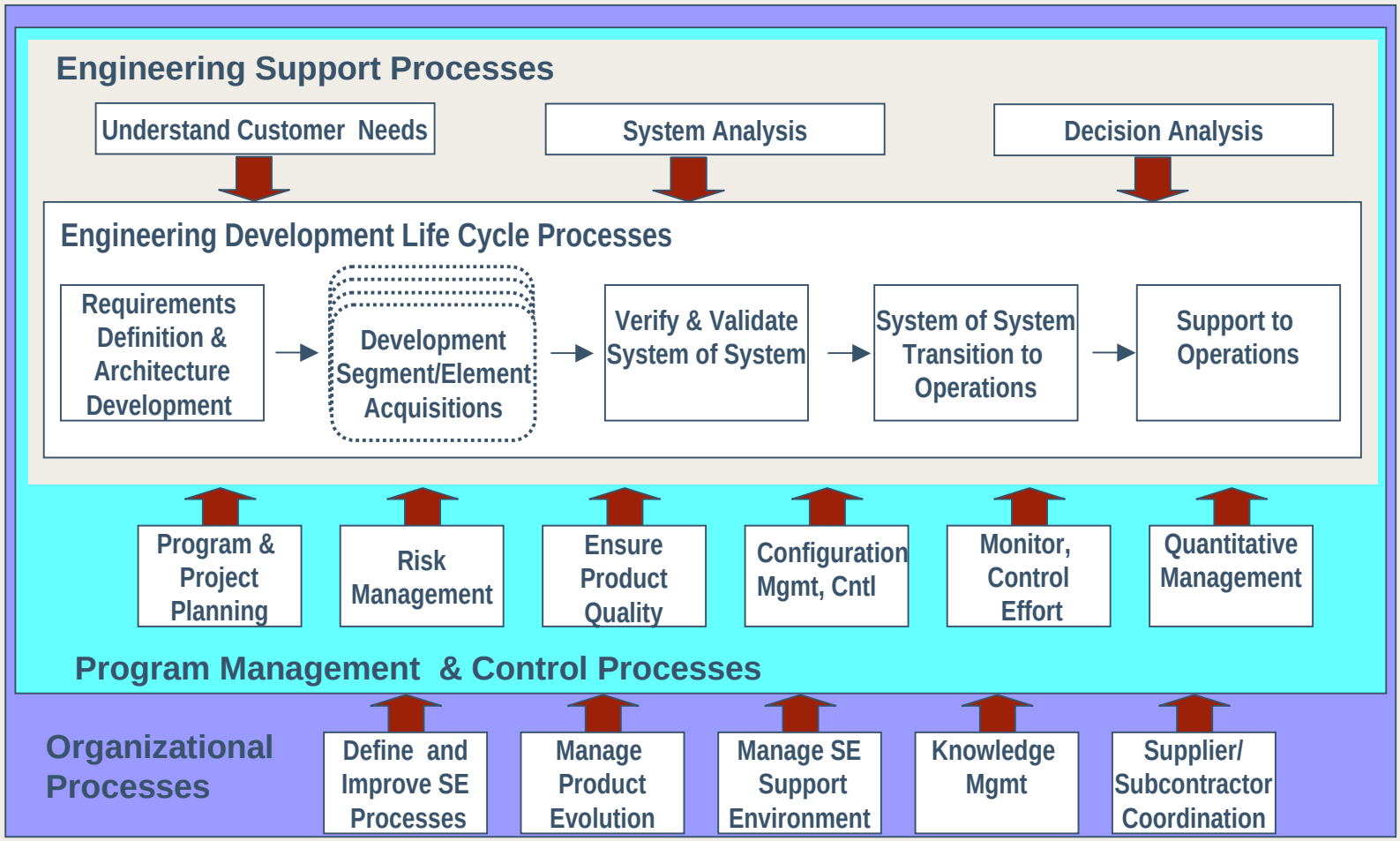



- Problem & goal statements
- Define boundaries
- Process maps
- "Management by Fact"

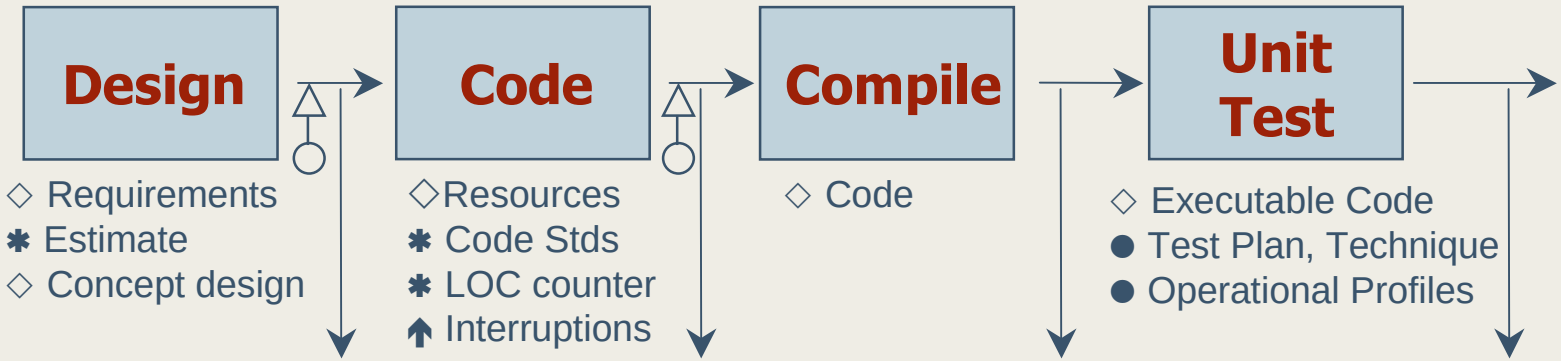
- Discovery: paretos, histograms, distributions, c&e
- Understanding: root cause, critical factors
- Improvement: adjust critical factors, redesign
- Performance: on target, with desired variation

**Y = f(defect profile, yield)**
**= f(review rate, method, complexity……)**

# A Very High-Level Process



# Project Boundaries Process Map




- **Detailed Design**
- **Test cases**
- **Complexity**
- **Data:** Design Review defects, Fix time, Phase duration

- **Code**
- **Data:** Defects, Fix time, Defect Injection Phase, Phase duration

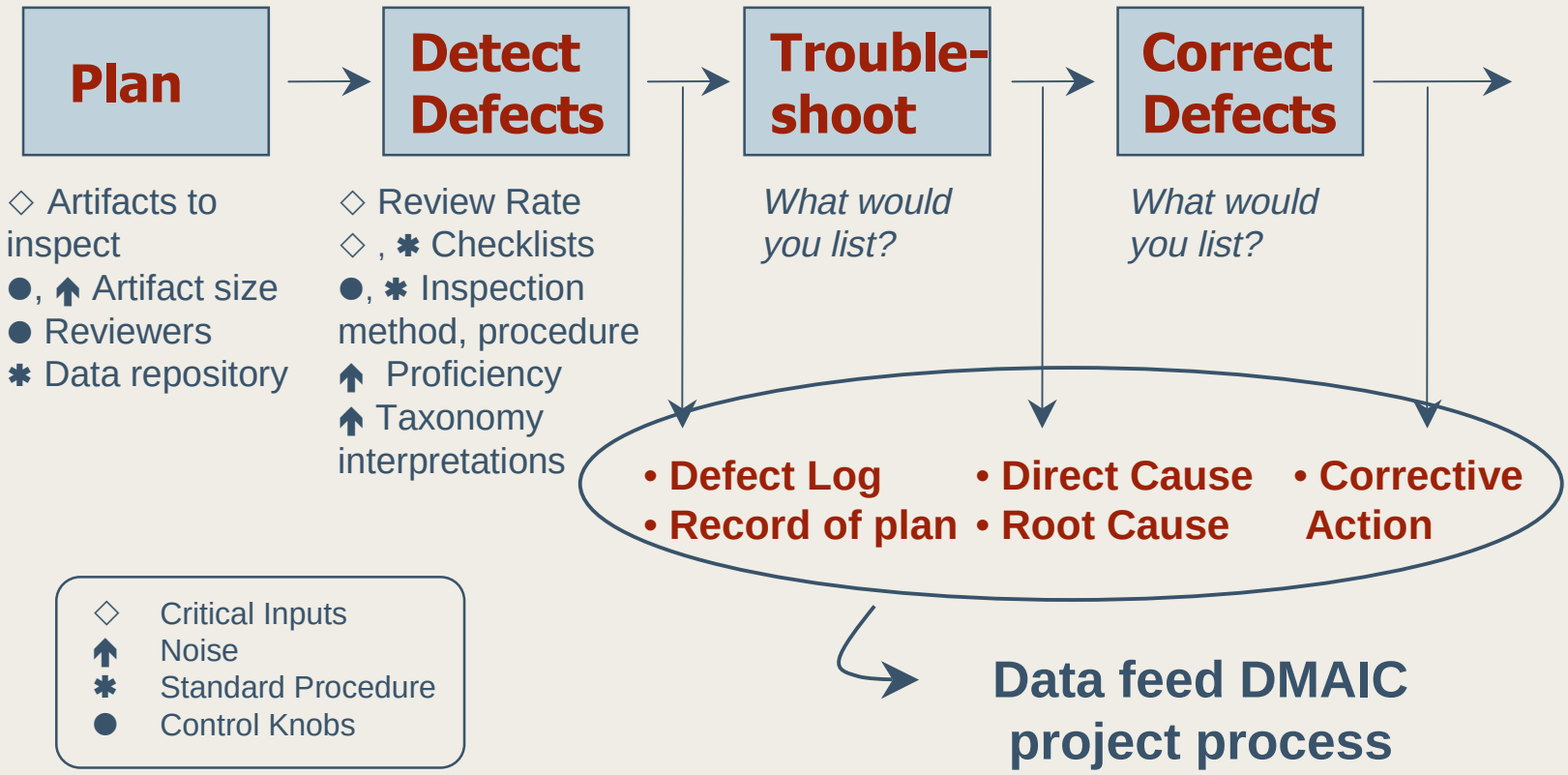
- **Executable Code**
- **Data**: Defects, Fix time, Defect Injection Phase, Phase duration

- **Functional Code**
- **Data:** Defects, Fix time, Defect Injection Phase, Phase duration

△ Inspection
○ Rework
◇ Critical Inputs
Noise
✱ Standard Procedure
● Control Knobs

# Drilldown to Inspection Process

## What are the sources of variation? the control knobs?



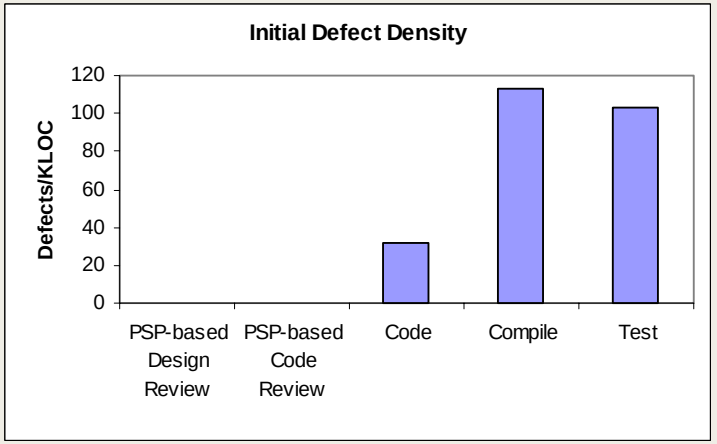
# Starting Out….

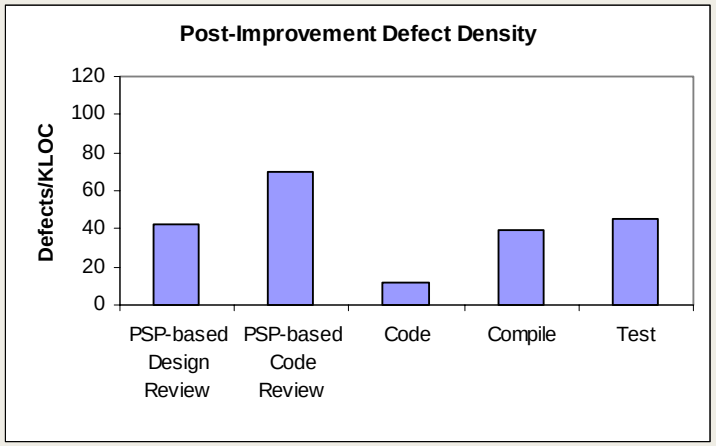
Collecting basic data

Refining processes
- inspections

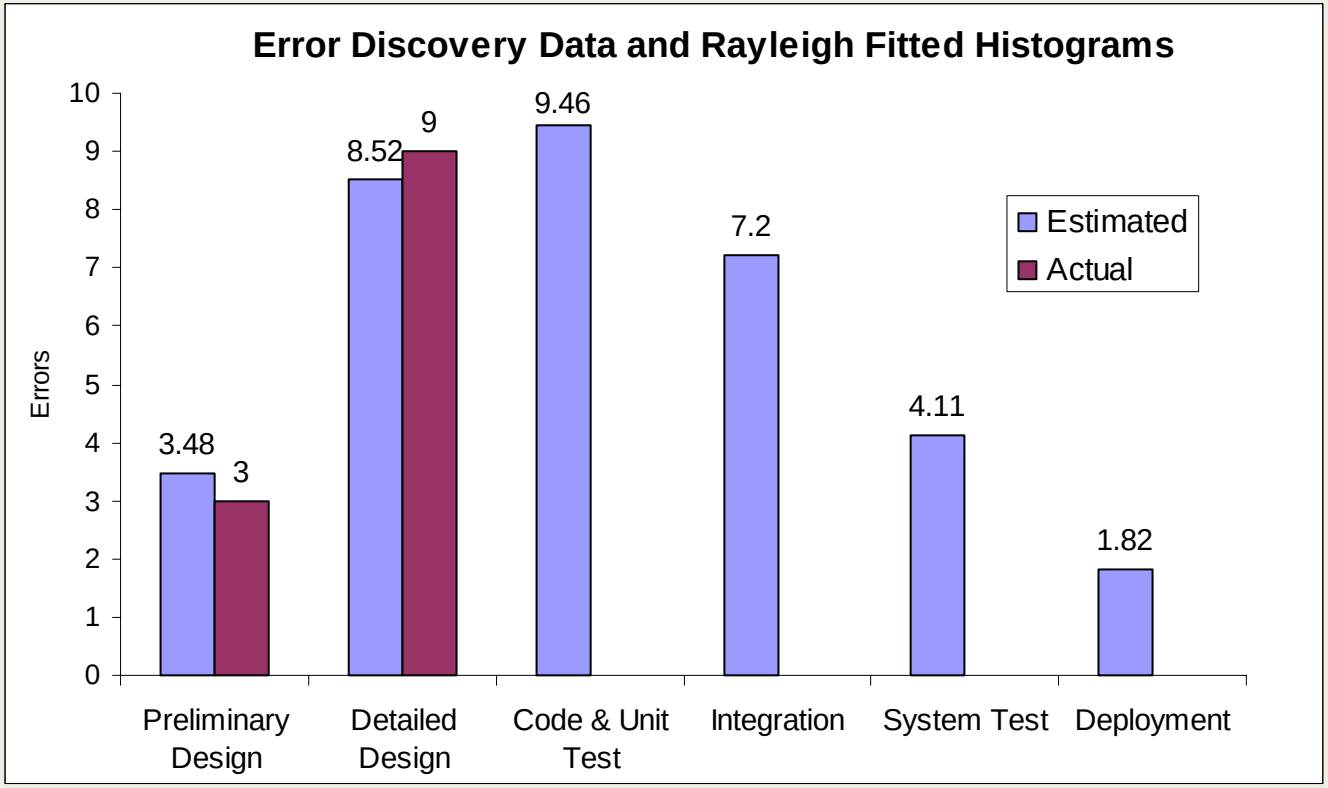
Improving
- cause & effect matrix
- pareto analysis

Leads to
- injecting fewer defects
- detecting defects earlier
- removing them efficiently
- process stability

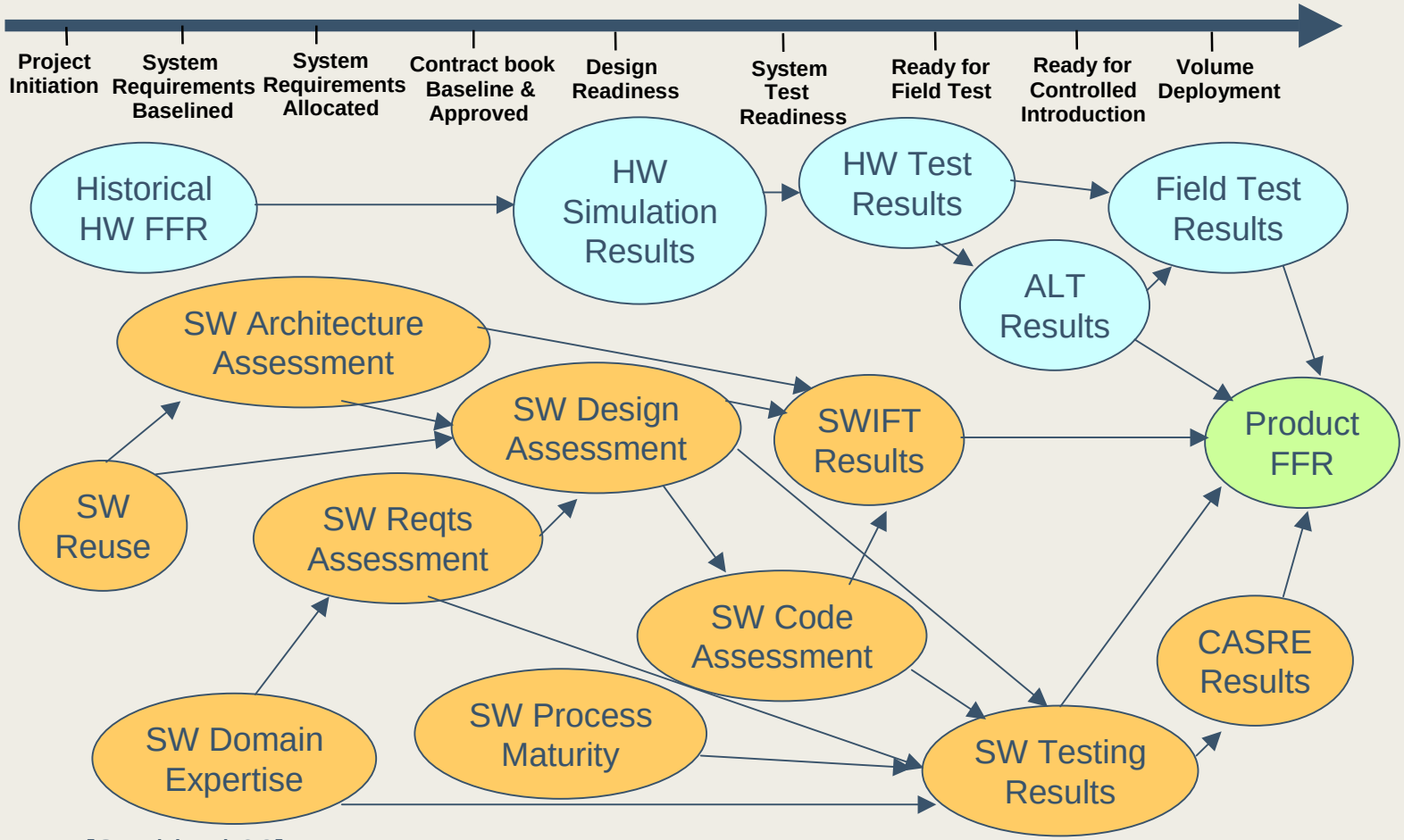


# Rayleigh Distribution

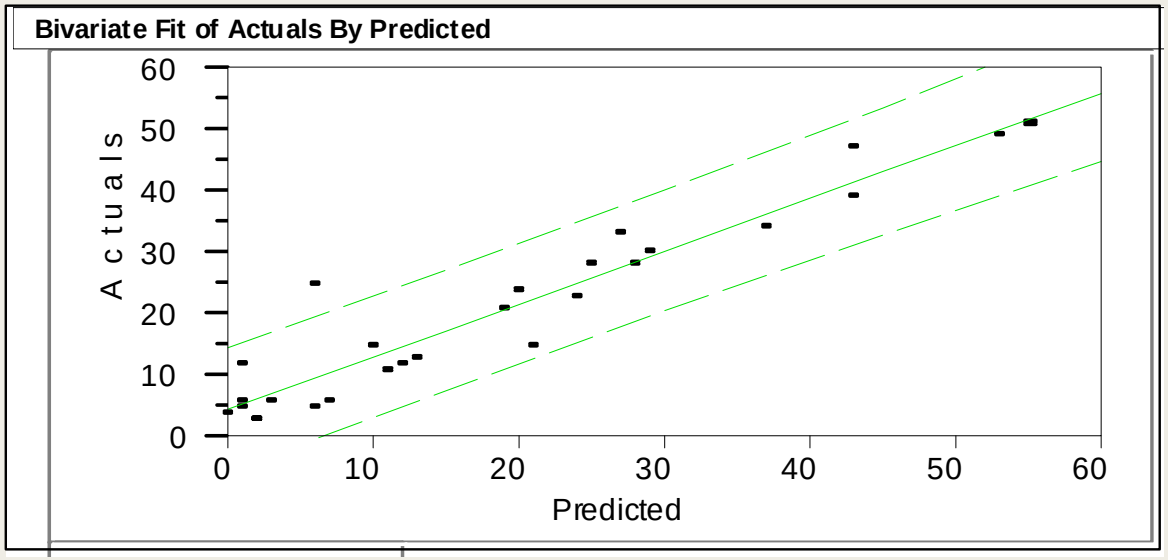


# Cause-Effect Model Using Bayesian Modeling




[Stoddard 02]

# CASRE* Predictions




**Actual field defects = f(CASRE predicted defects)**

**CASRE predicted defects = f(weekly arrival rate of SW failures, weekly test intensity measures )**

**$3M/year savings from premature SW releases**

[Stoddard 02], *CASRE = Computer Aided Software Reliability Estimation

# Outline

Objectives
Fundamentals
Implementation
**The “Black Belt” Project**
- project basics
- **analytical tools**

Case Study
Summary

# Toolkit

| Define | Measure | Analyze | Improve | Control |
|---|---|---|---|---|
| Benchmark Baseline<br>Contract/Charter<br>Kano Model<br>**Voice of the Customer**<br>Voice of the Business<br>Quality Function Deployment<br>**Process Flow Map**<br>Project Management<br>**"Management by Fact"** | Defect Metrics<br>Data Collection Methods<br>Sampling Techniques<br>Measurement Sys. Evaluation | **7 Basic Tools**<br>Cause & Effect Diagrams, Matrix<br>Failure Modes & Effects Analysis<br>Statistical Inference<br>Reliability Analysis<br>Root Cause Analysis<br>**5 Whys**<br>Hypothesis Test<br>ANOVA | Design of Experiments<br>Modeling<br>Tolerancing<br>Robust Design<br>Systems Thinking<br>Decision & Risk Analysis | Statistical Controls:<br>• Control Charts<br>• Time Series methods<br><br>Non-Statistical Controls:<br>• Procedural adherence<br>• Performance Mgmt<br>• Preventive activities |

# "Tool Tips" Outline

Reference overview (description, procedure, tips, examples) for

- Management by Fact
- Voice of the Customer
- Process Mapping
- 7 Basic Tools
- Lean

Brief highlights for

- Cause and Effect Matrix
- Quality Function Deployment
- Bayesian Modeling
- Systems Thinking

# Tool Tip: Management by Fact (MBF)

Description (CMMI M&A, QPM, CAR)

- a concise summary of quantified problem statement, performance history, prioritized root causes and corresponding countermeasures for the purpose of data-driven project management

Management by Fact

- uses the facts
- eliminates bias
- tightly couples resources and effort to problem-solving



# MBF: Procedure

Identify and select problem (M&A, QPM)
- use “4 Whats” to help quantify the problem statement
- quantify gap between actual and desired performance

Determine root cause (M&A, CAR)
- separate beliefs from facts
- use “7 Basic Tools”
- use “5 Whys”

Generate potential solutions and select action plan (M&A, OID)
- Must be measurable/sustainable
- Specific/assignable ownership
- Understand expected results from each action

Implement solutions and evaluate (M&A, OPP, OID)
- Compare data before and after solution
- Document actuals and side effects
- Compare with desired benchmark

# 4 Whats

**Customer satisfaction scores are too low.**
- What is too low?

**Compared to best-in-class benchmark of 81%, we are at 63%.**
- What is the impact of this gap?

**It represents lost revenue and earnings potential?**
- What is the correlation between customer satisfaction and revenue?

**Each percent of customer satisfaction translates to 0.25 percent of market share which equals $100M US revenue**.
- What is the lost potential?

**Final problem statement:**

**Customer satisfaction is 18% lower than best-in-class benchmark, which corresponds to a potential lost revenue of $1.8B US.**



# 5 Whys

**The marble in the Jefferson Memorial was deteriorating.**
• Why?

**The deterioration was due to frequent cleanings with detergent.**
• Why?

**The detergent was used to clean bird droppings from local sparrows.**
• Why?

**The sparrows were attracted by spiders.**
• Why?

**The spiders were attracted by midges.**
• Why?

**The midges were attracted by the lights.**

**Solution: Delay turning on the lights until later at dusk.**

# MBF: Format

**FACTUAL STATEMENT OF PROBLEM, PERFORMANCE TRENDS & OBJECTIVES**

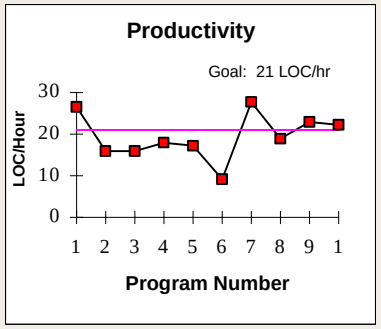
| Graph of performance over time | Graph of supportive or more detailed information |
|---|---|

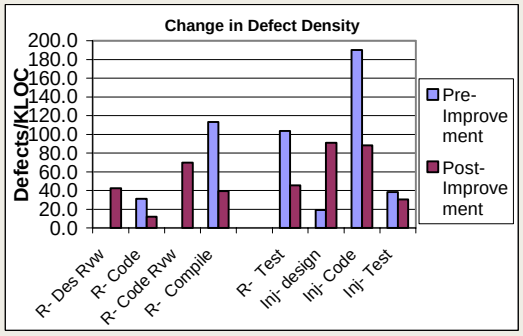
| Prioritization & Root Cause | Counter Measures & Activities | Impact, Capability |
|---|---|---|
| List of gaps in performance and true root cause | List of specific actions, who has ownership and due date | List of expected benefits and impact of **each** countermeasure |

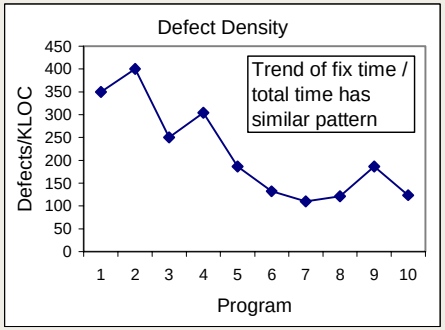
# MBF: Example

## Problem Statement

Customers A, B and C, representing x% of market share, are facing budget/cost constraints and require a 10% cost reduction in our product line XYZ in order to continue doing business with us. Baseline data shows that 33% of software development time is spent detecting and correcting defects.




| Prioritization & Root Cause | Counter Measures & Activities | Who | When |
|---|---|---|---|
| Large Quantity of Syntax & Similar defects that are repaired in <10 minutes on avg<br>*Goal is 50% reduction in time, relative to historical data* | Clarify type definitions | jms | ✓4/30/2001 |
| | Improve subcategory data collection | jms | ✓4/30/2001 |
| | Build a cause & effect diagram to be used for next round of analysis, improvement planning | jms | |
| | Increase correction efficiency by seeking all occurrences of a defect upon the detection of the first occurrence | jms | ✓4/30/2001 |
| | Increase and log (new) usage of off-line programs to test small pieces of functionality | jms | |
| | Create & Use a syntax checklist | jms | ✓4/30/2001 |
| "Big Hitter" (>10 minutes) defects involve a variety of errors that escape to testing. Design-injected and Test-removed errors fall into this category<br>*Goal is 25% reduction in time, relative to historical data* | Time breaks: phase completion & every hour | jms | ✓4/30/2001 |
| | Conduct a phase check prior to moving on | jms | ✓4/30/2001 |
| | Increase and log (new) usage of off-line programs to test small pieces of functionality | jms | ✓4/30/2001 |
| | Improve subcategory data collection to use for developing a more directed design review | jms | ✓4/30/2001 |
| | Build a cause & effect diagram to be used for next round of analysis, improvement planning | jms | |

| Expected Benefit/Impact |
|---|
| About 1/2 of goal. In normalized terms, ~1 LOC/hr increase |
| About 1/2 of goal. In normalized terms, ~1 LOC/hr increase. |

# Tool Tip: Voice of the Client (VOC)

Description (IPM – where customer is part of group, IPPD)

- a method to describe the stated and unstated needs or requirements of the customer
- can be captured in a variety of ways: direct discussion or interviews, surveys, focus groups, customer specifications, observation, warranty data, field reports, complaint logs, etc.

[isixsigma]



# VOC: Usage

Feeds Quality Function Deployment (QFD)

Risks (track via RSKM and DAR techniques)

- anecdotal, not quantitative
- difficult to get “the right answer”
- humans are PERFECT FILTERS!
- it is very easy to induce bias in VOC

Tips

- use existing information with care – it may be biased or too narrowly focused
- always use more than one source
- customer visits allow direct discussion and observation
- customer visits allow immediate follow-up questions and unexpected lines of inquiry



# VOC Interviews: Procedure 1

Define the customer.

Select customers to interview.

- Always interview more than one.

Plan interview. (use verification & validation techniques)

- Develop a checklist/guideline.
- Teams of 3: “Moderator,” “Scribe,” “Observer”

Conduct interviews. (collect metrics for trend analysis)

- Customer statements & observations need to be recorded VERBATIM.
- Keep asking “why.”

# VOC Interviews: Procedure 2

Create VOC table. (RM, RD)

- Interpret verbatim statements into new meanings.
- Document source of VOC or re-worked VOC.
  - "I" if internally changed or generated (by team)
  - "E" if externally generated (by customer) or not changed by team
- Classify each statement as:
  - a real need ➔ feeds QFD
  - a technical solution
  - a feature requirement ➔ feeds QFD
  - not a true need (e.g., cost issue, complaint, technology, hopes dreams, etc.)
- Quantify, Analyze, Prioritize

# VOC: Example Table

New process initiative under consideration

- interview statements recorded verbatim and classified
- column added for keyword sorting

Further development

- "interpreted" comments about the organization's true goals, the overlap of initiatives (and so on)
- evaluation for common themes
- additional data collection may be needed

| | | | Classification | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Customer comment** | **Interpreted, reworded** | **I/E** | perception, experience, context | barrier | root issue? | results, success | need | solutions | Keyword for sorting |
| We are already at maturity level x, so why do more? | | E | ✓ | ✓ | | | | | competing initiatives |

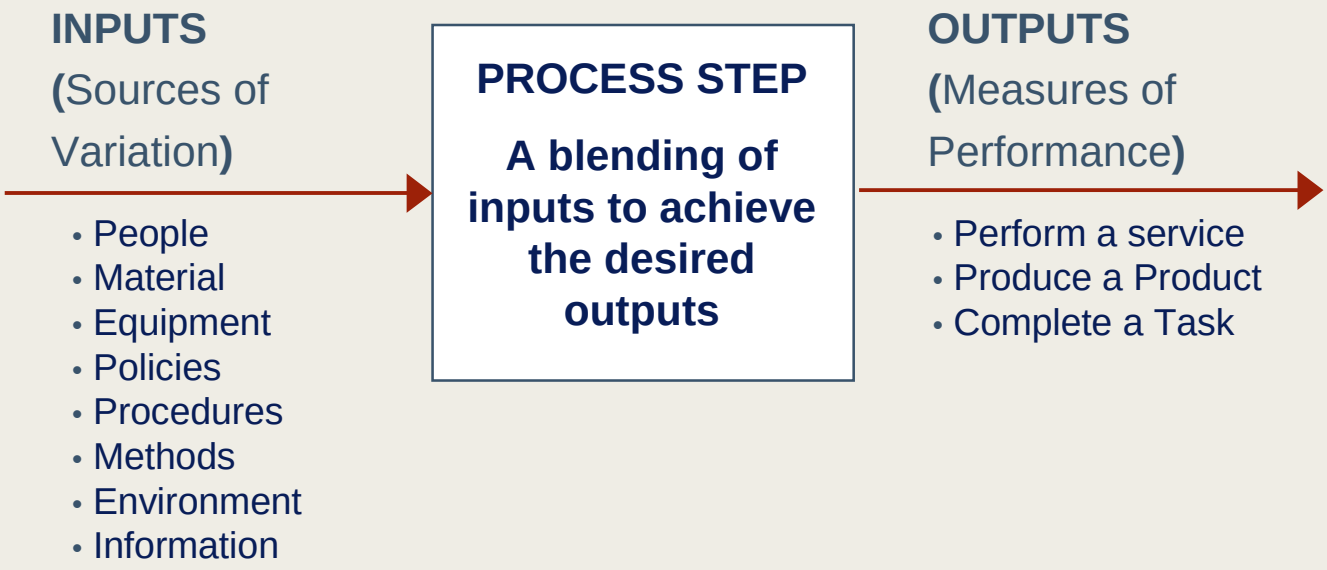
# VOC: Analysis

| Prioritization Method | Customer Time | Preparation Complexity | Analysis Complexity | Quality of Resulting Prioritization | Number of customers needed | Number of Needs to Prioritize | Recommend |
|---|---|---|---|---|---|---|---|
| Frequency of Response | short | low | low | low | large | large | NO |
| Constant Sum | medium | medium | medium | medium | medium | small | Yes |
| Rating | short | low | low | medium | medium | med-large | Yes |
| Simple Ranking | medium | low | low | medium | medium | small-med | Yes |
| Q-Sort | short | low | low | medium | medium | large | Yes |
| Paired Comparison | long | medium | high | high | large | small | Yes |
| Regression | short | medium | high | high | large | small-med | Yes |

# Tool Tip: Process Mapping

Description

- representation of major activities/tasks, subprocesses, process boundaries, key process inputs, and outputs



# Mapping: Usage

Feeds other tools (OID, OPP, CAR)

- Cause and Effects Matrix
- Failure Modes and Effects Analysis (FMEA)
- Control Plan Summary
- DOE planning

Tips for mapping current processes (OPP)

- Go to the **actual place** where the process is performed.
- Talk to the **actual people** involved in the process and get the real facts.
- Observe and chart the **actual process.**
- Consider creating “as is” and then “to be” maps.

**Reality is invariably different from perception - few processes work the way we think they do!**

# Mapping: Terms

**Controllable Inputs:** Key Process Input Variables (KPIVs) that can be changed to see the effect on Key Process Output Variables (KPOVs). Sometimes called “Knob” Variables.

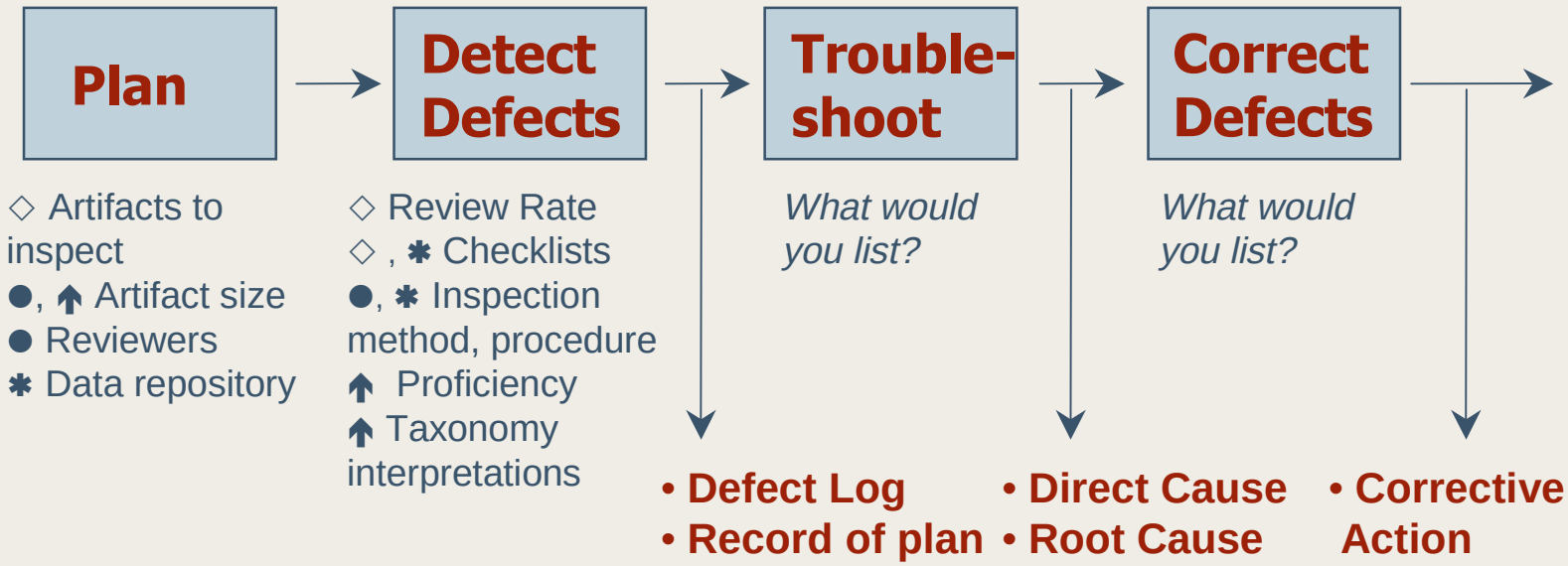
**Critical Inputs:** KPIV’s that have been **statistically** shown to have a major impact on the variability of the KPOVs.

**Noise Inputs:** Input variables that impact the KPOVs but are difficult or impossible to control. Example: Environmental variables such as humidity, ambient temperature, etc.

**Standard Operating Procedures:** A standard procedure for running the process.

# Mapping: Example

## Inspection process from earlier illustration





# Mapping Variation: Value Map

Identify the process to map.

Identify the boundaries.

Create input-process-output for the critical processes.

Create the process map.

Color code each step identifying value.

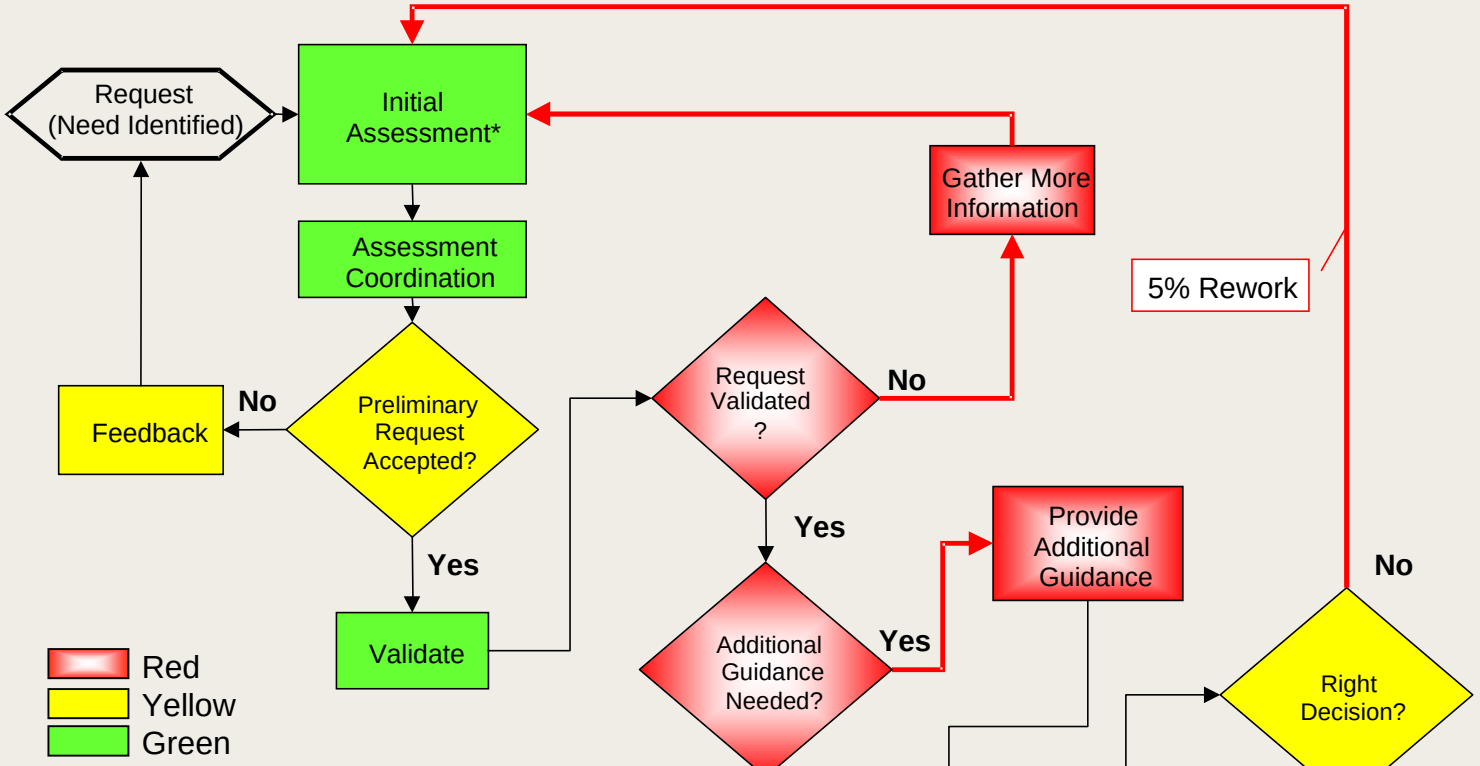
- green = value added
- red = non value added
- yellow = non value added but necessary

Identify hand-off points, queues, storage, and rework loops in the process.

Quantitatively measure the map (throughput, cycle time, and cost).

Validate map with process owners.

# Value Mapping: Example




*Initial Assessment will:
- Determine Impact Assessment
- Identify Stakeholder
- Coordinate with Product/Process Owner
- Perform Impact Analysis



# Process Map Practice

Complete the inspection process map presented in this "tool tip."

Or, create a new inspection process map based on your experience.

Note: This and the next slide are provided for post-tutorial process mapping practice.

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# Your Process Map Here

# Tool Tip: 7 Basic Tools

Description

- Fundamental data plotting and diagramming tools
  - Cause & Effect Diagram
  - Histogram
  - Scatter Plot
  - Run Chart
  - Flow Chart
  - Brainstorming
  - Pareto Chart
- The list varies with source. Alternatives include
  - Statistical Process Control Charts
  - Descriptive Statistics (mean, median and so on)
  - Check Sheets

# 7 Basic Tools: Usage

PLOT, PLOT, PLOT!

- use these tools to describe the process
- expand and extend the charts as needed

Used throughout Six Sigma projects and within many other tools:

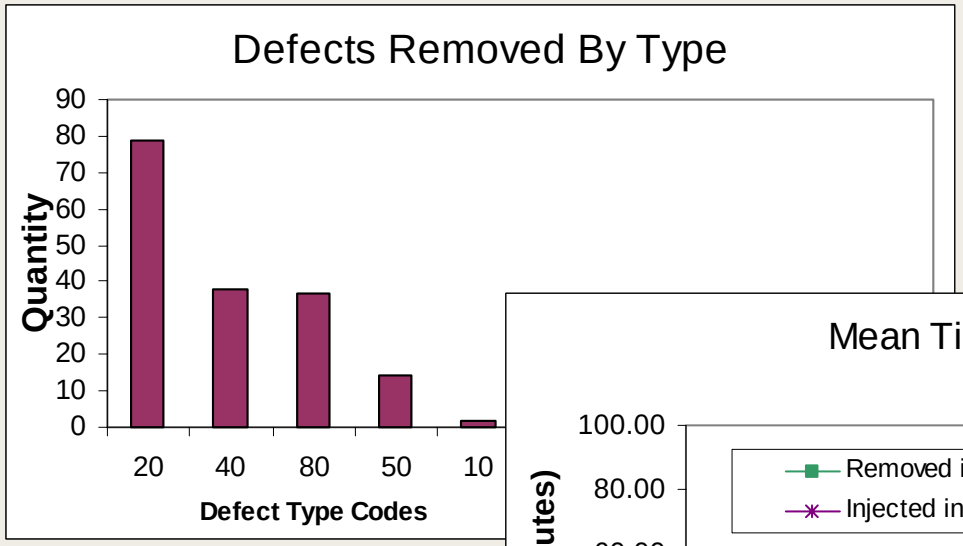
- MBF
- troubleshooting as a result of “out of control” point

Many accomplishments are built on these tools **alone.**

Handy resource: “The Memory Jogger”

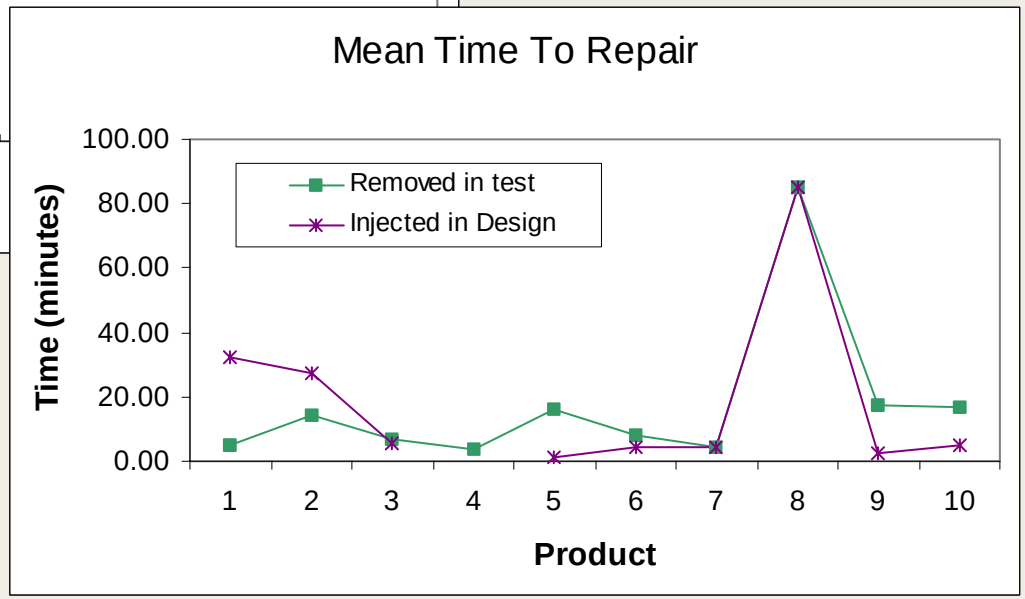
[Memory Jogger: http://www.goalqpc.com]

# 7 Basic Tools: Chart Examples

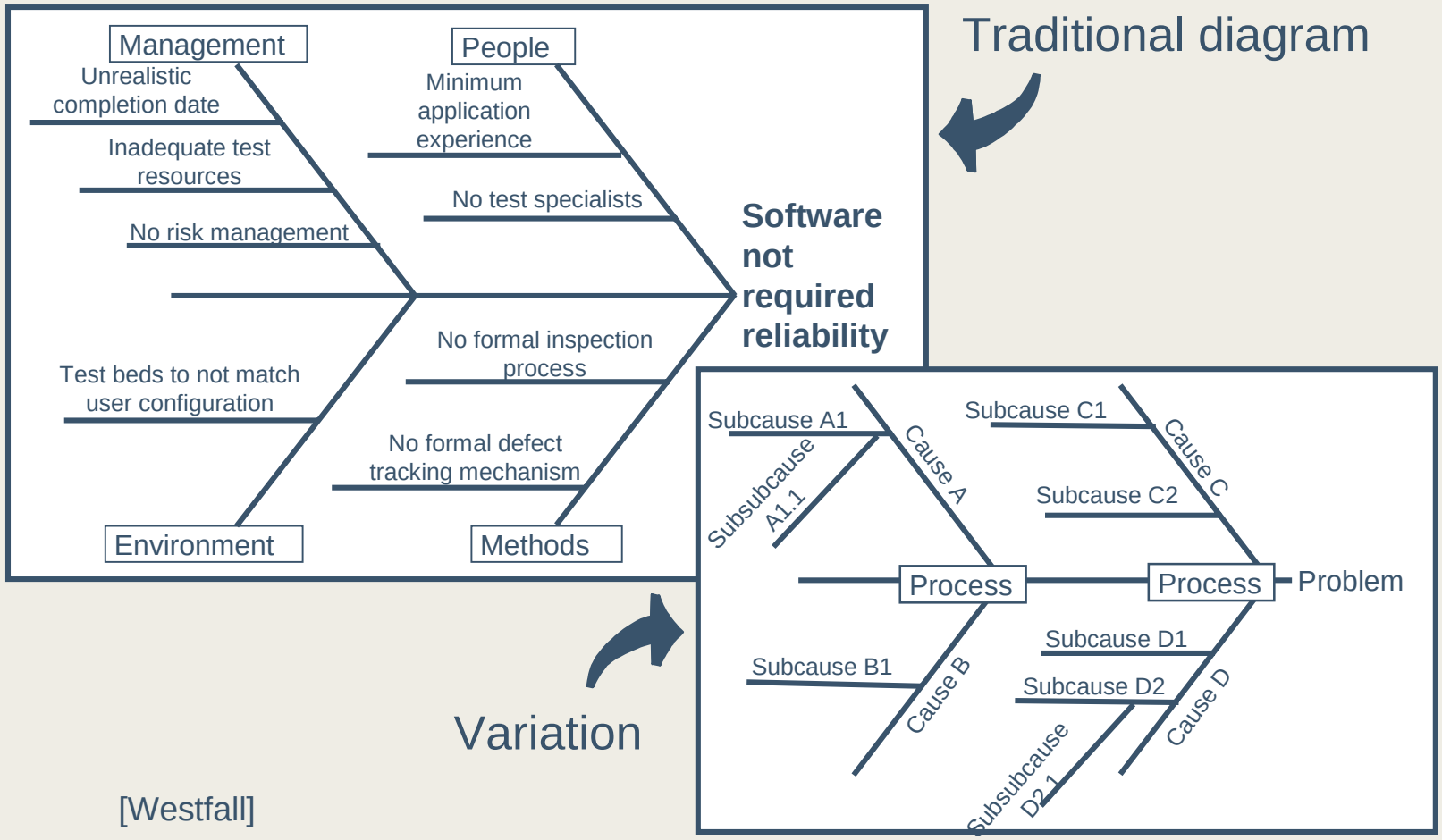



Pareto Chart

Run Chart



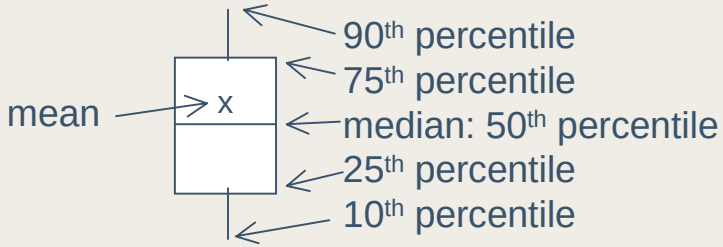
# 7 Basic Tools: Cause & Effect

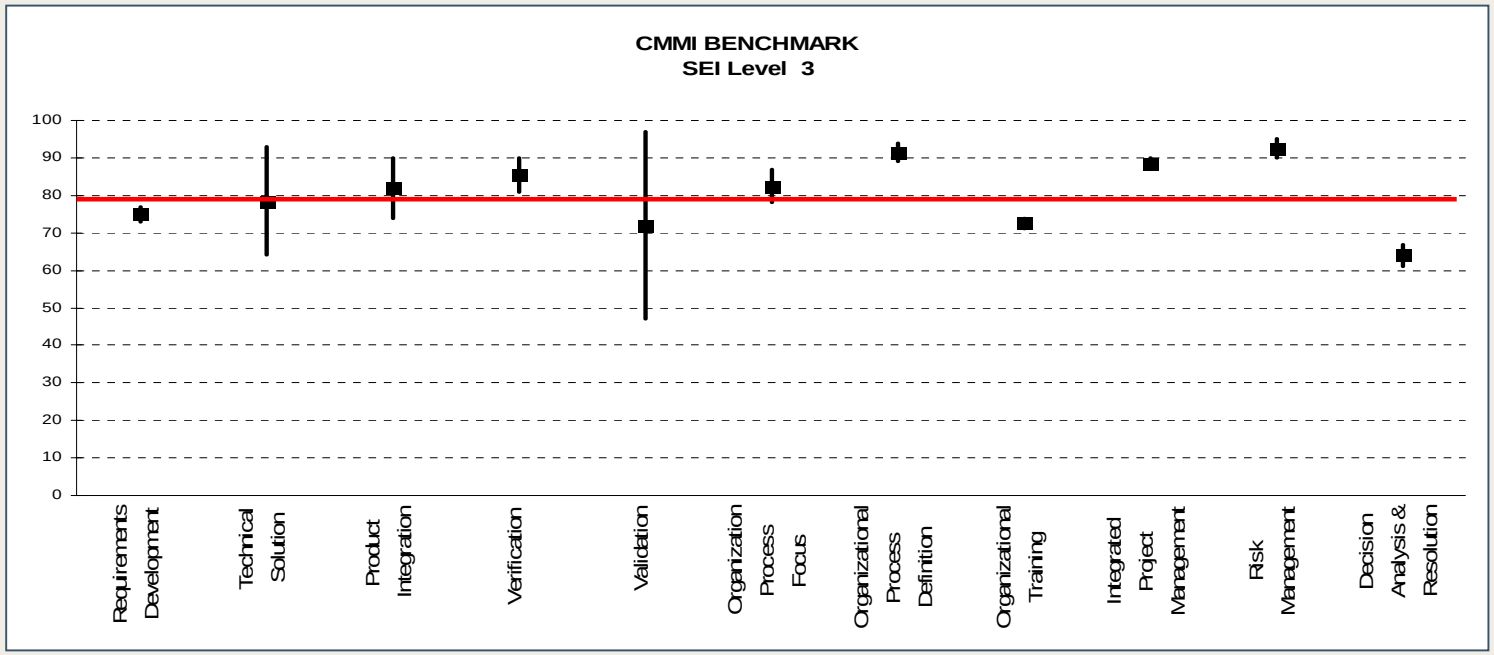



[Westfall]

# 7 Basic Tools: Chart Variations

Box & Whisker Plot
for assessment data

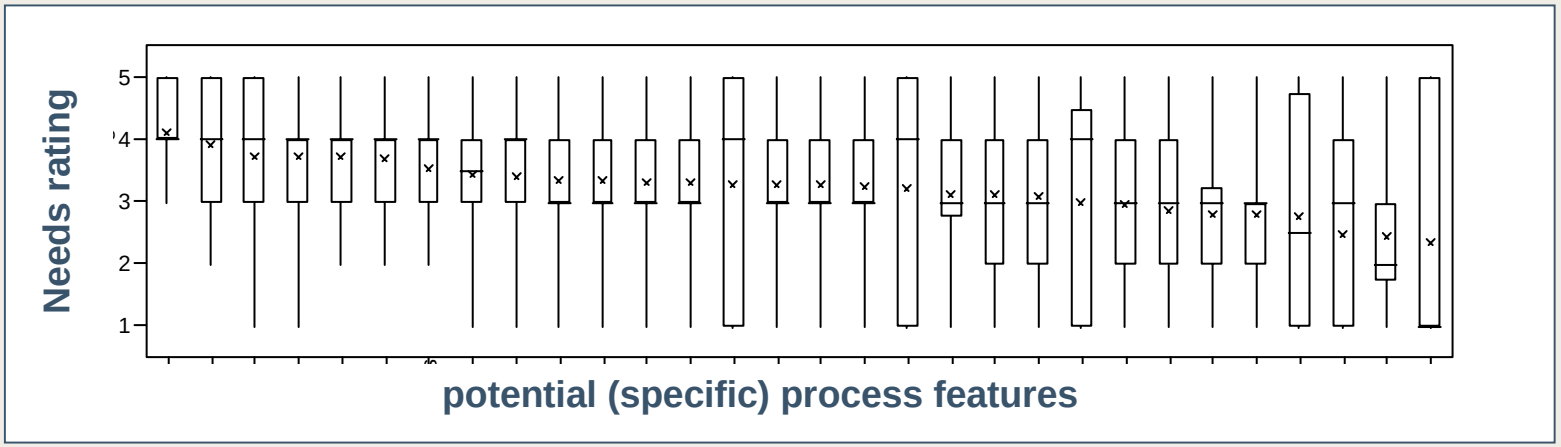


# 7 Basic Tools: Chart Variations

Boxplot variations:

- cost and schedule variance over time to show organizational average and also variability
- prioritized features for a new process technology rollout: a combination “pareto-boxplot”



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# Tool Tip: Lean

**"An organization working together to make continuous improvements without large capital investment"**

Purpose

- brings the right people together to understand the process and make immediate improvements to the process.
- evaluates opportunities to reduce cycle time, cost, inventory and eliminate all waste.

# Lean: Terms & Usage

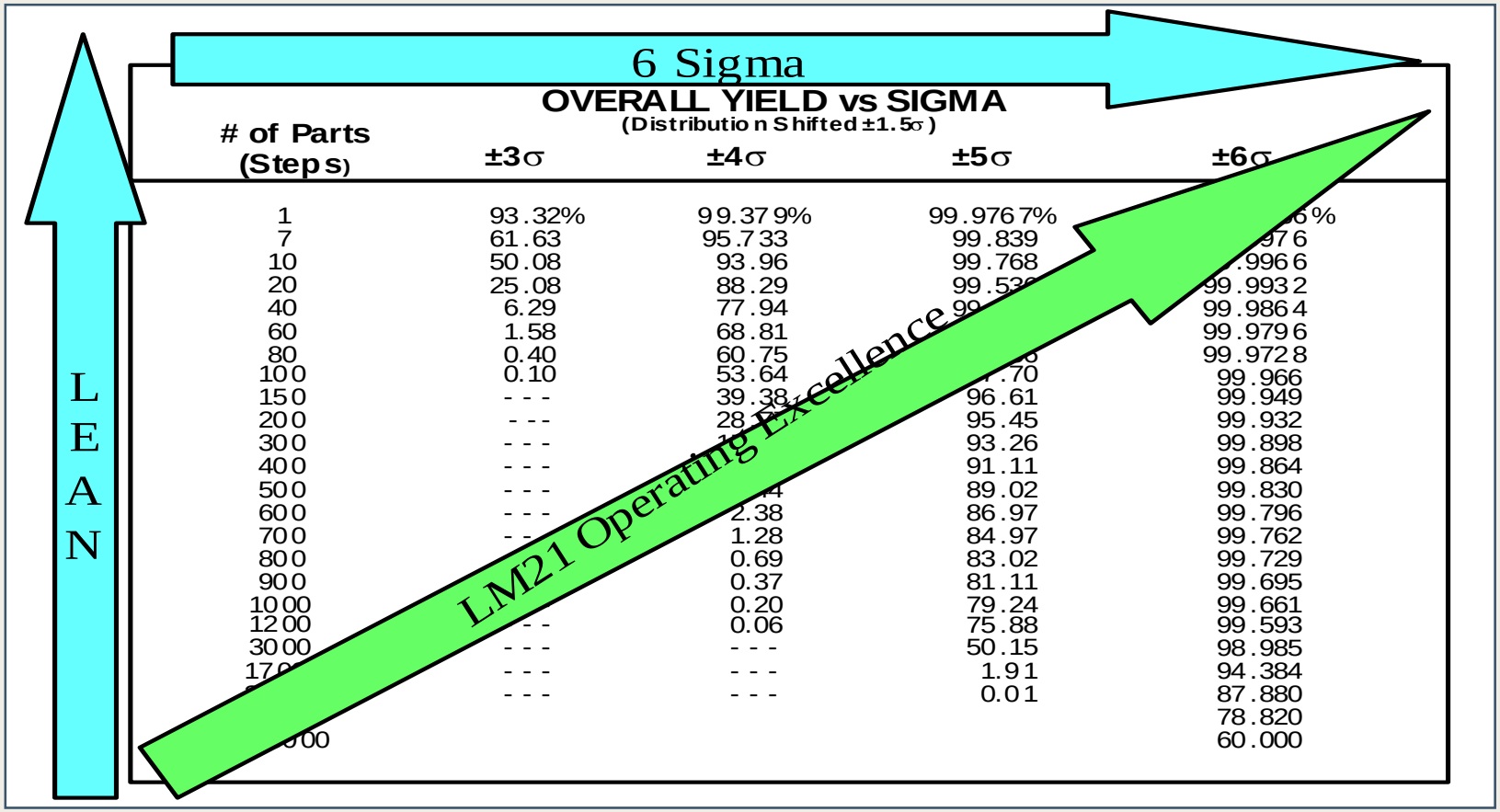
Kaizen - Make people's jobs easier by taking them apart, studying them, and making improvements.

- "KAI" - take apart and make anew
- "ZEN" - think, make good the actions of others, do good deeds and help others

Kaizen tips (VAL, M&A, QPM, CAR, OPP)

- Get rid of old assumptions.
- Look for ways to make things happen now.
- Say "NO" to the status quo.
- Don't worry about being perfect.
- It doesn't have to cost money.
- If something's wrong, fix it on the spot.
- Ask "WHY" five times to get to the root cause.
- Look for wisdom from many people rather than one.
- Never stop improving.
- Full-time participation of team members.
- Keep all affected employees informed of changes.

# Lean: Six Sigma Representation




**OVERALL YIELD vs SIGMA**
(Distribution Shifted ±1.5σ)

| # of Parts (Steps) | ±3σ | ±4σ | ±5σ | ±6σ |
|---|---|---|---|---|
| 1 | 93.32% | 99.379% | 99.9767% | 6% |
| 7 | 61.63 | 95.733 | 99.839 | 976 |
| 10 | 50.08 | 93.96 | 99.768 | .9966 |
| 20 | 25.08 | 88.29 | 99.536 | 99.9932 |
| 40 | 6.29 | 77.94 | 99 | 99.9864 |
| 60 | 1.58 | 68.81 | | 99.9796 |
| 80 | 0.40 | 60.75 | | 99.9728 |
| 100 | 0.10 | 53.64 | .70 | 99.966 |
| 150 | - - - | 39.38 | 96.61 | 99.949 |
| 200 | - - - | 28.9 | 95.45 | 99.932 |
| 300 | - - - | 1 | 93.26 | 99.898 |
| 400 | - - - | | 91.11 | 99.864 |
| 500 | - - - | 4 | 89.02 | 99.830 |
| 600 | - - - | 2.38 | 86.97 | 99.796 |
| 700 | - - | 1.28 | 84.97 | 99.762 |
| 800 | | 0.69 | 83.02 | 99.729 |
| 900 | | 0.37 | 81.11 | 99.695 |
| 1000 | | 0.20 | 79.24 | 99.661 |
| 1200 | - - | 0.06 | 75.88 | 99.593 |
| 3000 | - - - | - - - | 50.15 | 98.985 |
| 17 | - - - | - - - | 1.91 | 94.384 |
| | - - - | - - - | 0.01 | 87.880 |
| | | | | 78.820 |
| 000 | | | | 60.000 |

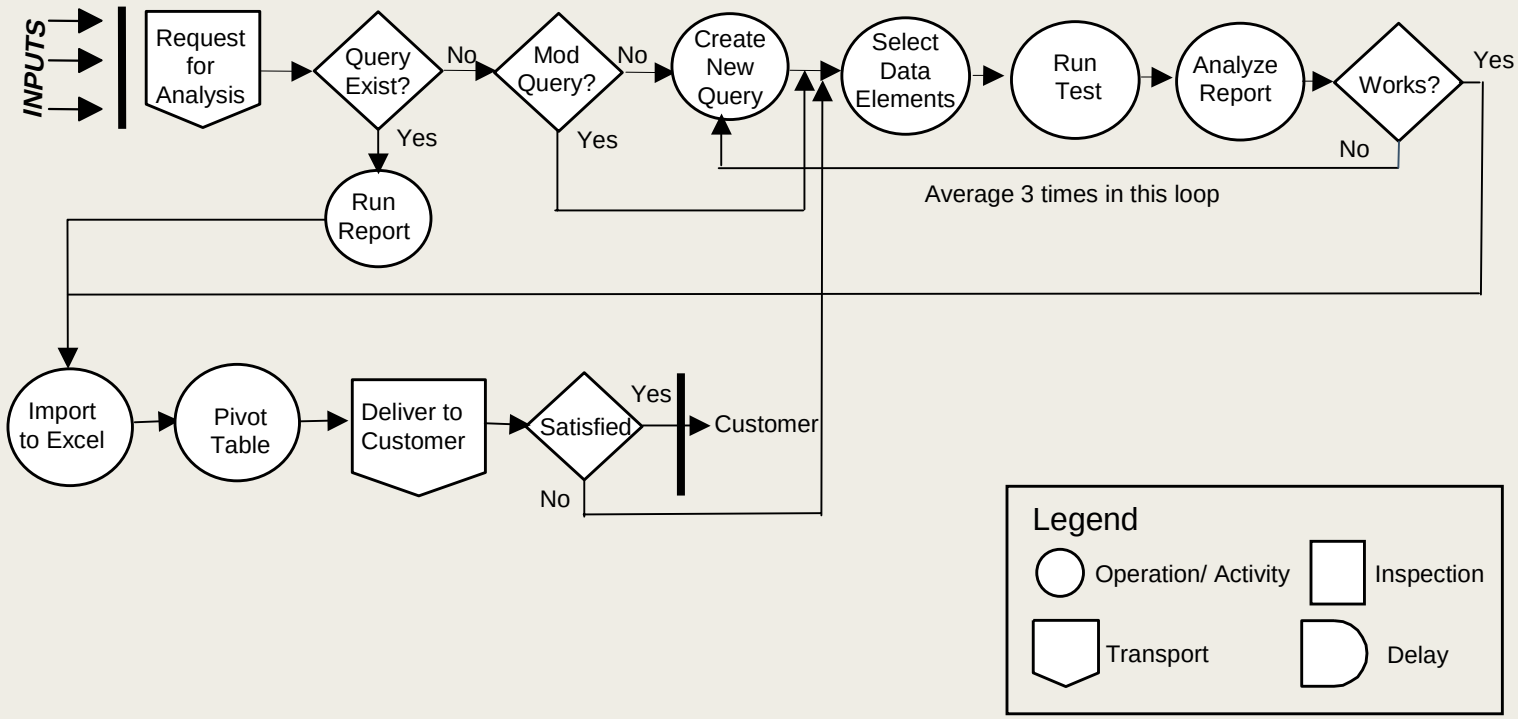


# Lean: Kaizen Procedure

Top Mgmt Kick-off of event
Determine Team Objectives and Goals
Lean/Six Sigma Training
Map as-is Process
Identify Waste in the process
Use root cause analysis to evaluate issues
Brainstorm solutions
Evaluate the solutions against the objectives
Report to Sponsor
Implement validated solutions to improve the process
Standardize: Map the to-be / improved process
Report to Sponsor

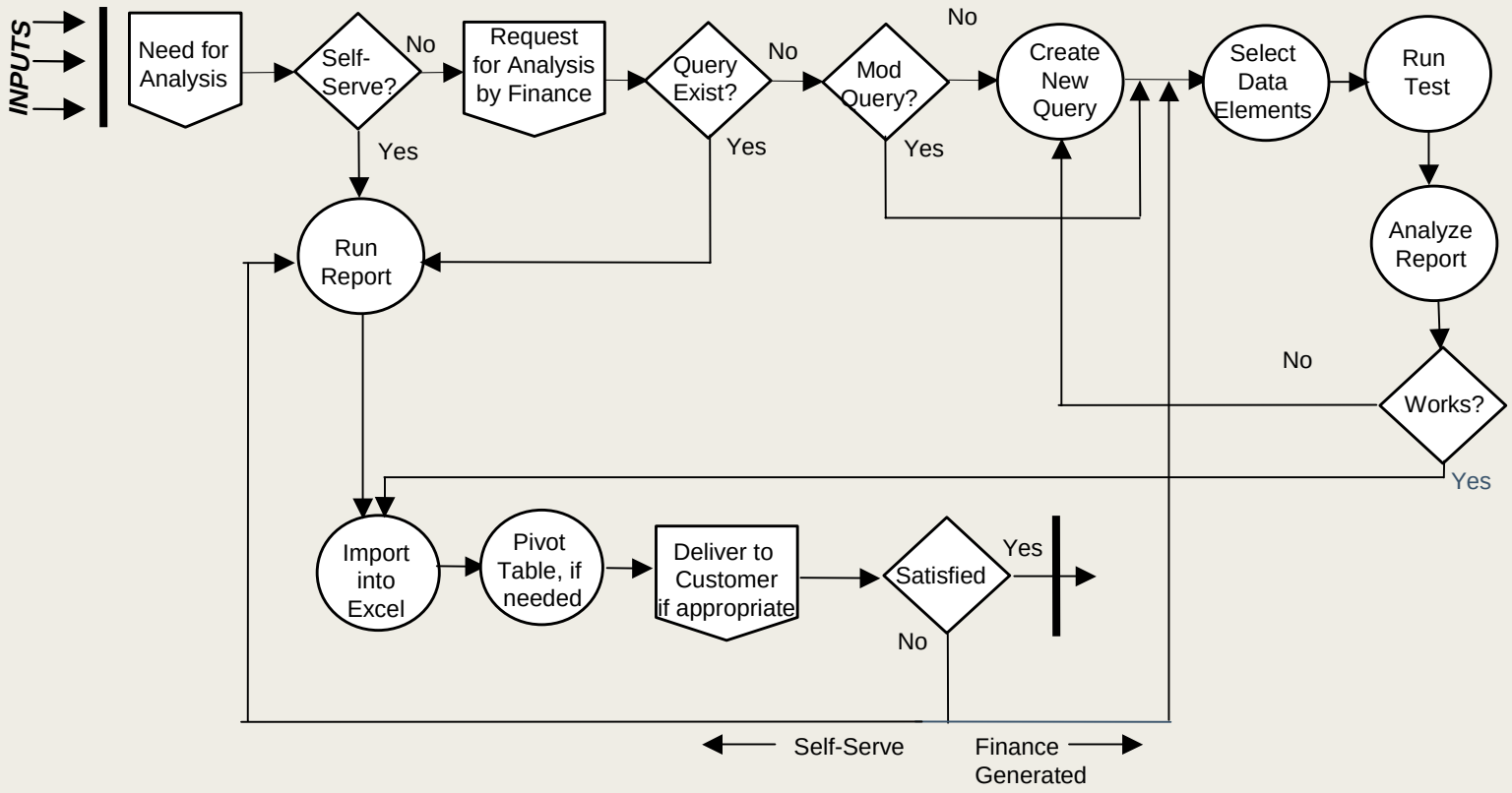
# Lean: Staffing Analysis Example 1

## "As Is" Logical Process Map



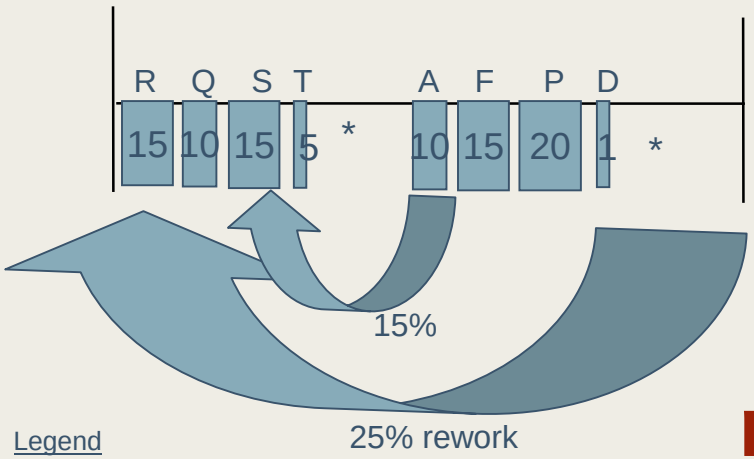
# Lean: Staffing Analysis Example 2

## "To be" Logical Process Map

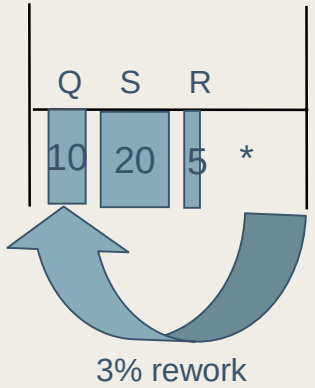


# Lean: Staffing Analysis Example 3

## Time Value Map: As Is = 19 hours




## Time Value Map: To Be = 7 hours




**63% reduction in cycle time**

Legend
R = Request
Q = Query
S = Select data
T = Test Report
A = Analysis
F = Format
P = Pivot table
D = Deliver
* = Variable wait time

# Additional Analytical Tools

Quality Function Deployment (RM, RD)
- designs what customers REALLY want
- prevents designing unnecessary product features

Bayesian Modeling (VER, VAL, PI)
- alternative to classical regression-based models
- accounts for prior knowledge and likelihood
- network diagrams show cause & effect relationships

Systems Thinking (TS, DAR, M&A, QPM, OPP)
- for chronic, describable, important problems with previous unsuccessful attempts to solve
- several tools to map and understand process

See Addendum for additional information about selected tools.



# LMC M&DS Lessons Learned

Six Sigma is more than statistical analysis

- It is a tool box of methodologies that align with an organization's process improvement.
- The alignment is directly related to high maturity but is not restricted to that.

# Outline

Objectives
Fundamentals
Implementation
The “Black Belt” Project
**Case Study**
Summary

# Applications

**Six Sigma applications for Systems and Software Engineering are emerging.**

# Survey of Applications 1

Motorola
- inspection data analysis & unit test optimization
- risk-based software inspections
- design of experiments methods & test cases
- complexity analysis & resource allocations
- quantitative risk management via uncertainty modeling

General Electric
- DFSS
- Six Sigma & Extreme Programming

Allied Signal
- 1997 air supply control system shutdowns
- black belt project team commissioned to find solution

[Harry 00], [Stoddard 00], [Kelliher 01]
Motorola & GE presentations available at http://seir.sei.cmu.edu

# Survey of Applications 2

Honeywell

- PSP[SM]/TSP[SM] & Six Sigma
  - "TSP provides the data needed to apply Six Sigma"

JP Morgan

- Capability Maturity Model® (CMM®) & Six Sigma
  - "…Six Sigma methodology is beneficial on all levels of maturity."

NCR

- CMM & Six Sigma
  - "…helps organizations working towards Level 4 & 5 deliver the best business results."

[Pavlik 00], [A-M 99], [Demery 01]
Presentations available at http://seir.sei.cmu.edu

# LMC M&DS - Strategy

Analyzed Principles

- Value from the customers' perspective
- Value Stream – measured
- Flow
- Pull
- Perfection – rapid feedback / mistake proofing

World-wide Benchmarking Results

- A 4 Sigma company will spend > 10% of revenue on internal and external repair.
- A 6 Sigma company will spend < 1 % of revenue on internal and external repair.

# LMC M&DS Project Selection

1. Process Improvement Recommendation (PIR)
   - any one can submit
   - process suggestion passed to Process Owner to evaluate, determine feasibility, determine level of institutionalization (and determine if pilot is necessary)

2. E-Transformation
   - all business processes that affect overhead are applicable
   - selection based on ROI and relevance to business – firm understanding of the before state
     - Just do it Projects
     - Kaizen event with rollout plan
   - require use of Six Sigma methodologies/ tools to pursue optimization

3. Technology Change Management Working Group (TCMWG)
   - once a year call for ideas – process oriented
   - can also be used to pilot ideas from PIRs
   - selection based on understanding the before state to measure the after state
   - modeling techniques implementing a six sigma target

# LMC M&DS Technology Change Management [1]

Purpose (M&A, RSKM, TS, QPM, OPP, OID)

- identify and assess emerging process-related technologies (e.g., Tools, Commercial Practices)
- guide those having benefit into our development activities in an orderly manner

Implementation (OID)

- Technology Change Management (TCM) Working Group (TCMWG) formed to identify process improvement needs and oversee the planning, progress, and application of solutions
- each functional organization represented on TCMWG
- annual call for TCM project proposals
  - parallel effort with call for IRAD projects
  - based on needs expressed in the strategic plan
- meets monthly to review ongoing projects, assess new business needs, and communicate new technology



# LMC M&DS Technology Change Management 2

Definition
- process-centric (as opposed to product-centric)
- separation of former and latter based on legal barriers
- Technology changes for product is accomplished by extensive IRAD effort
- enterprise wide

Focus on TCM motivated by Acquisition Reform in 1995
- considerable maturing of TCM process in six years
- business results rather than just “ticket punching”
- utilizes value added methodology – 6 Sigma Tools

Driven by LMC M&DS Strategic Plan
- TCM participants contribute to Strategic Plan

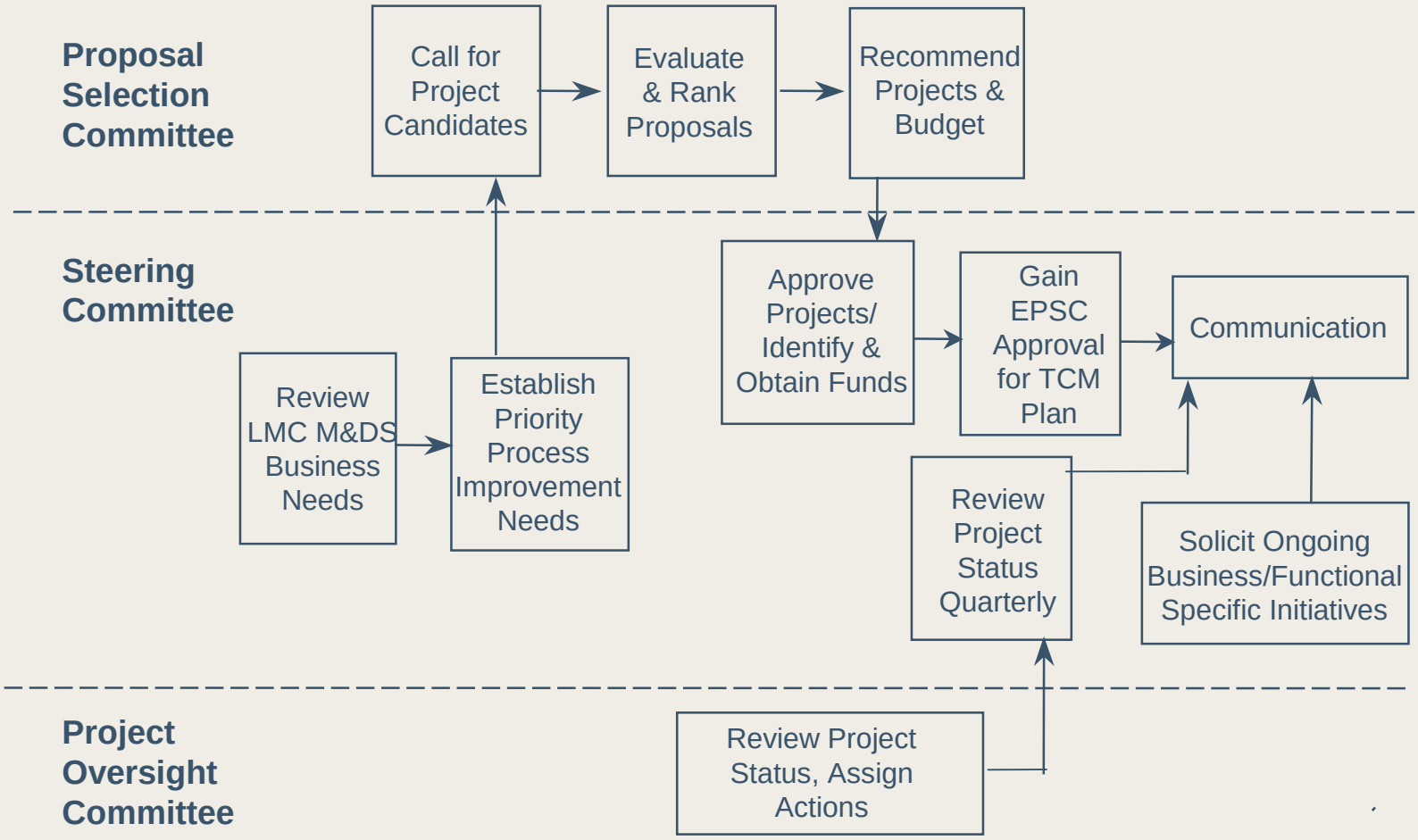
Harmonious with company-wide process philosophy

# LMC M&DS Technology Development Programs: There are Two!

| Focus: | Product Technology | Process Technology |
|---|---|---|
| Develop For: | What you sell | How you do your work |
| Catalyst: | Continued rapid advances in IS enabling technologies, e.g., microelectronic devices, fiber optics, and wireless communications | Acquisition Reform |
| Funding: | NBAE/IR&D | OH/Indirect $ |
| Sponsor: | IR&D Program | TCM Program |

**Each program develops technology discriminators and enhances our win probabilities**

# TCMWG Organization and Operations





# TCM Proposal Results

Representation

- All LMC M&DS regions represented on the selection team.
- All LMC M&DS regions had proposals submitted.

Quality of proposals - good

Quantity of proposals managed (typical year)

- 51 proposals received
- 23 proposals ranked
- 12 proposals identified and ranked for the TCM Program Plan.

Proposed budget for TCM Program Plan



# Focus, Focus, Focus

Goal – shift defect detection curve to find more defects earlier in the life cycle

Focused Technology Change

- Incorporates both new processes in utilizing goal into the existing process
- Integrates new tools into the inspection process and defect tracking measurements

Before State

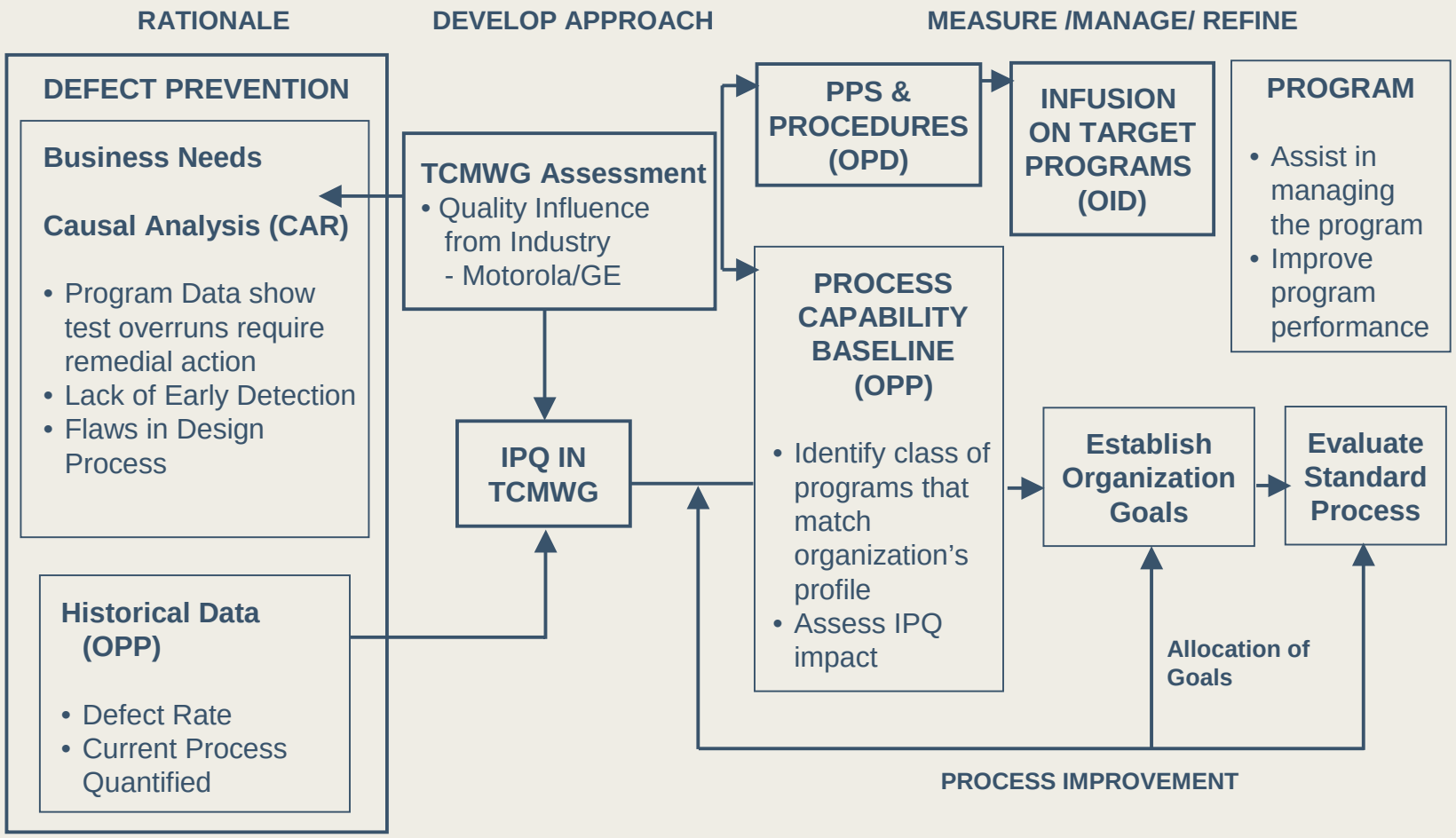
- Defect curve shows later defects - 14 defects/KSLOC during test phase

After State

- Decrease in test defects because found earlier in process
  - Goal X defects/KSLOC during test phase
  - Pilot actually beat the goal

One technology thread to address

# TCM Flow Example



# Focus, Focus, Focus

Process Change - Common Inspection Process

Focused Process Change

- Institutionalization of one inspection process method
- Single process for inspections on all programs in all phases

Before State - Walkthrus

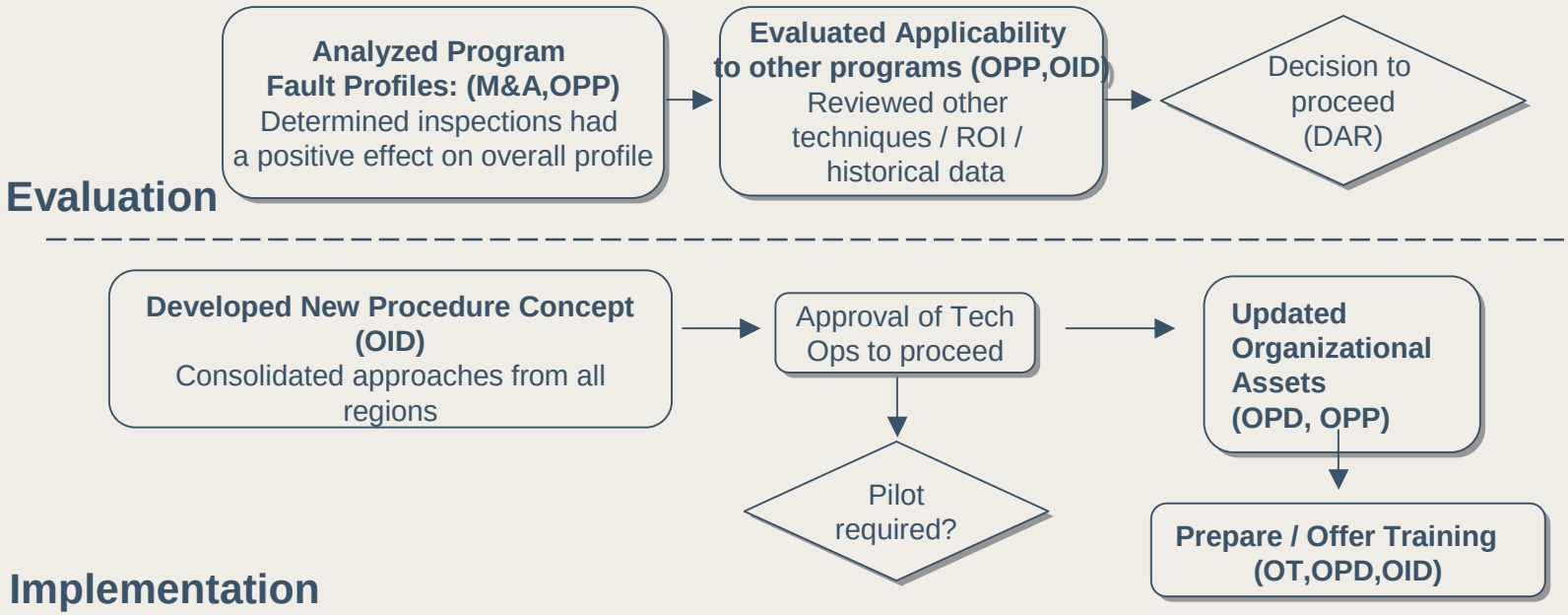
- X Defects / KSLOC during Detailed Design
- X Defects / KSLOC during Code & Unit Test

After State - Inspections

- X Defects / KSLOC during Detailed Design
- X Defects / KSLOC during Code & Unit Test

One process thread to address

# Process Change Flow





# LMC M&DS TCM Summary

The TCM Program is driven by the strategic process needs of our product lines.

TCM projects have had a positive impact on new business pursuits.

TCM projects have resulted in cost savings as well as cost avoidance.

TCM projects can result in changes to the standard processes.

Our business leaders are encouraged to push process boundaries through TCM.

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# Pinched Ideas

What are your “take-away” learnings?

What is immediately useful in your workplace?



# Outline

Objectives
Fundamentals
Implementation
The “Black Belt” Project
Case Study
**Summary**

# Key Points

Six Sigma is about customer satisfaction and business profitability.

Software and systems engineering organizations are using Six Sigma.

- They are effectively blending it with their overall set of processes, models, standards.
- Each “blend” is based on organizational context (sorry, no “silver bullet”).
- They are applying it to projects, programs, products, and engineering processes.

The analytical toolkit contains familiar and new, extended tools.

- They are applicable to software and systems engineering.
- Some are “statistical” and some are “analytical.”

The industry needs a comprehensive set of case studies of Six Sigma in SW/SE (similar to what is available in manufacturing).

# Advancing the State of 6σ & SW/SE

## Discussion Group

- http://groups.yahoo.com/group/6S_SWSE
- current issues, most recent works

## Repository of Examples & Benefits

- http://seir.sei.cmu.edu
- concrete visualization
- relationship to models, initiatives
- variety of analytical methods
- multiple perspectives
  - –project, process, product
  - –software, systems
  - –maturity/capability levels

# Advancing the State: Publishing

**Call for papers: *Software Quality Professional***

- Seeking practical, experience-based articles
  - case studies
  - solutions/improvements to critical process, products
  - training issues, multi-initiative usage

**Call for reviewers**

- Green, Black or Master Black Belts

**Contact jmsiviy@sei.cmu.edu**
**if you would like to participate**
**or want more information**
**(flyers available post-tutorial)**

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# Advancing the State: Birds of a Feather Session

**Wednesday evening**

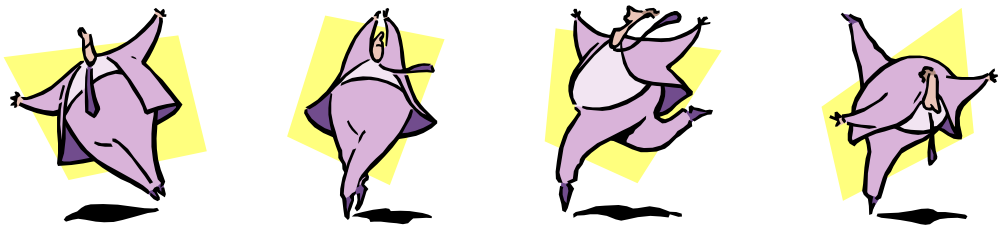
**Proposed agenda**

- 10 minute “what’s new”
- discussions:
  - Six Sigma basics (for newbies)
  - comparisons of different approaches to integrating intiatives
  - tailoring training for software and systems engineers
  - lessons learned from the field

**Signup sheet posted in registration area**

# Summary

## Customer satisfaction is key driver



## All efforts should link to business results

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Measurement & Analysis Initiative
Email: jmsiviy@sei.cmu.edu
412-268-7994

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[Vickroy 03] Idea to strategically select MA, OPP, QPM as first PAs in which to achieve capability 5 offered by Robert Vickroy, ABS Group, at CMMI course on 17 january 2003

[Westfall] From http://www.westfallteam.com/Cause&Effect_Diagrams.pdf

# Addendum

## Additional reading

Additional analytical tools:  abbreviated “tool tips”
Additional illustration
Change Agent References
CMMI Process Areas

# Additional Reading 1

**Six Sigma Books (not software-specific):**

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Breyfogle, III, Forrest W., Cupello, James M., Meadows, Becki, *Managing Six Sigma*, John Wiley & Sons

Harry, Mikel, *Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations*, Doubleday, 2000

Pyzdek, Thomas, The *Six Sigma Handbook*, McGraw-Hill Professional Publishing, 2001

**Web pages & Web sites:**

American Society for Quality Six Sigma Forum, http://www.sixsigmaforum.com/concepts/var/index.shtml

International Quality Federation, http://www.iqfnet.org (Follow the black belt links)

iSixSigma, http://www.isixsigma.com

Six Sigma Academy, http://www.6-sigma.com

Smarter Solutions, http://www.smartersolutions.com

Software Engineering Information Repository: http://seir.sei.cmu.edu (Follow links to Measurement area then to Six Sigma)

SEI Software Technology Review: http://www.sei.cmu.edu/str/descriptions/sigma6.html

# Additional Reading 2

**Papers, presentations, journal articles (URL's subject to change without notice)**

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# Addendum

Additional reading

**Additional analytical tools:  abbreviated “tool tips”**

Additional illustration

Change agent references

CMMI Process Areas

# Tool Tip: Cause & Effect Matrix

Description

- method to determine possible causes of variation in the process and to feed future experimental designs

Purpose

- to organize problem-solving efforts when there are multiple responses involved
- to prioritize the number of factors to study
- to build team consensus about what is to be studied

[Hexsab 02]

# Cause & Effect Matrix: Usage

When to use:

- team is overwhelmed with the number of variables affecting process
- not possible to experiment with **all** of the variables – need to narrow down the list
- team is struggling with which factors may have the biggest impact
- it is not clear how each factor impacts customer requirements

Feeds other tools:

- Failure Mode and Effects Analysis
- Data collection plans
- Experimentation
- Control plans

[Hexsab 02]



# Cause & Effect Matrix: Terms

**Process:** The combination of people, equipment, materials, methods and environment that produce output (product or service). It is a repeatable sequence of activities with measurable inputs and outputs.

**Parameter:** A measurable characteristic of a product or process.

**Process Parameter:** A measurable characteristic of a process that may impact product performance but may not be measured on the product. (The “x.”)

**End-Product Parameter:** A parameter that characterizes the product at the finished product stage. (The “Big Y.”)

**In-Process Product Parameter:** A parameter that characterizes the product prior to the finished product stage. It is measured on the product upstream and is the result of a process step. (The “little y.”)

**Input Variable:** An output from other processes. (Neither x’s or y’s.)

[Hexsab 02]

# Cause & Effect Matrix: Procedure

Identify the y's from process map.

Rate the y's on a scale from 1-10.
- Involve the "customers" to determine the ratings.
- Ratings are relative.

List the process steps and all of the x's from the process map.

Rate the relationship of each x to each y on a 0, 1, 3, 9 scale.

0 = No relationship between x and y
1 = Remote relationship between x and y
3 = Moderate relationship between x and y
9 = Strong relationship between x and y

For each x
- Multiply each relationship rating by the corresponding y rating
- Sum the products

Use the summations to rank and select x's for future experiments or focused efforts

[Hexsab 02]

# Cause & Effect Matrix: Format

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Y's: | |
| | | | | | | | | Y ratings: | |
| Process steps | X's | X relationship to Y | | | | | | | Sum |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

[Hexsab 02]

# Tool Tip: Quality Function Deployment (QFD)

Description

- a structured methodology used to identify customers' requirements and translate them into key process deliverables
- helps you focus on ways to improve your process or product to meet customers' expectations
- systematically translates and prioritizes customer-level CTQ's into clear, quantifiable design objectives

[isixsigma], [harrold 99-2]

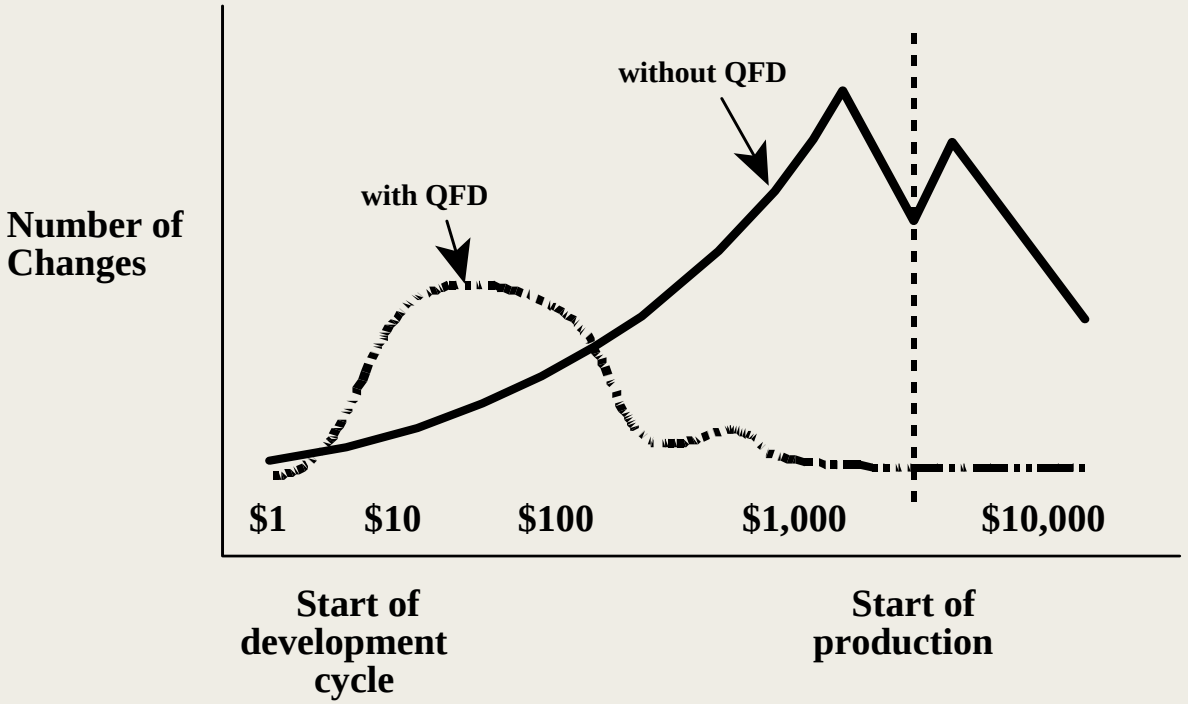
# QFD: Usage

Benefits

- Designs what customers REALLY want
- Prevents designing unnecessary product features
- Aligns business unit and engineering tactics & goals
  - a series of QFD matrices can link CTQ's of product specifications with product design with process design with process control*
- Defines and sets realistic product specifications
- Optimizes product **and** process costs
- Reduces post-introduction problems and surprises
- Gives quicker starts on next product generation(s)

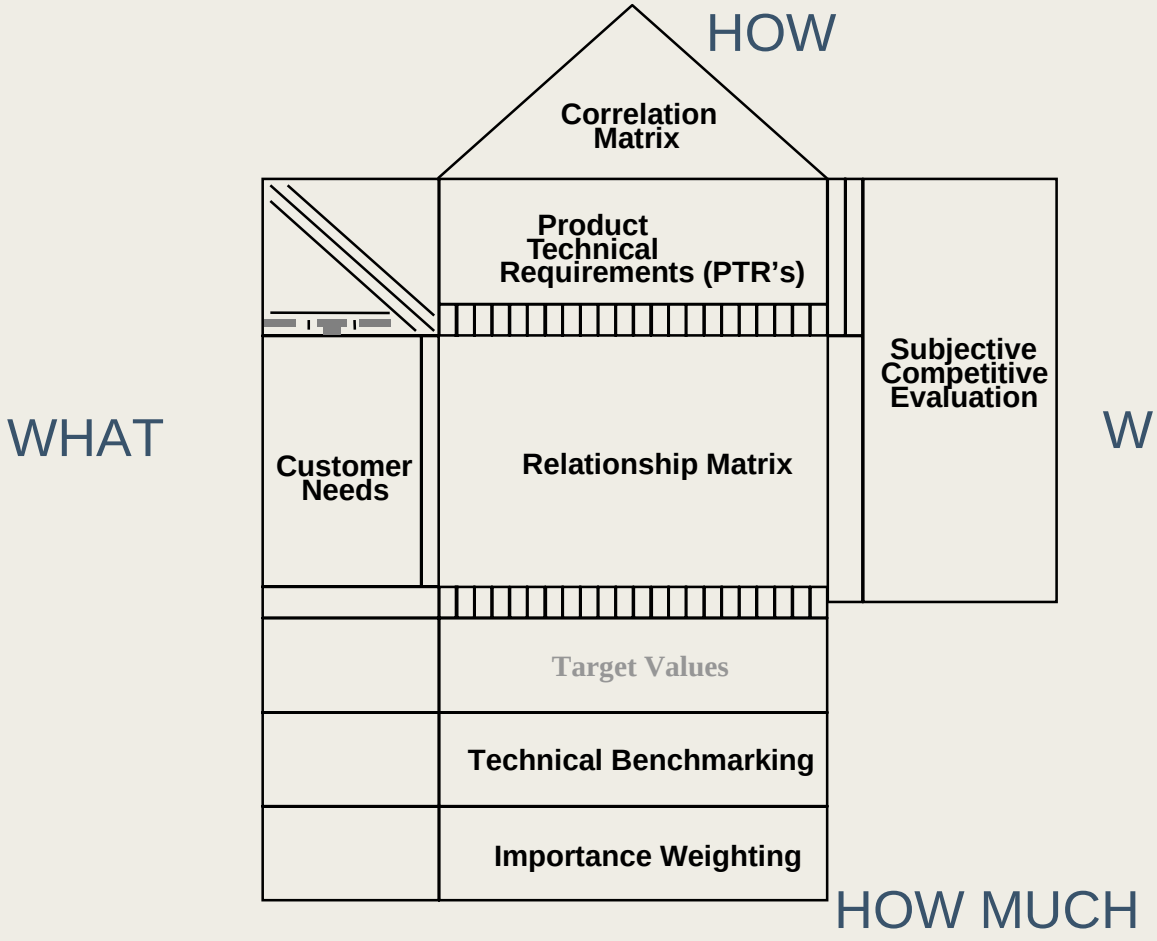
*[brecker.com]

# Quality Function Deployment




Source: L.P. Sullivan, "Quality Function Deployment," *Quality Progress,* June 1986, p. 39

# QFD: House of Quality



# Tool Tip: Systems Thinking

Description
A discipline for seeing interrelationships, patterns and wholes

Event driven thinking:
- Put out the fire.

Statistical thinking:
- Based on history and likelihood of fires, where should fire prevention equipment be concentrated?

Systems thinking:
- How can the fires be avoided?



# Systems Thinking: Tools

Theory of constraints (TOC)

- prerequisite trees
- current reality trees
- future reality trees
- transition trees
- conflict resolution diagrams

Causal loop diagrams



# Systems Thinking: Senge's laws

- Today's problems come from yesterday's solutions.
- The harder you push, the harder the system pushes back.
- Behavior grows better before it grows worse.
- The easy way out usually leads back in.
- The cure can be worse than the disease.
- Faster is slower.
- You can have your cake and eat it too - but not at once.
- Dividing the elephant in half does not produce two small elephants.
- There is no blame.
- Cause and effect are not closely related in time and space.
- Small changes can produce big results - but the areas of highest leverage are often the least obvious.



# Systems Thinking: Dettmer's TOC Principles

- Systems are analogous to chains - having a weakest link or constraint.
- Strengthening anything but the weakest link does not strengthen the chain.
- The system optimum is not the sum of the local optima.
- Systems operate in a complex cause and effect environment.
- Most undesirable effects are due to a few core problems.
- Core problems are almost never superficially apparent.
- System constraints can be physical or policy.
- Optimal solutions deteriorate over time as the environment changes.
- Ideas are not solutions.



# Tool Tip: Statistical Process Control

Description:

- run chart with statistical limits
- distinguishes common cause variation from special cause variation and identifies when actions need to be taken to correct a process

# SPC: Terms

**Common cause variation**: the variation which is inherent to the process as it normally occurs

**Special (or "assignable") cause variation**: variation which is unusual and indicative of a change in the process.

**In control**: stable, random, predictable; only common cause variation present.

**Out of control**: unstable, shifting data with trends or patterns; special cause variation present

**Corrective Action Guidelines (CAGs)**: the rules to follow when assignable causes are present; When causes are not well-understood, then CAG may be an analytical troubleshooting guide (i.e., how to drilldown through the data and rule things out)

# SPC: Tips

Reacting to Common Cause Variation as if it were Special Cause Variation cannot improve the process and will result in increased variability.

Check your data distributions!

- Defect counts are never negative and may not be normally distributed.

Set control limits based on statistics, engineering knowledge and risk of escaping defects.



# Addendum

Additional reading
Additional analytical tools:  abbreviated “tool tips”
**Additional illustration**
Change Agent References
CMMI Process Areas

# Illustration – "Define" 1

Business Driver

- Need 10% cost reduction in order to compete in the marketplace and stay in business

Baseline data (PSP)

- Productivity: 19 LOC/hr
- 33% of development time spent fixing defects
- Approximately 250 defects/KLOC

# Illustration – "Define" 2

Goal:

- Reduce or prevent defects to reduce cost

Quantitatively speaking:

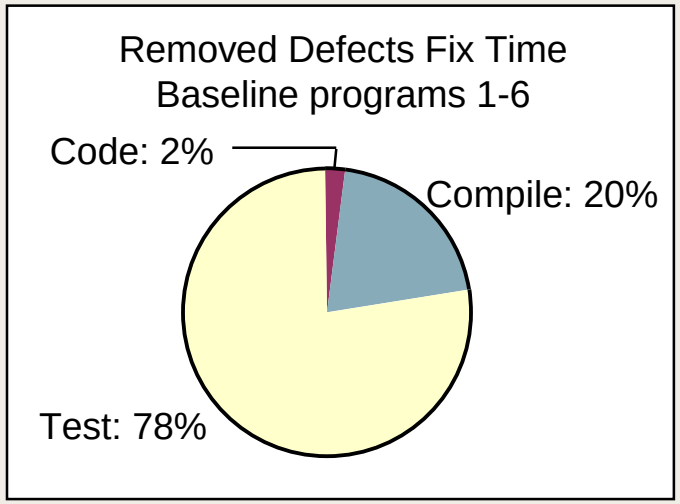
- Reduce cycle time by 22 minutes/program
- Reduce fix time by 1.3 minutes/defect
- Reduce defects by 6/program
- Reduce defect density to 190 defects/LOC

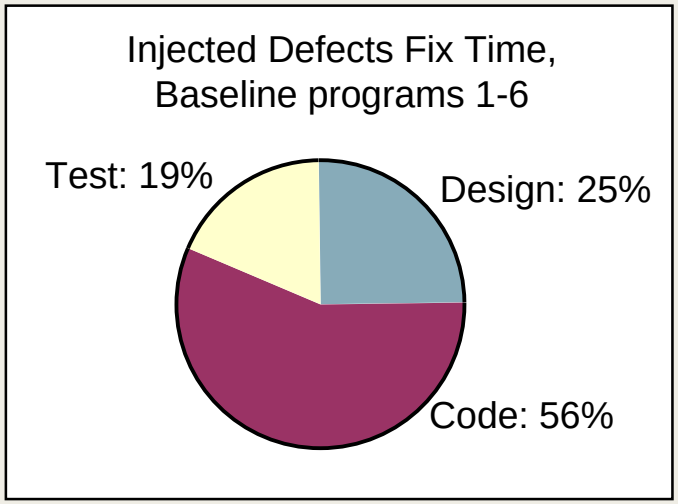
… or a combination that produces 21 LOC/hr

# Illustration – "Analyze"

Opportunities to reduce repair time

- Defects removed in test: 78% of repair time
- Defects injected in design: 25% of repair time
- Defects injected in code: 56% of repair time
- Syntax defects in general: 63% of defects

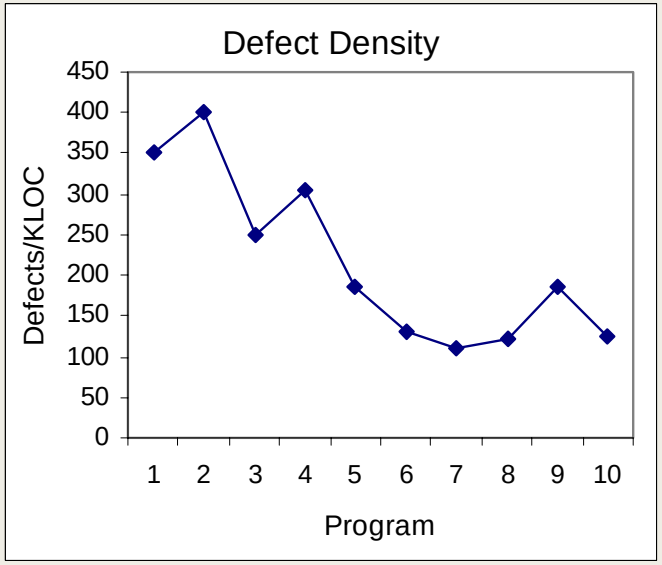


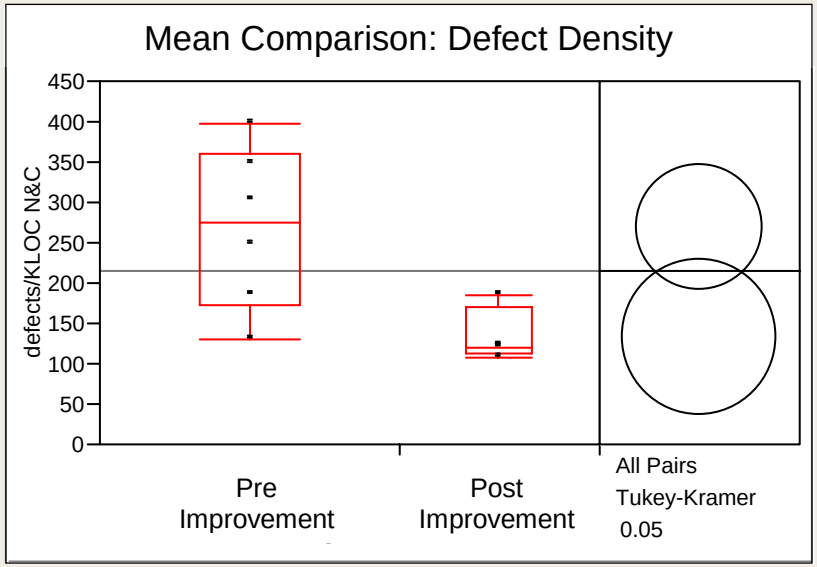



# Illustration – "Improve"

Improvement Plan at Program 6

- Syntax checklist
- Well-timed reviews
- Subcategories within defect types

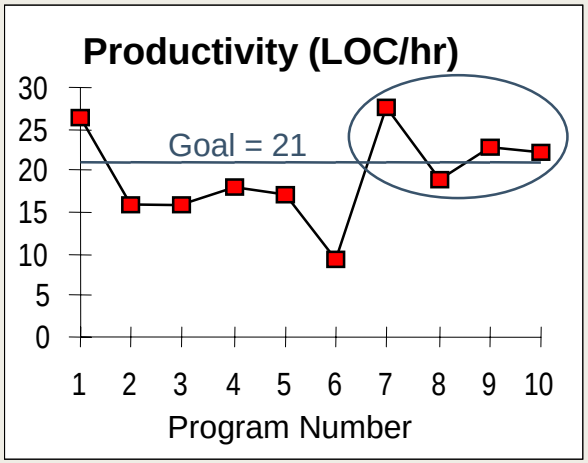


# Illustration – "Control"

Tracking performance

- Quantitative goal statement
- Hypothesized root causes
- Countermeasures & contribution to impact
- Key impact indicators




Direct causes (from countermeasures):

- Fewer defects injected in code & test
- Defects removed earlier, faster (i.e., in design & code)

Root cause (need new countermeasures):

- "Re-learning" curve



# Illustration – Analysis Summary

Tools used in full analysis included

- Process Mapping
- Descriptive statistics
- Means comparisons & significance testing
- Plots
  - Pie Charts
  - Trends
  - Phase profiles
  - Histograms
  - Pareto charts
  - Correlation plots
- Cause & Effect Diagrams
- “Management by Fact”

Focus was exploratory, investigative

- Ready for stability & control monitoring

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# Illustration – Scaling up

## Illustration

- Quickly drilled down from high level cost goal to personal improvement
- Defined process in place
- Measures in place
- Continuous incremental improvements
- Event-based "step-change" improvements
- Re-learning curve
- Personal data
- Used productivity as one of impact measures

## Real Life

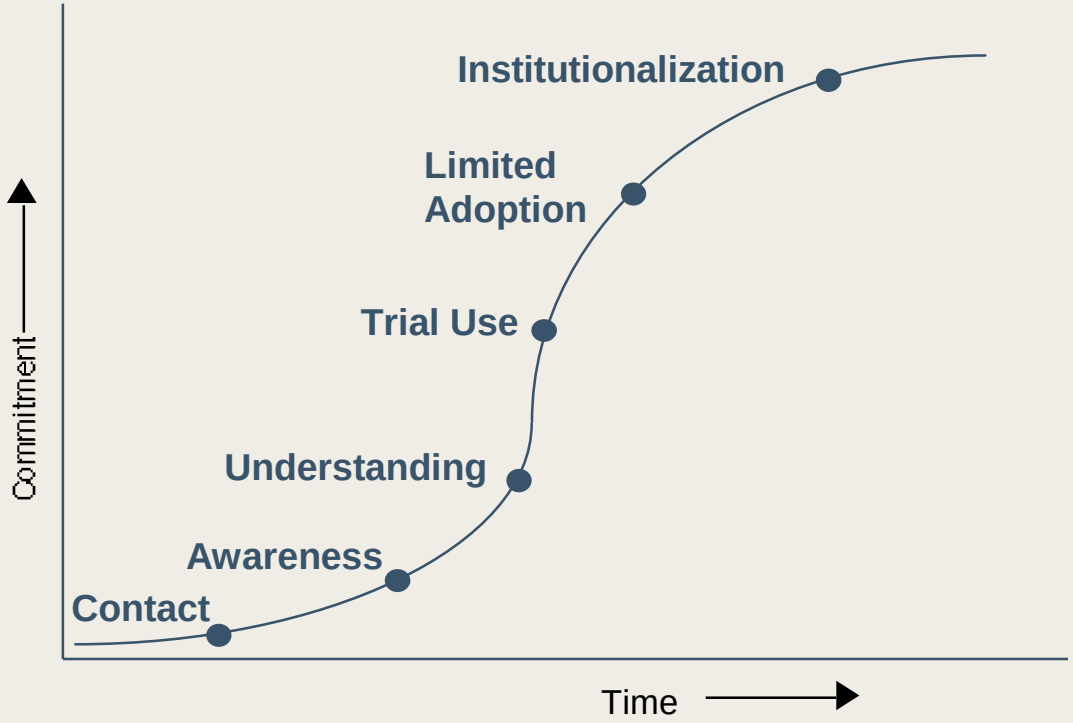
- Drill down may be complex, may span wide breadth of organization
- May need to select or define process
- May need to develop measures
- Continuous incremental improvements
- Event-based "step-change" improvements
- Constantly changing skills, technologies
- Non-attributed data (e.g., team, project)
- Excessive productivity focus may drive unwanted behaviors



# Addendum

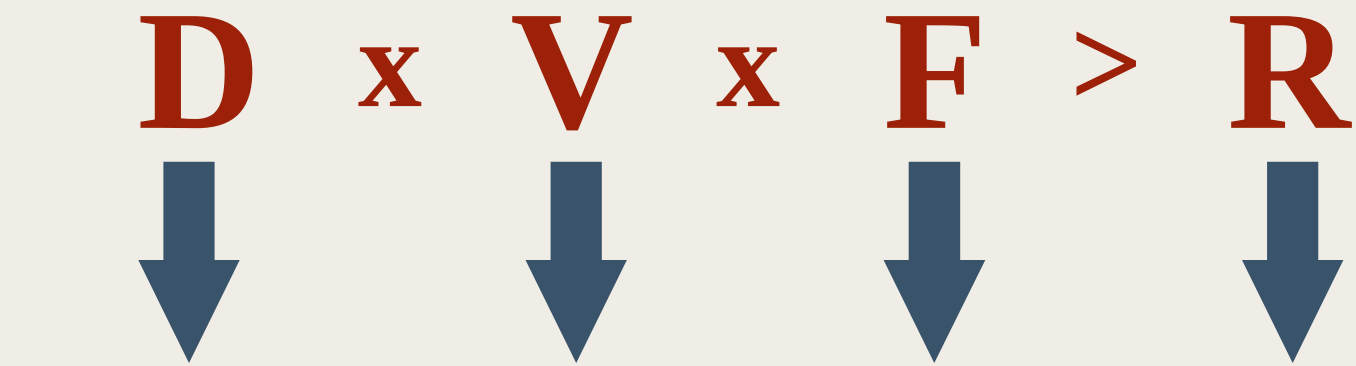
Additional reading
Additional analytical tools:  abbreviated “tool tips”
Additional illustration
**Change Agent References**
CMMI Process Areas

# How Organizations Commit to Change




from Daryl R. Conner and Robert W. Patterson. "Building Commitment to Organizational Change," *Training and Development Journal* (April 1983):18-30.

# A Formulaic Approach to Change




**"All elements of the formula must be present or resistance to the change will not be overcome."**

**Richard Beckhard**



# Continuous Improvement Antibodies

We tried that before
Our place is different
It costs too much
That's not my job
They're too busy to do that
We don't have the time
Not enough help
It's too radical a change
The staff will never buy it
It's against company policy
The union will scream
Runs up our overhead
We don't have the authority
Let's get back to reality
That's not our problem
I don't like the idea
You're right, but…
You're two years ahead of you time
We're not ready for that
It isn't in the budget
Can't teach an old dog new tricks
Good thought, but impractical
Let's give it more thought
We'll be the laughingstock
Not that again
Where'd you dig that one up?
We did all right without it
It's never been tried before
Let's put that one on the back burner
Let's form a committee
I don't see the connection
It won't work in our plant/office
The committee would never go for it
Let's sleep on it
It can't be done
It's too much trouble to change
It won't pay for itself
It's impossible
I know a person who tried it
We've always done it this way
Top management won't buy it
We'd lose money in the long run
Don't rock the boat
That's all we can expect
Has anyone else ever tried it?
Let's look into it further (later)
Quit dreaming
That won't work in our school
That's too much ivory tower
It's too much work

# The Ten Challenges [1]

**The Ten Challenges**, as discussed in The Dance of Change by Peter Senge
copied from http://www.gwsae.org/ThoughtLeaders/SengeTenChallenges.htm

**Challenges of Initiating**

These challenges are often sufficient to prevent growth from occurring, almost before it starts. They are consistently encountered at the early stages of significant organizational change. The capabilities to deal with them must be developed under high pressure; but in managing these challenges effectively, organizations develop capabilities much sooner than otherwise for dealing with challenges down the road.

**1 Not Enough Time:"We don't have time for this stuff!"**

This is the challenge of control over one's time. This challenge is represents a valuable opportunity for reframing the way that workplaces are organized, to provide flexibility and time for reflection and innovation.

**2 No Help: "We're like the blind leading the blind**!"

Some managers believe that asking for help is a sign of incompetence; others are unaware of the coaching and support they need. Meeting this challenge means building the capabilities for finding the right help, and for mentoring each other to develop successful innovations.

**3 Not Relevant: "Why are we doing this stuff?"**

A top priority for pilot groups is a clear, compelling case for learning and change. If people are not sufficiently committed to an initiative's goals, a "commitment gap" develops and they will not take part wholeheartedly. Building relevance depends on candid conversations about the reasons for change and the commitments people can make.

**4 "Walking the Talk" - Leadership values**

What happens when there is a mismatch between the things the boss says and his or her actual behavior? People do not expect perfection, but they recognize when leaders are not sincere or open. If executive and line leaders do not provide an atmosphere of trust and authenticity, then genuine change cannot move forward.



# The Ten Challenges 2

**Challenges of Sustaining Momentum**

These challenges occur sometime during the first year or two, when the group has clear goals and has discovered that new methods save more than enough time to put them into practice. Now the pilot group's real troubles begin. Sustained activity confronts boundaries - between the work of the pilot group and "internal" attitudes and beliefs, and between the pilot group's needs and the larger-scale company's values and ways of measuring success.

**5 Fear and Anxiety: "This stuff is ----"**

The blanks represent the fact that everyone expresses their fear and anxiety with a different form of defensiveness. How do you deal with the concerns of team members about exposure, vulnerability and inadequacy, triggered by the conflicts between increasing levels of candor and openness and low levels of trust? This is one of the most frequently faced challenges and the most difficult to overcome.

**6 Assessment and Measurement: "This stuff isn't working"**

How do you deal with the disconnect between the tangible (but unfamiliar) achievements of a pilot group and the organization's traditional ways of measuring success?

**7 Believers and Nonbelievers: "We have the right way!" say pilot group members. "They're acting like a cult!" say their other colleagues and peers.**

Riding on a wave of early success, speaking their own language, the pilot group becomes increasingly isolated from the rest of the organization. Outsiders, meanwhile, are put off and then turned off by the new, unfamiliar approaches and behavior. These misunderstandings easily accelerate into unnecessary, but nearly unavoidable, opposition.

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Software Engineering Institute

LOCKHEED MARTIN

# The Ten Challenges 3

**Challenges of System wide Redesign and Rethinking**

These challenges appear as a pilot group's work gains broader credibility and confronts the established internal infrastructure and practices of the organization.

**8 Governance: "They won't give up the power."**

As the pilot group's capabilities and activities increase, it runs into the priorities and established processes of the rest of the organization. This leads to conflicts over power and autonomy and to a destructive, "us-versus-them" dynamic that nobody wants - and that could be avoided if the capabilities are in place for organizational redesign.

**9 Diffusion: "We keep reinventing the wheel!"**

Unless organizations learn to recognize and deal with their mysterious, almost unnoticed inability to transfer knowledge across organizational boundaries, people around the system will not build upon each other's successes.

**10 Strategy and Purpose: "Where are we going? and "What are we here for?"**

How do you revitalize and rethink the organization's intended direction for success, its contribution to its community and its future identity? How do you improve the processes of conversation that lead people to articulate and refine their aspirations and goals for achieving them?

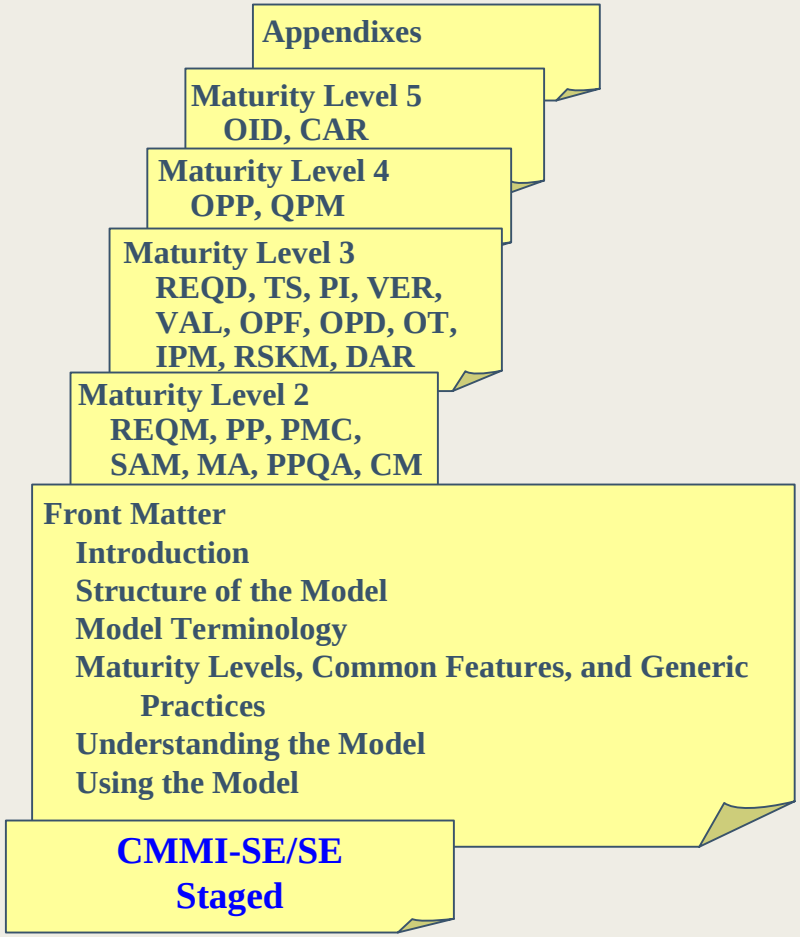
NOTE: This material is drawn from The Dance of Change and The Fifth Discipline Fieldbook Project site.

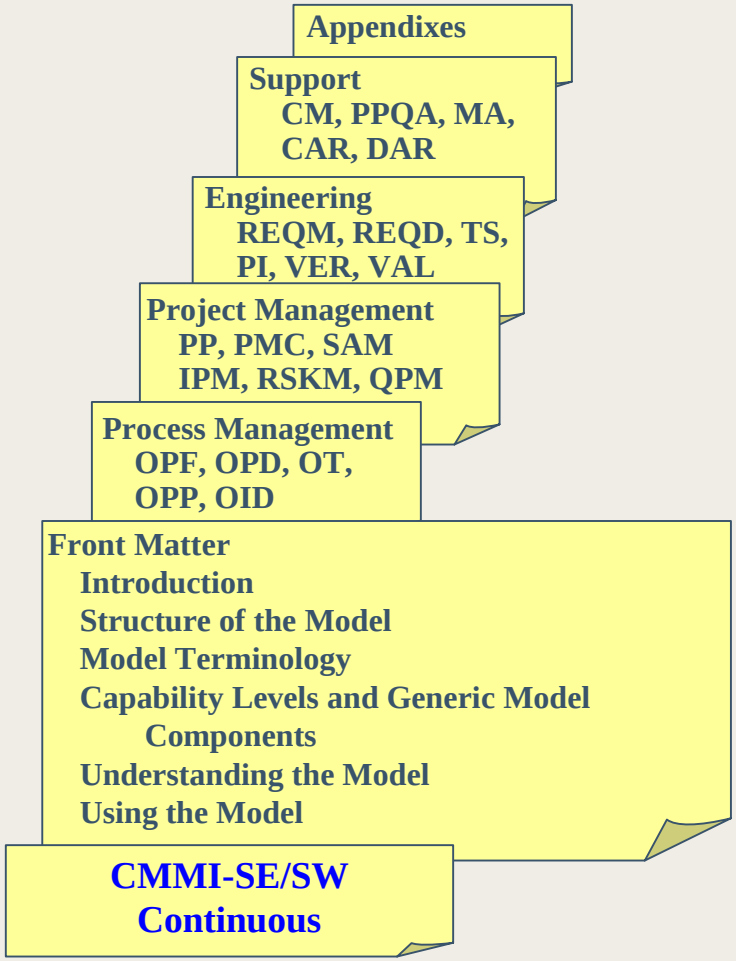


# Addendum

Additional reading
Additional analytical tools:  abbreviated “tool tips”
Additional illustration
Change Agent References
**CMMI Process Areas**

# CMMI Structure



# CMMI Process Areas

| Category | Process Areas |
|---|---|
| Process Management | Organizational Process Focus (OPF)<br>Organizational Process Definition (OPD)<br>Organizational Training (OT)<br>Organizational Process Performance (OPP)<br>Organizational Innovation and Deployment (OID) |
| Project Management | Project Planning (PP)<br>Project Monitoring and Control (PMC)<br>Supplier Agreement Management (SAM)<br>Integrated Project Management (IPM)<br>Risk Management (RSK)<br>Quantitative Project Management (QPM) |
| Engineering | Requirements Management (REQM)<br>Requirements Development (RD)<br>Technical Solution (TS)<br>Product Integration (PI)<br>Verification (VER)<br>Validation (VAL) |
| Support | Configuration Management (CM)<br>Process and Product Quality Assurance (PPQA)<br>Measurement and Analysis (MA)<br>Causal Analysis and Resolution (CAR)<br>Decision Analysis and Resolution (DAR) |