Measurement Strategies in the CMMI

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Background

- **Software measurement remains a challenge for many projects and organizations**

- **It is difficult to select a set of measures that are easy to define and collect, yet offer real insight into progress, process, and quality**

- **This presentation will discuss strategies for starting and enhancing a CMMI-compliant measurement system**

Rick Hefner, "Measurement Strategies in the CMMI", 2007

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Agenda

- **Measurement Principles**

- **CMMI Measurement and Analysis Practices**

- **Typical Measures by Maturity Level**

- **Lessons Learned**

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What is the Capability Maturity Model Integration?

- **The CMMI is a collection of industry best-practices for engineering and management**
  - Developed under the sponsorship of DoD
  - Consistent with DoD and commercial standards
  - Addresses both software and systems engineering, project and organizational practices

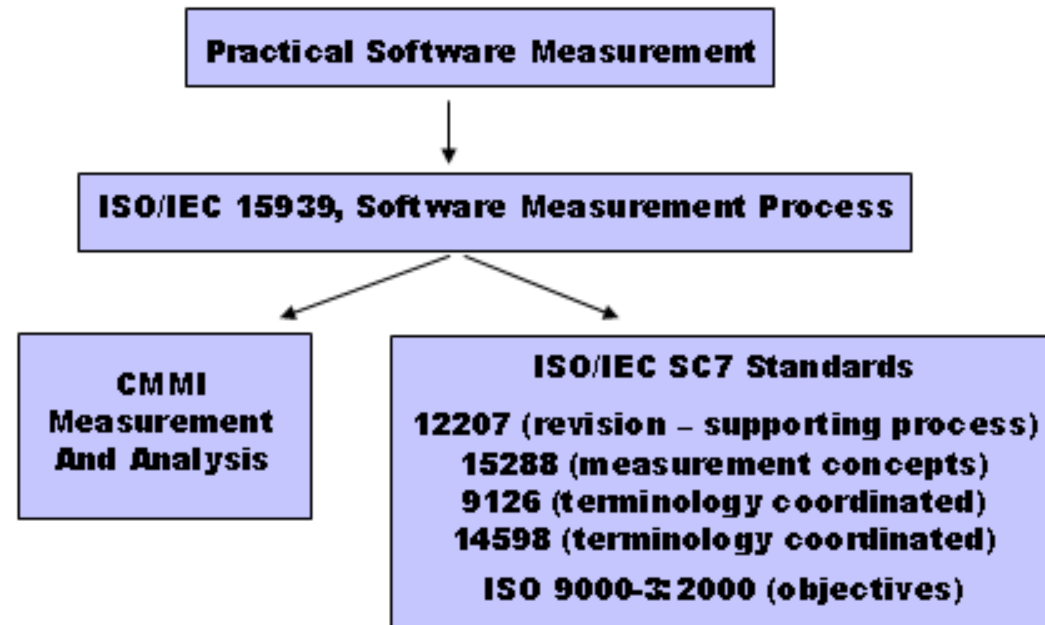| Project Management	Engineering	Support	Process Management
▪ Project Planning ▪ Project Monitoring and Control ▪ Supplier Agreement Management ▪ Integrated Project Management) ▪ Risk Management ▪ Quantitative Project Management	▪ Requirements Development ▪ Requirements Management ▪ Technical Solution ▪ Product Integration ▪ Verification ▪ Validation	▪ Configuration Management ▪ Process and Product Quality Assurance ▪ Measurement and Analysis ▪ Decision Analysis and Resolution ▪ Causal Analysis and Resolution	▪ Organizational Process Focus ▪ Organizational Process Definition ▪ Organizational Training ▪ Organizational Process Performance ▪ Organizational Innovation and Deployment

Rick Hefner, "Measurement Strategies in the CMMI", 2007

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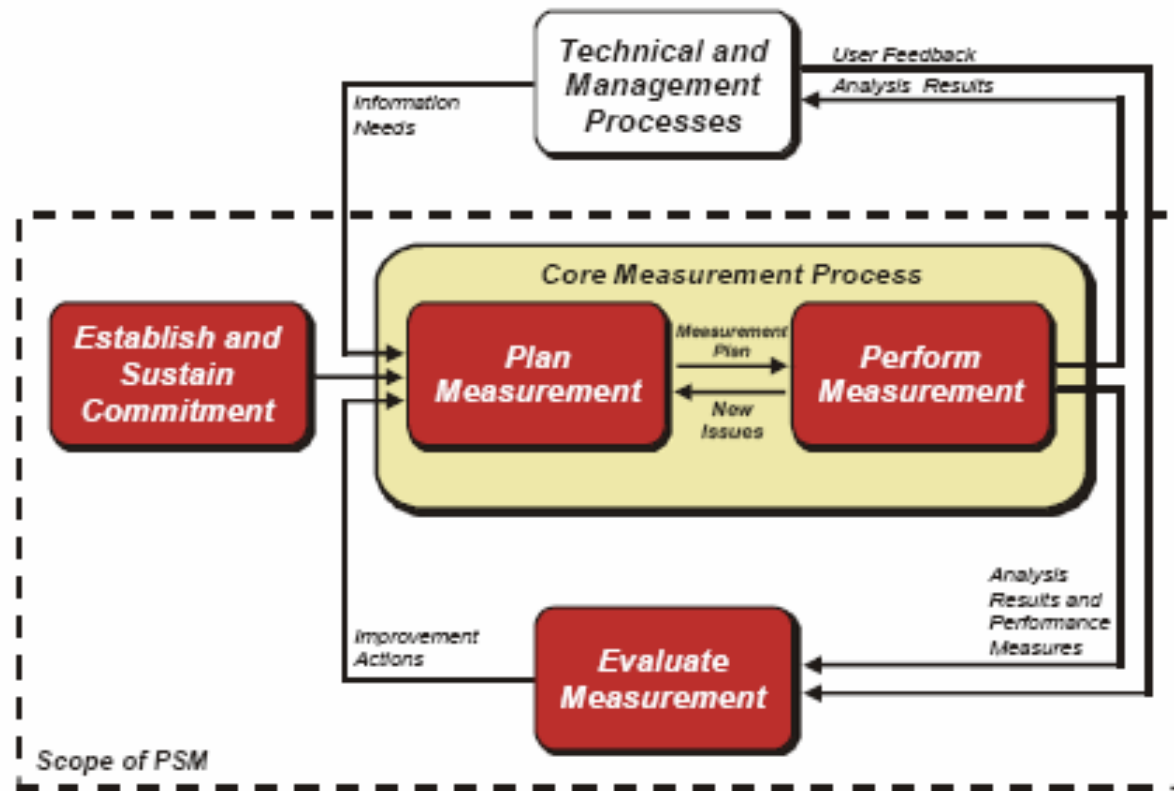
Measurement and Analysis Process Area

- **Purpose**
  - Develop and sustain a measurement capability that is used to support management information needs

- **Involves specifying:**
  - Information needs and measurement objectives
  - Measures
  - Data collection and storage mechanisms
  - Analysis techniques
  - Reporting and feedback mechanisms

- **Written to conform to ISO/IEC 15939, Software Engineering – Software Measurement Process**

Practical Software Measurement

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ISO/IEC 15939, Software Measurement Process

CMMI Measurement And Analysis

ISO/IEC SC7 Standards
12207 (revision – supporting process)
15288 (measurement concepts)
9126 (terminology coordinated)
14598 (terminology coordinated)
ISO 9000-3:2000 (objectives)

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Measurement Principles

- **Measurement is a consistent but flexible process that must be tailored to the unique information needs and characteristics of the project or organization**

- **Decision makers must understand what is being measured and trust the information**
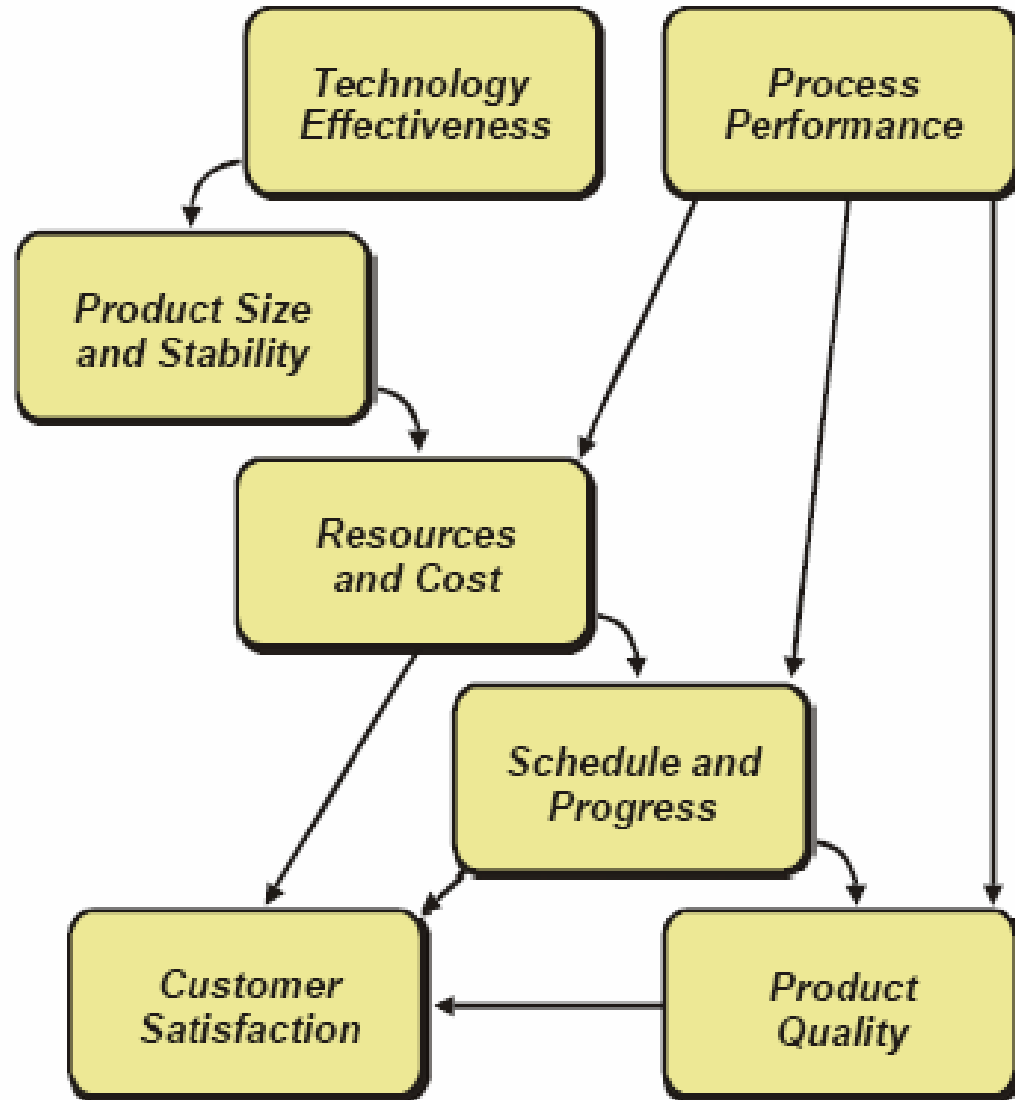
- **Measurement must be used to be meaningful**

Reference: http://www.psmsc.com

Rick Hefner, "Measurement Strategies in the CMMI", 2007

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Multi-Level Measurement Requirements

- **Different types of information are needed at different levels of the infrastructure**

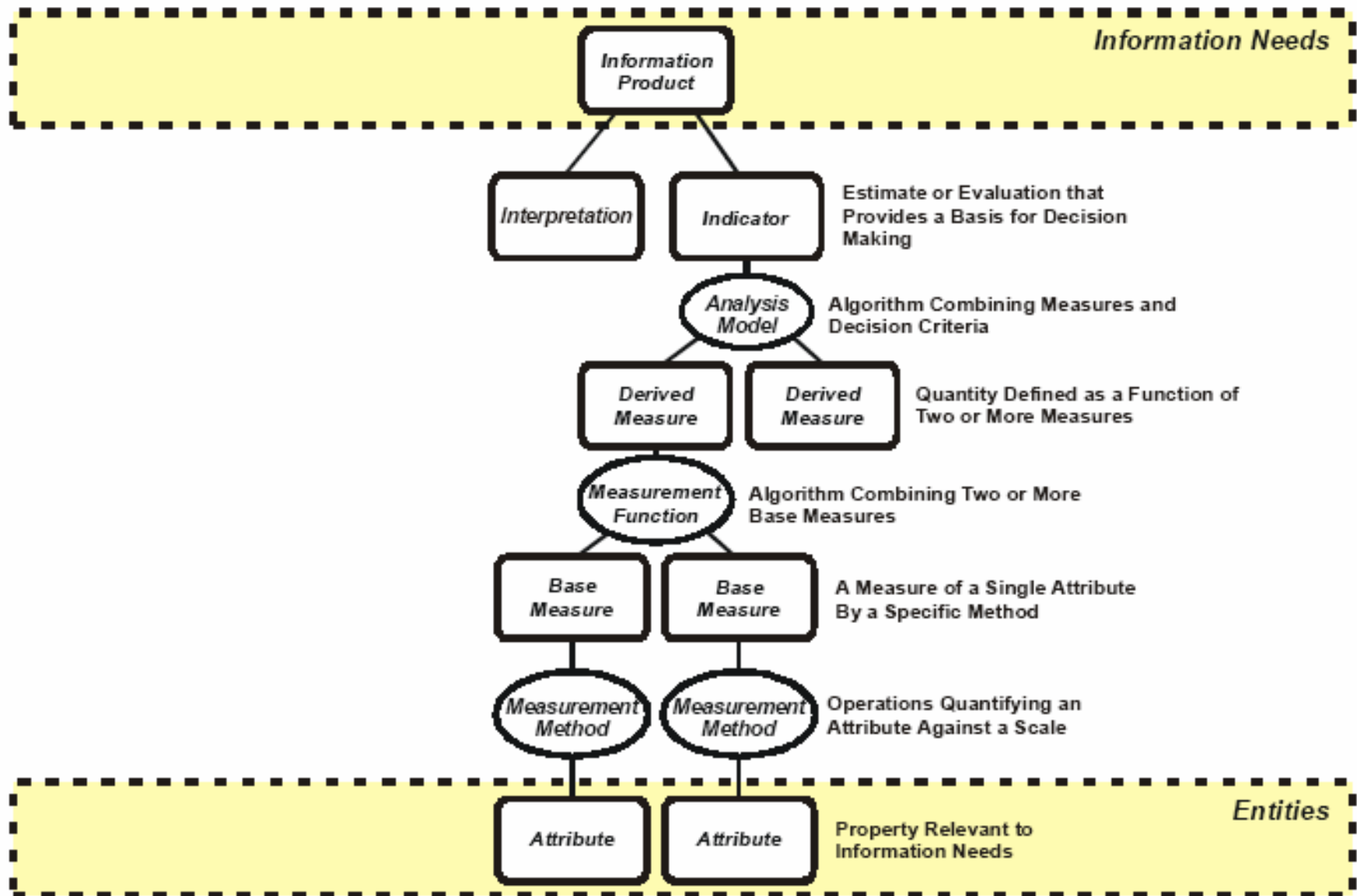| Enterprise Management | • Performance Measurement
• Normative Performance Baselines
• Technical and Business Policy
• Investment Decisions & Analysis | Risk Management Process |
| Organizational Management | • Process Improvement
• Project Planning Guidelines
• Performance Based Guidelines
• Organizational Norms & Benchmarks | Information - Driven Measurement Process |
| Project Management | • Project Estimation & Planning
• Project Performance Tracking
• Project Tradeoff Analysis
• Resource Management | |

Rick Hefner, "Measurement Strategies in the CMMI", 2007

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ISO/IEC 15939, Software Engineering - Software Measurement Process

Measurement and Analysis – Goal 1

Goal/Practices	Notes	Typical Evidence
SG 1 Align Measurement and Analysis Activities Measurement objectives and activities are aligned with identified information needs and objectives.	Focus is on alignment with objectives, not just specifying a set of metrics	
SP 1.1 Establish Measurement Objectives Establish and maintain measurement objectives that are derived from identified information needs and objectives.	See following slide	Information needs Measurement objectives
SP 1.2 Specify Measures Specify measures to address the measurement objectives.		List of metrics, operational definitions
SP 1.3 Specify Data Collection and Storage Procedures Specify how measurement data will be obtained and stored.		Collection and storage procedures
SP 1.4 Specify Analysis Procedures Specify how measurement data will be analyzed and reported.		Analysis procedures

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Information Needs & Measurement Objectives

- **Information needs set requirements for determining the needed metrics**

- **Measurement objectives set requirements for determining the needed metrics collection, storage, analysis, and reporting mechanisms**

Information Needs

What types of information are needed by the project?

- **Progress**
- **Quality**
- **Information needed by the organization**
- **Information needed by the customer**

Measurement Objectives

What objectives influence how the measures are collected, analyzed, stored, reported?
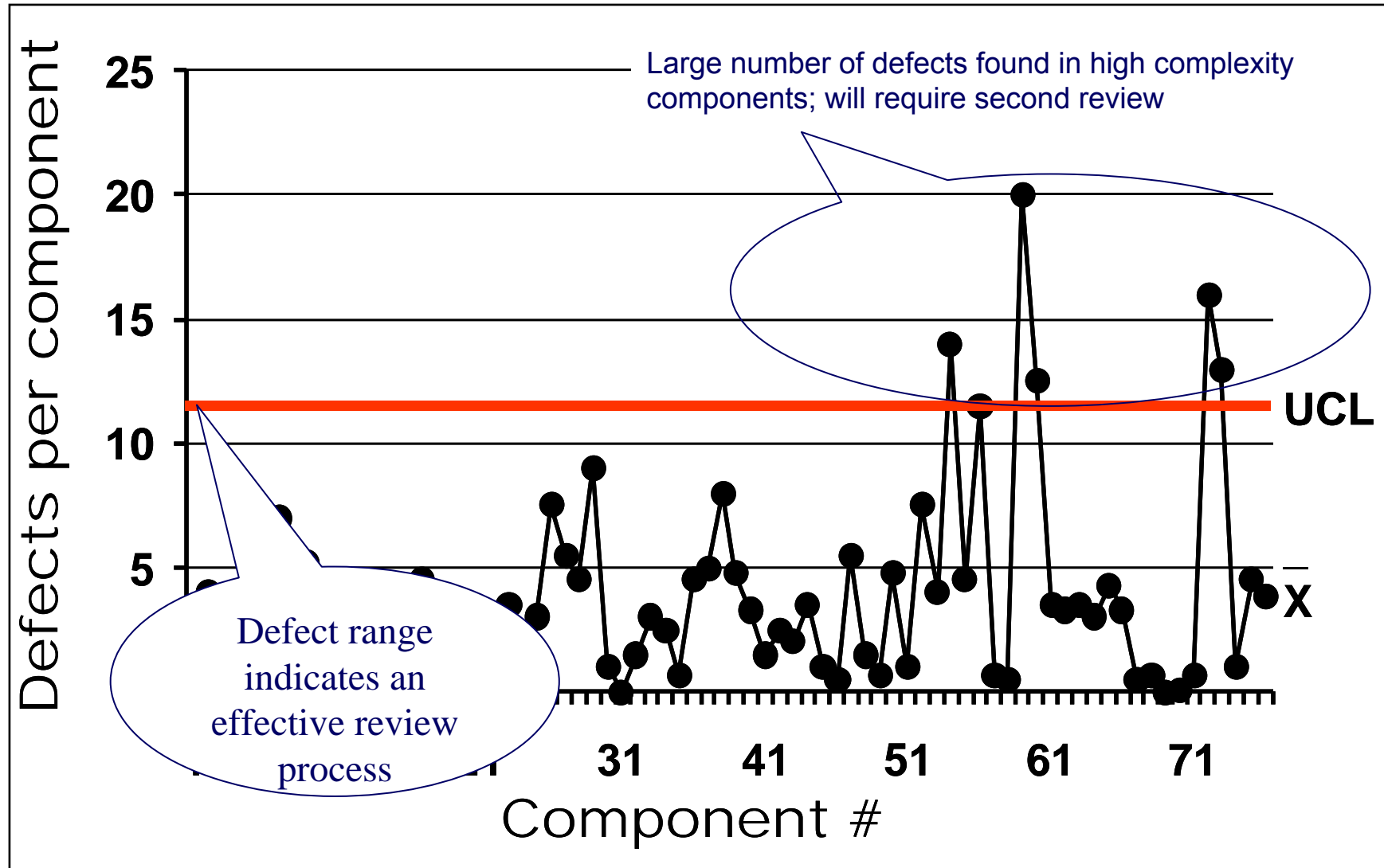
- **Accuracy**
- **Timeliness**
- **Security**

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Measurement and Analysis – Goal 2

Goal/Practices	Notes	Typical Evidence
SG 2 Provide Measurement Results Measurement results that address identified information needs and objectives are provided.	Following defined procedures	
SP 2.1 Collect Measurement Data Obtain specified measurement data.		Measurement collection records
SP 2.2 Analyze Measurement Data Analyze and interpret measurement data.	Evidence should explicitly show interpretations	Analysis results Interpretations
SP 2.3 Store Data and Results Manage and store measurement data, measurement specifications, and analysis results.		Data storage records
SP 2.4 Communicate Results Report results of measurement and analysis activities to all relevant stakeholders.		Metrics reports/ briefings

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What Does the Data Mean?

Large number of defects found in high complexity components; will require second review

Defect range indicates an effective review process

Defects per component (y-axis: 5, 10, 15, 20, 25)

Component # (x-axis: 31, 41, 51, 61, 71)

UCL

$\bar{X}$

Management Styles in the CMMI

Project

Organizational

Quantitative management →

Proactive management →

Reactive mgmt. (plan, track, and correct) →

Level	Process Areas
5 Optimizing	**Causal Analysis and Resolution** **Organizational Innovation and Deployment**
4 Quantitatively Managed	**Quantitative Project Management** **Organizational Process Performance**
3 Defined	**Requirements Development** **Technical Solution** **Product Integration** **Verification** **Validation** **Organizational Process Focus** **Organizational Process Definition** **Organizational Training** **Risk Management** **Integrated Project Management** (for IPPD*) **Integrated Teaming*** **Integrated Supplier Management*** **Decision Analysis and Resolution** **Organizational Environment for Integration***
2 Managed	**Requirements Management** **Project Planning** **Project Monitoring and Control** **Supplier Agreement Management** **Measurement and Analysis** **Process and Product Quality Assurance** **Configuration Management**
1 Performed	

← **Quantitative improvement**

← **Qualitative improvement**

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Measurement - Project Planning

Goal/Practices	Notes	Typical Evidence
SG 1 Establish Estimates Estimates of project planning parameters are established and maintained.		
SP 1.2 Establish Estimates of Work Product and Task Attributes Establish and maintain estimates of the attributes of the work products and tasks.	Attributes are characteristics used to determine effort ▪ Size (e.g., SLOC) ▪ Complexity (e.g., COCOMO parameters) Will be tracked in PMC	Parametric model parameters
SP 1.4 Determine Estimates of Effort and Cost Estimate the project effort and cost for the work products and tasks based on estimation rationale.		Effort/cost estimates

Goal/Practices	Notes	Typical Evidence
SG 2 Develop a Project Plan *A project plan is established and maintained as the basis for managing the project.*		
SP 2.1 Establish the Budget and Schedule *Establish and maintain the project's budget and schedule.*		*Budget, schedule*

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Measurement - Project Monitoring & Control

Goal/Practices	Notes	Typical Evidence
SG 1 Monitor Project Against Plan Actual performance and progress of the project are monitored against the project plan.		
SP 1.1 Monitor Project Planning Parameters Monitor the actual values of the project planning parameters against the project plan.	See PP SP 1.2 and 1.4; includes monitoring of attributes against estimates	Periodic metrics reports

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Measurement – Integrated Project Management

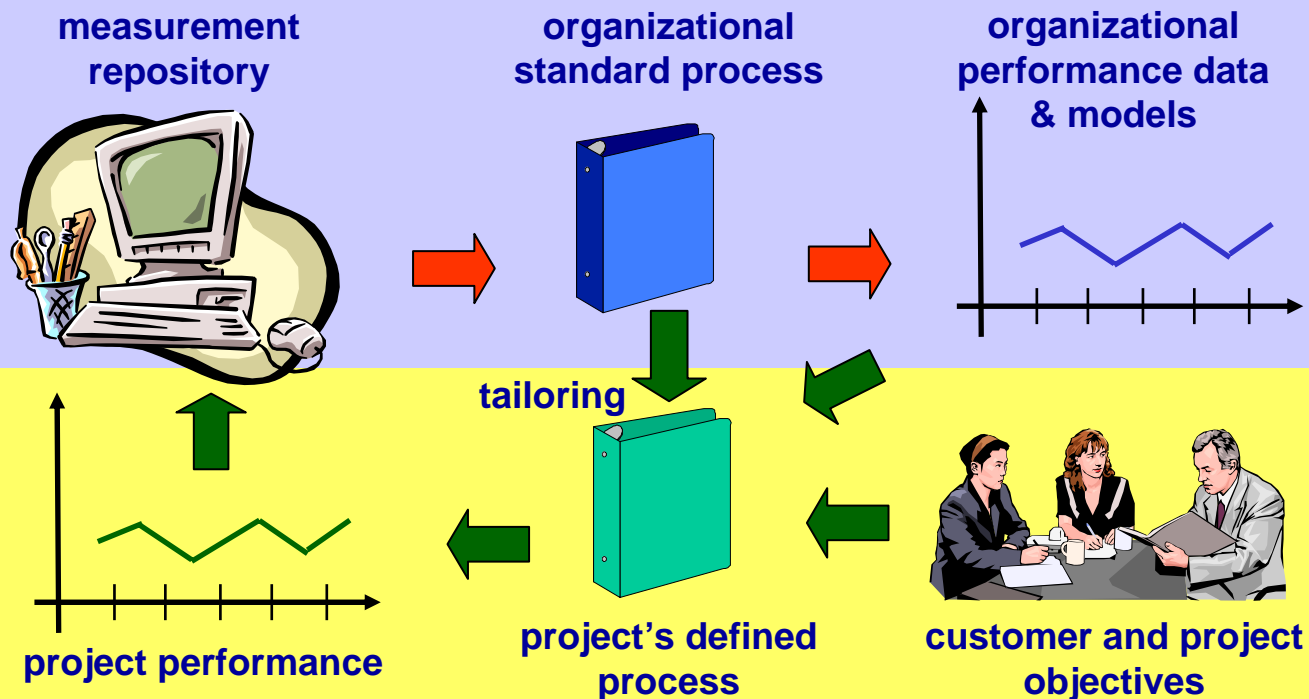| Goal/Practices	Notes	Typical Evidence
SG 1 Use the Project's Defined Process The project is conducted using a defined process that is tailored from the organization's set of standard processes.		
SP 1.5 Manage the Project Using the Integrated Plans Manage the project using the project plan, the other plans that affect the project, and the project's defined process.	Proactive management may be expected Discuss with Lead Appraiser	Metrics reports

- **Informative material in the CMMI suggests that project management becomes more proactive at Level 3**
    - Monitoring the activities that could significantly affect the actual values of the project's planning parameters
    - Tracking the project's planning parameters using measurable thresholds that will trigger investigation and appropriate actions
    - Risk management
    - Earned value management

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Measurement at CMMI Level 4

- **Organizational Process Performance**
    - Establishes a quantitative understanding of the performance of the organization's set of standard processes
    - Provides process performance data, baselines, and models to quantitatively manage the organization's projects

measurement repository   **organizational standard process**   **organizational performance data & models**

tailoring

project performance   **project's defined process**   **customer and project objectives**

- **Quantitative Project Management**
    - Quantitatively manage the project's defined process to achieve the project's established quality and process-performance objectives.

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What is Quantitative Management?

- **Suppose your project conducted several peer reviews of similar code, and analyzed the results**
  - Mean = 7.8 defects/KSLOC
  - $+3\sigma$ = 11.60 defects/KSLOC
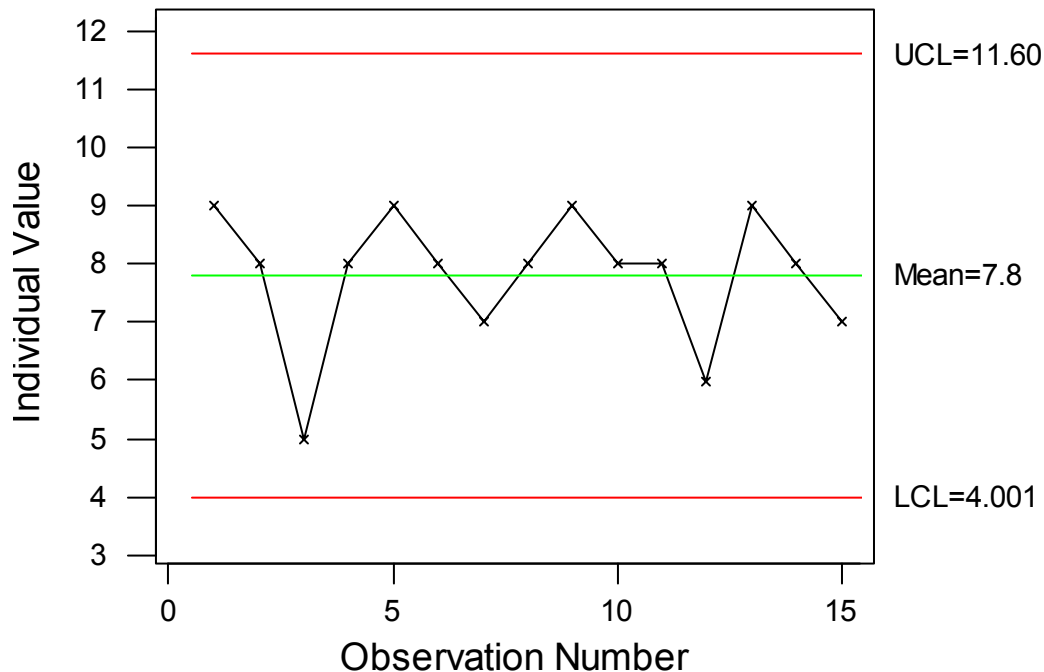 - -3σ = 4.001 defects/KSLOC
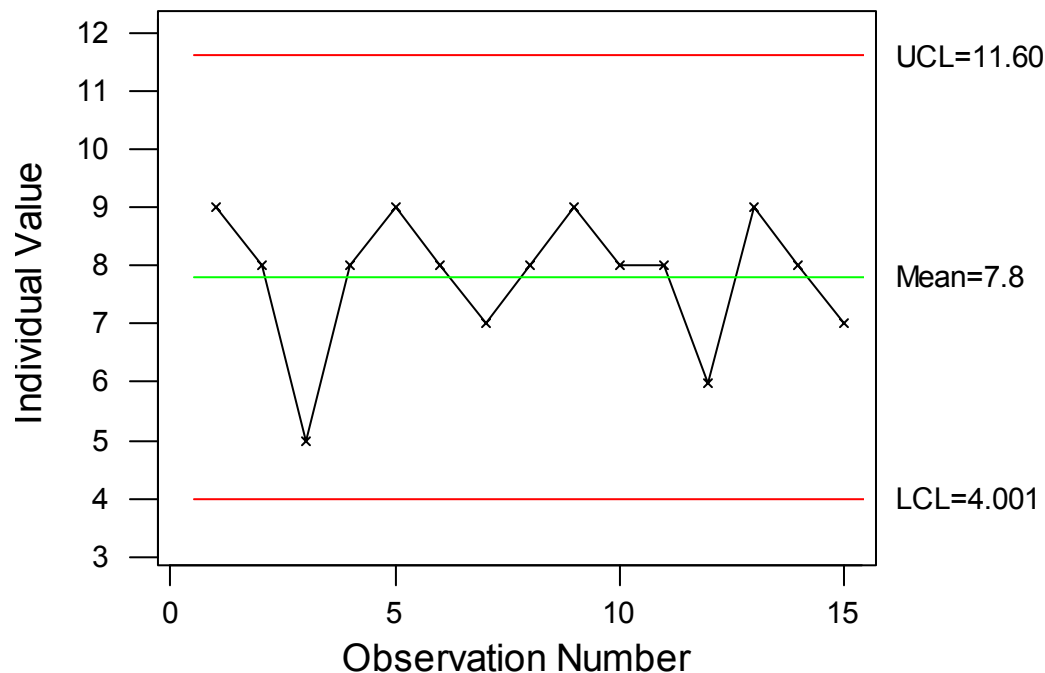
- **What would you expect the next peer review to produce in terms of defects/ KSLOC?**

- **What would you think if a review resulted in 10 defects/KSLOC?**

- **3 defects/KSLOC?**

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- **What is needed to develop the statistical characterization of a process?**

- **The process has to be stable (predictable)**
  - Process must be consistently performed
  - Complex processes may need to be stratified (separated into simpler processes)

- **There has to be enough data points to statistically characterize the process**
  - Processes must occur frequently within a similar context (project or organization)

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Typical Choices in Industry

- **Most customers care about:**
  - Delivered defects
  - Cost and schedule

- **So organizations try to predict:**
  - Defects found throughout the lifecycle
  - Effectiveness of peer reviews, testing
  - Cost achieved/actual (Cost Performance Index – CPI)
  - Schedule achieved/actual (Schedule Performance Index – SPI)

Defect Detection Profile
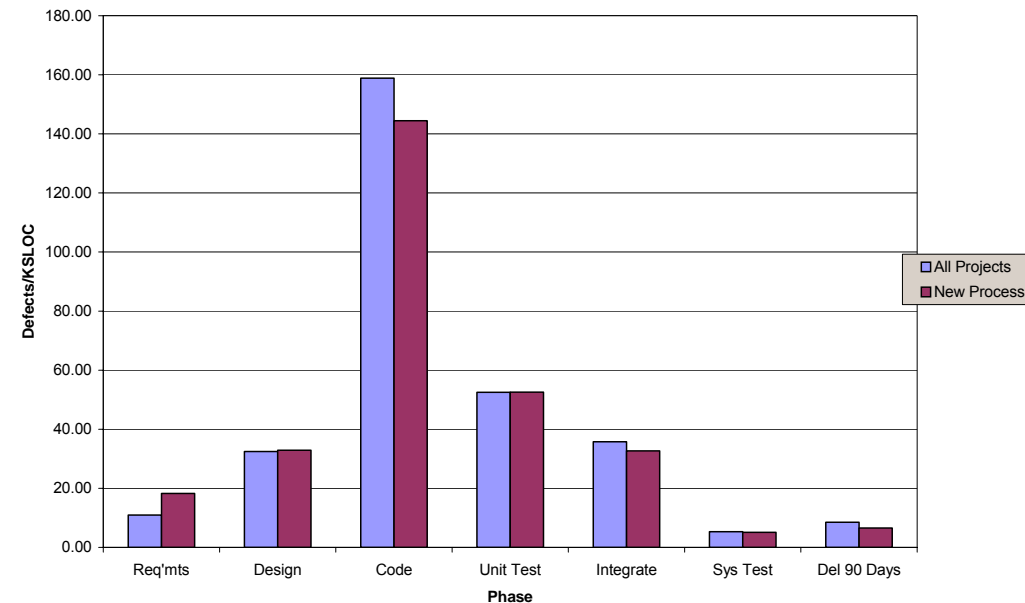
Process performance
- **Process measures** (e.g., effectiveness, efficiency, speed)
- **Product measures** (e.g., quality, defect density).

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Measurement at CMMI Level 5

- **Organizational Innovation & Deployment**
    - Set quantitative improvement goals (e.g., reduce variation by X%, reduce mean by Y%)
    - Seek innovative improvements - cause a shift in process capability
    - Analyze potential improvements to estimate costs and impacts (benefits)
    - Pilot improvements to ensure success
    - Measure the impact of improvements quantitatively (variation and mean)

- **Causal Analysis & Resolution**
    - Identify and analyze causes of defects and other problems
    - Take specific actions to remove the causes -- prevent the occurrence of those types of defects and problems in the future
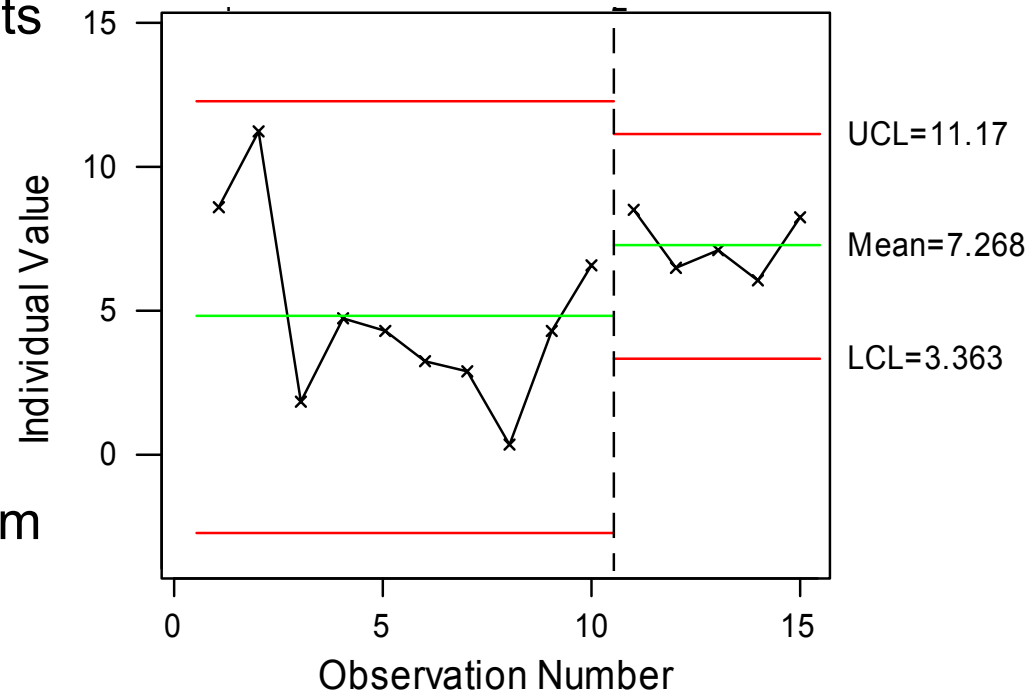
Peer Reviews – Improving the Process

- **Reduce the variation**
  - Train people on the process
  - Create procedures/checklists
  - Strengthen process audits

- **Increase the effectiveness (increase the mean)**
  - Train people
  - Create checklists
  - Reduce waste and re-work
  - Replicate best practices from other projects

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Lessons Learned

- **To establish (revitalize) a measurement system, start by identifying all the stakeholders and what information they need to make decisions**
  - Look for common needs, which drive common metrics than can be used by many stakeholders
  - There is no "magic" set of metrics that works for every project or every organization

- **It takes several months, if not years, to develop an effective measurement system**
  - Initially, focus is on ensuring data is provided
  - Next, focus in on data definition problems
  - Finally, focus on effective use of the data
  - Concentrate on developing a data-driven culture

- **When moving to Levels 4 and 5, expect a period of trial-and-error to discover the metrics you need**
  - Focus on management by variation (e.g., Six Sigma)

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