Getting Started in Software Project Measurement
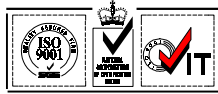
Beth Layman
Senior Consultant
Consultative Engineering


Presentation Objectives

- ❒ *Define the characteristics of an effective* *Project Measurement Process*.

- ❒ *Provide a process for* *tailoring* *a measurement program to fit project-specific needs.*

- ❒ *Provide a systematic process for* *analyzing and using* *measurement results to manage projects.*
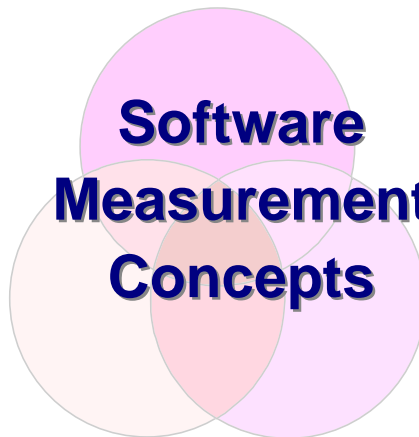
Presentation Outline

- *Software Measurement Concepts*
- *Project Measurement Overview*
- *Selecting Project Measures*
- *Applying Project Measures*
- *Tips for Getting Started*
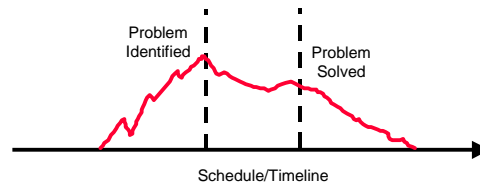- *Summary*
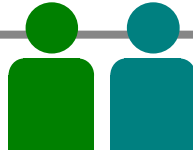
Software Measurement Concepts

Role of Measurement

Measurement:

Provides Information that Improves Decision Making <u>in Time</u> to Affect the Business or Mission Outcome

Problem
Identified

Problem
Solved

Schedule/Timeline

Key Measurement Concepts

- *Measurement is a <u>Process</u>*
- *Measurement must be used in <u>Decision-Making</u> to be Worthwhile*
- *Information must be Available <u>in time</u> to Influence the Outcome*
- *Measurement must be <u>linked</u> to Business or Mission Goals*
- *Measurement can be a <u>powerful tool</u> for Business Success*
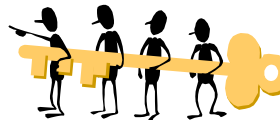
Measurement at Each Level

Enterprise	• *Return on Investment*
	• *Comparative Analysis*

Process	• *Activity-Based Costing*
	• *Benchmarking*
	• *Statistical Process Control*

Project	• *Schedule/Progress*
	• *Resources/Cost*
	• *Growth/Stability*

| Product	• *Defect Management*
	• *Maintainability*
	• *Reliability*

Why Project Measurement?

- ❑ *Forms basis for process improvement and organizational performance measurement*
- ❑ *Software projects (Development and Maintenance) represent 80% of IT investment*
- ❑ *Fundamentals first*
- ❑ *Many people start top-down (fine for goal alignment - bad for implementation success)*

PSM Overview
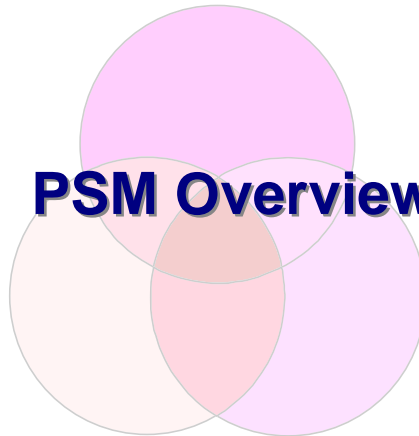
Practical Software Measurement (PSM)

- *Sponsored by the Joint Logistics Commanders (JLC) and Office of the Secretary of Defense (OSD)*
- *Purpose was help DoD Software Programs (Projects) improve their performance*
- *Developed by Technical Consensus*
- *Presenter is a Principal Author*
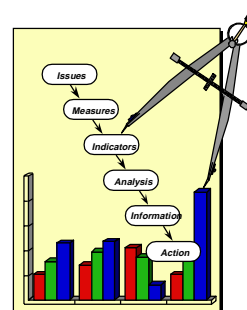
Issues → Measures → Indicators → Analysis → Information → Action

Lockheed Martin's Role

- *Transition Partner for PSM Products & Services*
- *Translate PSM for Commercial Software Industry (Training, Hypertext version of Guidance)*
- *Help Get PSM Implemented within Commercial Software Organizations*

PSM Objectives

- *Help Project and Technical Managers Meet Software Cost, Schedule, and Technical Objectives*
- *Provide a Basis for Objective Communication and Informed Decision Making*
- *Establish a Foundation for Organizational Performance Measurement*

PSM - Scope

- *Project Manager - Development Team*
- *MIS --> Embedded Projects*
- *New and Ongoing Projects*
- *Life Cycle Application - All Phases*
- *Single Project Focus (vs. cross-project comparisons)*
- *Fundamental Practices - "How To" Guidance*

PSM Principles

- *Project Issues and Objectives Drive the Measurement Requirements*
- *The Real Development Process Defines How the Software is Actually Measured*
- *Collect and Analyze Data at a Level of Detail Sufficient to Identify and Isolate   Software Problems*
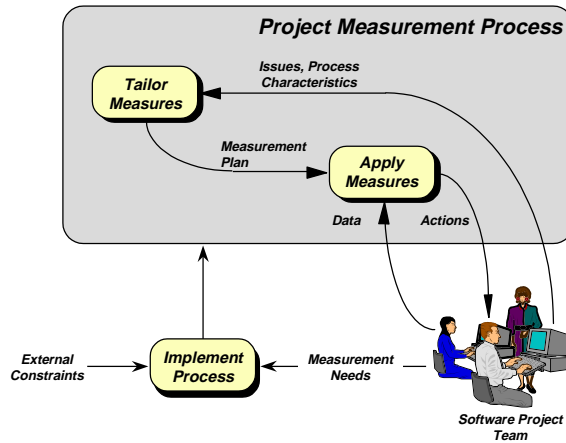
Principles (cont)

- *Implement an <ins>Independent</ins> Analysis Capability*
- *Use a <ins>Systematic</ins> Analysis Process to Trace the Measures to the Decisions*
- *Interpret the Measurement Results In the <ins>Context</ins> of Other Project Information*
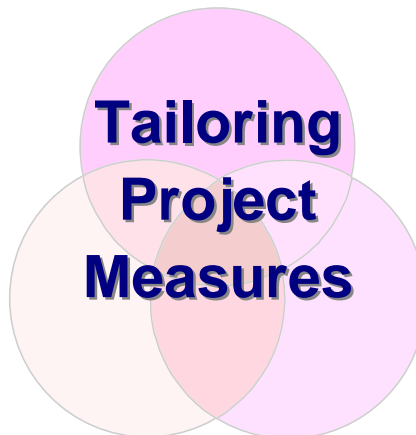
Principles (cont)

- *<ins>Integrate</ins> Software Measurement Into the Project Management Process <ins>Throughout</ins> the Life-Cycle*
- *Focus Initially on <ins>Single Project</ins> Analysis*
- *Use the Measurement Process as a Basis for <ins>Objective Communications</ins>*

PSM Process Overview

Project Measurement Process

Tailor Measures
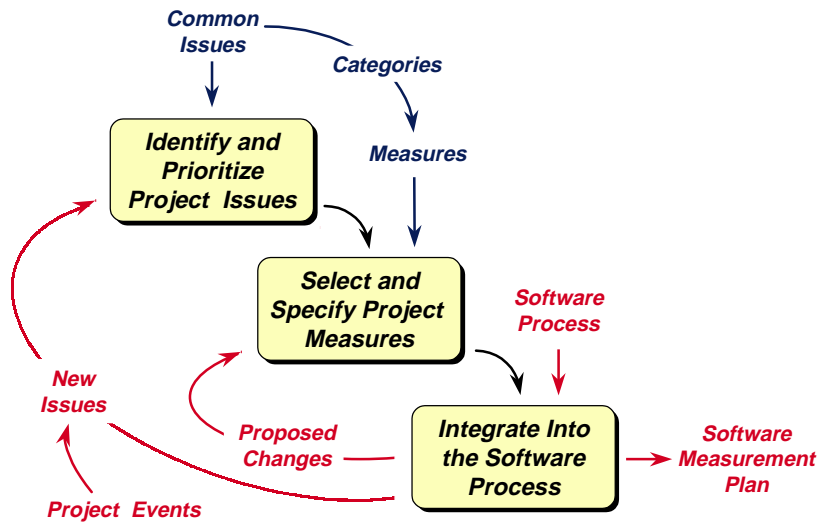
Issues, Process Characteristics

Measurement Plan

Apply Measures

Data   *Actions*

Implement Process

External Constraints   *Measurement Needs*

Software Project Team

Tailoring Project Measures

Phase 1 - Tailor Measures

Project Measurement Process

Tailor Measures

Issues, Process Characteristics

Measurement Plan

Apply Measures

Data   *Actions*

Implement Process

External Constraints

Measurement Needs

Software Project Team

Tailoring - Key Concepts

- *Each Software Project Is Described By a Unique Set of Issues*
- *Unique Project Issues Can be Grouped Into Six "Common Issues"*
- *The Project Issues Define the Software Measures that You Need to Use*
- *The Measurement Definitions and Methods are Determined by the Developer's Software Process*

Tailoring Software Measures

Common
Issues

Categories

Measures

Identify and Prioritize Project Issues

Select and Specify Project Measures

Software Process

New Issues

Proposed Changes

Integrate Into the Software Process

Software Measurement Plan

Project Events

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Tailoring "Mechanisms"

*Common **Issues***

*Measurement **Categories***

Measures
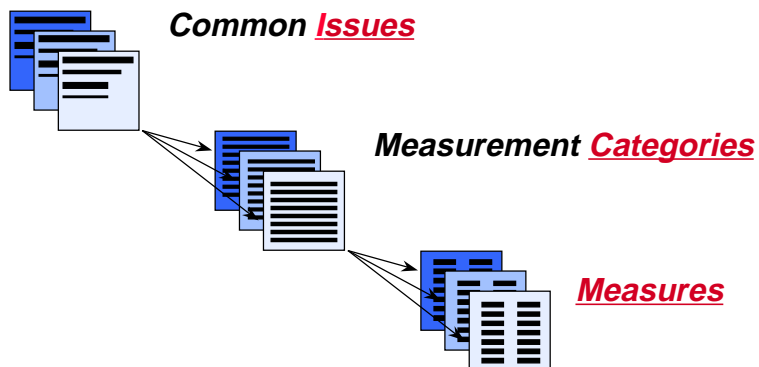
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Common Software Issues
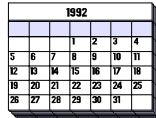
Schedule and Progress

Growth and Stability

Resources and Cost

Product Quality

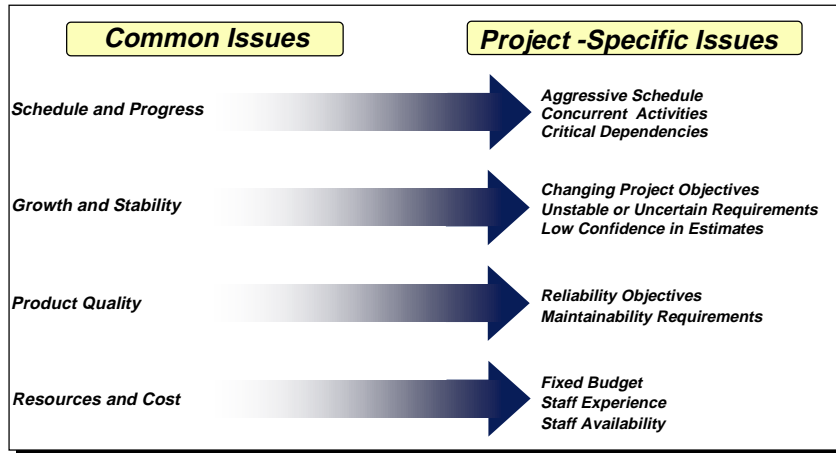Development Performance

Technical Adequacy

Criteria for Defining and Prioritizing Project Specific Issues

- *Risk Analysis Results*
- *Project Constraints and Objectives*
- *Leveraged Software Technologies*
- *Product Acceptance Criteria*
- *External Requirements*
- *Experience*

Development of Project -Specific Issues

Common Issues	Project -Specific Issues
Schedule and Progress	Aggressive Schedule Concurrent Activities Critical Dependencies
Growth and Stability	Changing Project Objectives Unstable or Uncertain Requirements Low Confidence in Estimates
Product Quality	Reliability Objectives Maintainability Requirements
Resources and Cost	Fixed Budget Staff Experience Staff Availability

---

Issues - Measurement Categories

Schedule and Progress
- Milestone Performance
- Work Unit Progress
- Schedule Performance
- Incremental Capability

Growth and Stability
- Product Size and Stability
- Functional Size and Stability
- Target Computer Resource Utilization

Product Quality
- Defect Profile
- Complexity

Resources and Cost
- Effort Profile
- Staff Profile
- Cost Performance
- Equipment Availability

Development Performance
- Process Maturity
- Productivity
- Rework

Technical Adequacy
- Technology Impacts

Measures by Category

Milestone Performance
- *Milestone Dates*

Work Unit Progress
- *Requirements*
- *Components*
- *Test Cases*
- *Problem Reports*
- *Changes*

Schedule Performance
- *Schedule Variance*

Incremental Capability
- *Build Content - Component*
- *Build Content - Function*

Effort Profile
- *Effort*

Staff Profile
- *Staff Level*
- *Staff Experience*
- *Staff Turnover*

Cost Performance
- *Cost Variance*
- *Cost Profile*

Environment Availability
- *Resource Availability Dates*
- *Resource Utilization*

Measures by Category (cont.)

Product Size & Stability
- *Lines of Code*
- *Number of Components*
- *Words of Memory*
- *Database Size*

Functional Size & Stability
- *Requirements*
- *Function Points*

Target CRU
- *CPU*
- *I/O*
- *Memory*
- *Storage*
- *Response Time*

Defect Profile
- *Problem Trends*
- *Problem Aging*

Complexity
- *Cyclomatic Complexity*

Process Maturity
- *CMM Level*

Productivity
- *Functional Size/Effort Ratio*
- *Product Size/Effort Ratio*

Rework
- *Rework Size*
- *Rework Effort*

Selecting Measures

Schedule and Progress
- *Milestone performance*
- *Work unit progress*
- *Schedule performance*
- *Incremental capability delivered*

Measures
- *Components designed*
- *Components implemented*
- *Components integrated and tested*
- *Requirements allocated*
- *Requirements tested*
- *Test cases completed*
- *Paths tested*
- *Problem reports resolved*
- *Reviews completed*
- *Changes implemented*

Criteria for Selecting Project Specific Measures

- ❑ *Measurement Effectiveness*
- ❑ *Domain Characteristics*
- ❑ *Size/Origin of the Software*
- ❑ *Project Management Practices*
- ❑ *Cost and Availability*
- ❑ *Life Cycle Coverage*
- ❑ *External Requirements*

Software Process Maturity
Influences the Measurement Process

SEI Capability Maturity Level

5 In — Out
4 In — Out
3 In — Out
2 In — Out
1 In — Out
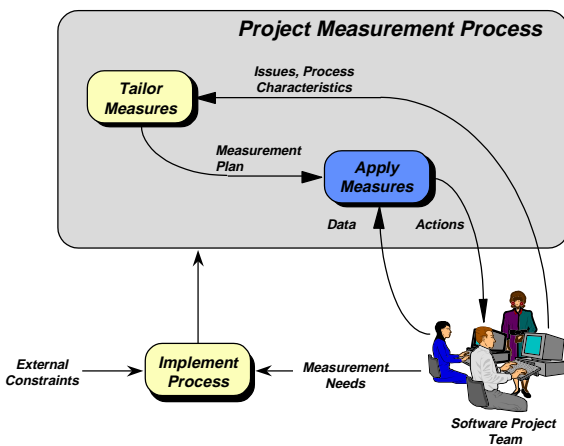
Increasing Measurement Capability
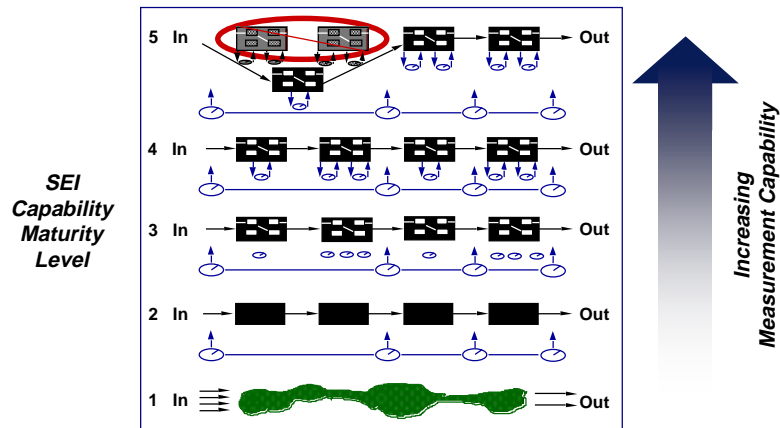
Software Measurement Plan

- ❑ *Issues and Selected Measures*
- ❑ *Measurement Specifications and Definitions*
- ❑ *Data Sources*
- ❑ *Measurement Levels and Aggregation*
- ❑ *Structures*
- ❑ *Frequency of Data Collection*
- ❑ *Methods of Data Delivery*
- ❑ *Lines of Communication and Interfaces*
- ❑ *Frequency of Analysis and Reporting*
- ❑ *Working Document*

Applying Project Measures
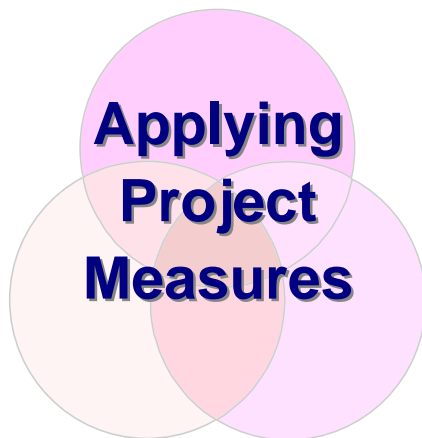
Phase 2 - Applying Measures

Project Measurement Process

- Tailor Measures
- Issues, Process Characteristics
- Measurement Plan
- Apply Measures
- Data
- Actions
- Implement Process
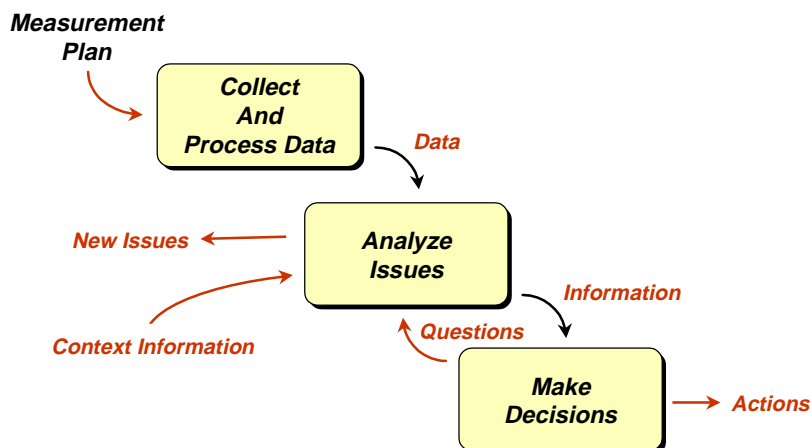- External Constraints
- Measurement Needs
- Software Project Team

Applying - Key Concepts

- *Method for Converting Data Into Information*
- *Quantitative Information must be integrated into decision-making process*
- *Analysis is flexible, yet systematic and repeatable*
- *Qualitative Data Must be Considered in the Analysis and Decision-Making Activities*
- *The Analysis Focus Changes Across the Life-cycle*

Applying Software Measures

Measurement Plan

Collect And Process Data

Data

Analyze Issues

New Issues

Context Information

Questions

Information

Make Decisions

Actions

Collect and Process Data

- *Collect Both Planned and Actual Data Values*
- *Collect Data at a Level Appropriate to Localize Problems*
- *Question Unusual Trends and Inconsistencies in the Data*
- *Collect Data at Least Monthly*
- *Develop Clear and Concise Definitions to Guide*
- *Data Collection - Know What the Data Means*
- *Expect the Data to be "Noisy"*

Levels of Data Aggregation
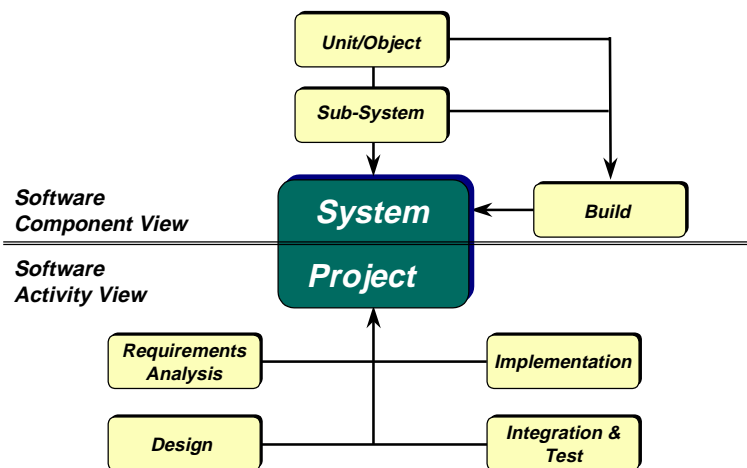
Analyze Issues

❏ *Indicators are generated and systematically analyzed, resulting in an assessment of the status of known issues and the identification of new issues.*
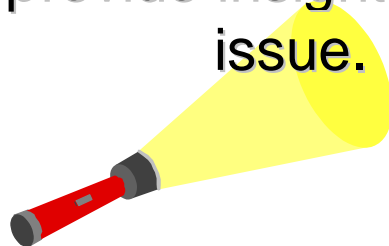
❏ *Steps:*
  - *Identify Problems*
  - *Assess Problem Impact*
  - *Project Outcome*
  - *Evaluate Alternatives*

Indicators

Indicators are the key mechanism used to provide insight into an issue.

Project Measurement Model

Issues

provide
insight
into

are
monitored
with

Indicators

are
combined
into

are
built
with

Measurement Data
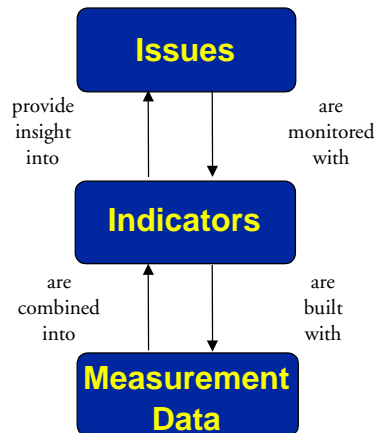
Generating Useful Indicators

- *Use **Consistent Conventions***
- *Keep it **Simple**; Keep the Message Clear*
- ***Unique Titles** should Reflect Insight and Scope*
- *Include an **As-Of** Line or Date*
- ***Label** each Axis and Provide **Scale** Markers*
- ***Annotate** with Milestones and Significant Events*
- *Use **Same** Axes and Scales if Indicators will be Compared*
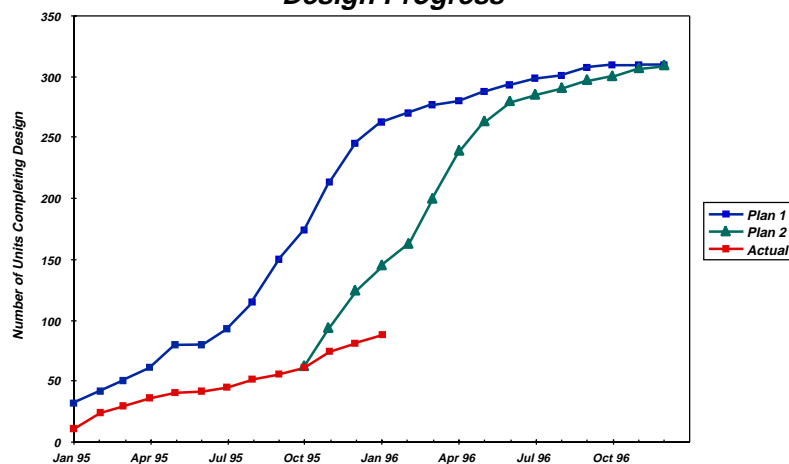
Measurement Indicator Baselines
What Are You Comparing?

☐ *Meaningful Analysis Requires a Measurement* *Baseline* *Against Which Actual Values Can Be Compared*

☐ *Baselines May be Derived From:*

- *Plans*   - *Completion criteria*
- *Rules of thumb*   - *Typical values*
- *Totals or goals*   - *Norms*
- *Threshold values*   - *Averages*

Work Unit Progress Example

Design Progress

Legend: Plan 1, Plan 2, Actual

Y-axis: Number of Units Completing Design (0, 50, 100, 150, 200, 250, 300, 350)

X-axis: Jan 95, Apr 95, Jul 95, Oct 95, Jan 96, Apr 96, Jul 96, Oct 96

Problem Report Example

Problem Report Status
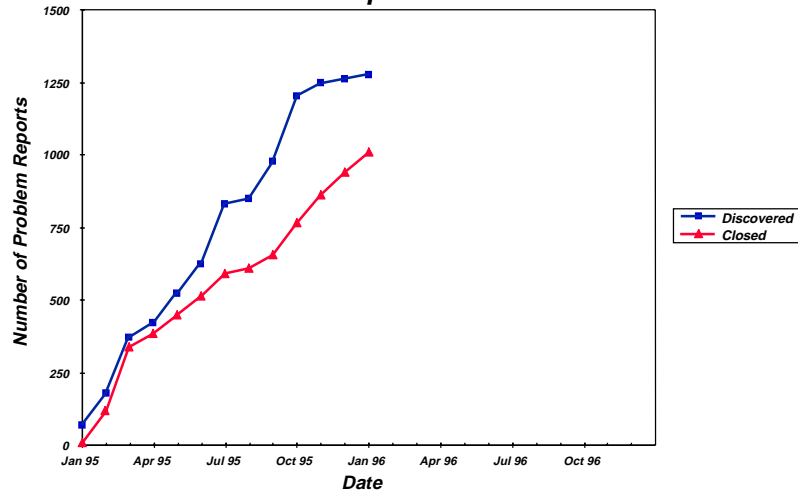
Software Complexity Example

Software Complexity
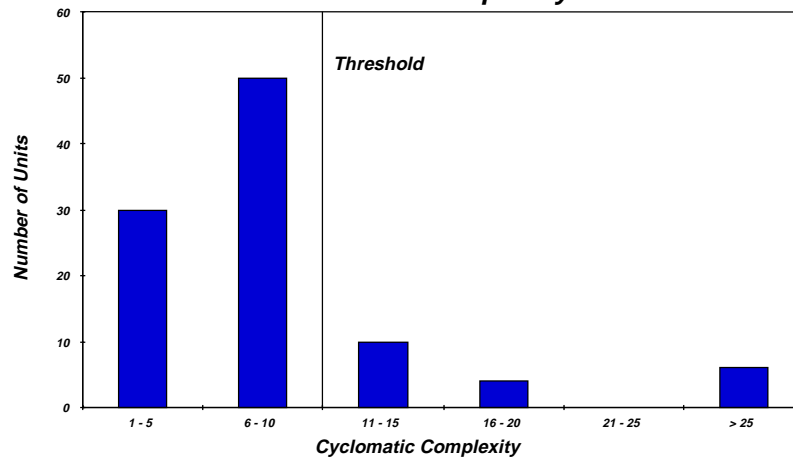
Types of Measurement Analysis

Estimation

Performance Analysis

Cost · Schedule · Performance · Functionality · Quality

Feasibility Analysis
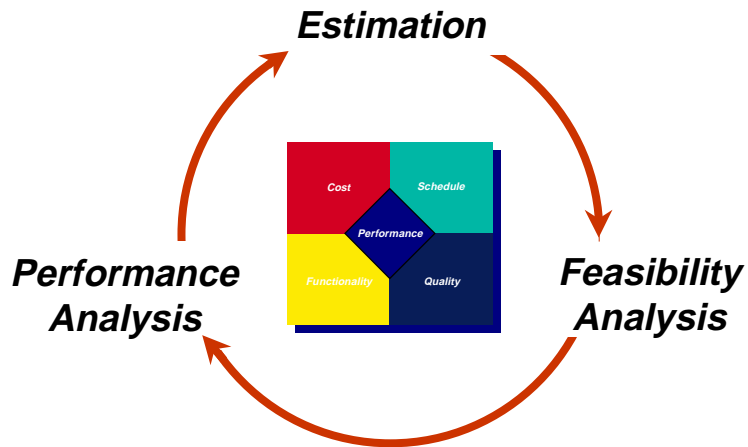
Estimation

☐ *Analysis conducted to establish target values for use in project planning; usually starts with historical data and a set of assumptions. Should be conducted throughout the project as assumptions change. Includes:*
  - *Size Estimation*
  - *Effort Estimation*
 - *Schedule Estimation*
  - *Quality Estimation*

Estimation Approaches

☐ *Parametric Models*
  - *Assumes mathematical relationships exist between factors (size, effort, schedule…)*
  - *Parameters inflate/deflate estimates*

☐ *Engineering Estimates*
  - *Bottom-up approach*
  - *Also uses parameters*

☐ *Analogy*
  - *Detailed comparison of characteristics from past projects*

☐ *Simple Estimating Relationships*
  - *Based on local historical data*

Estimator Indicators

Size - Effort
Estimating Relationship
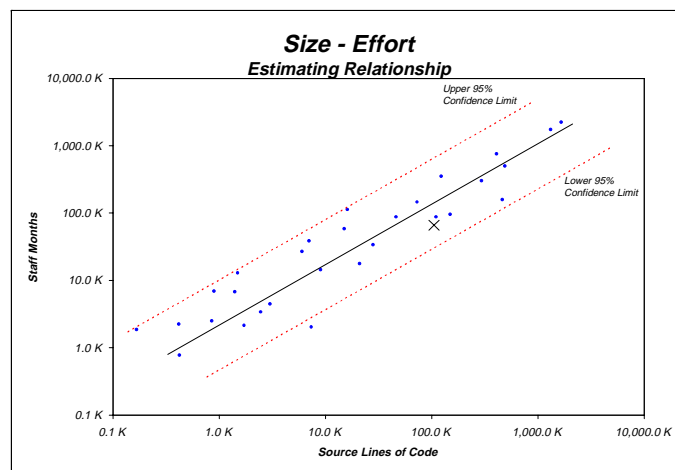
Size Estimation

□ *Three widely used measures:*
  - *FPs counted from requirements and design specs*
  - *SLOC counted by analogy and rules of thumb (SLOC/unit)*
  - *Change Requests counted by analogy*

□ *Size estimates improve as project progresses*

□ *Consider separately:*
  - *New*
  - *Modified*
  - *Reused*
  - *Purchased/COTS*

How big is the problem and solution space?

Effort Estimation

□ *Best supported by existing models*

□ *Models use Size-Effort relationship*

□ *Models provide 15-100 productivity adjustments:*
  - *Product - reliability, complexity, environment*
  - *Process - tools, skill, maturity*

□ *Must determine which factors most influence your organization's productivity*

How much effort will it take?

Schedule Estimation

- *Models spread effort over time (e.g., Rayleigh distribution)*
- *Combination of model-based and bottom-up approaches useful here*
- *Usually deals with optimum staffing profiles also*

How long will it take?

Quality Estimation

- *Assumes process capability-product quality relationship*
- *Helps predict defect rates*
- *Two models used:*
  - *Reliability Models*
  - *Transactions Models (insertion and detection)*

**Can my quality objectives be met?**

Feasibility Analysis

□ **Analysis conducted to determine whether** *plans and targets are realistic and achievable;* **should be conducted during the initial planning activity and at all subsequent re-plans. Looks at:**
  - **Realism of planning assumptions (availability, productivity, etc.)**
  - **Completeness of Plans**
  - **Plan Integration and Coordination**

Feasibility Analysis Example
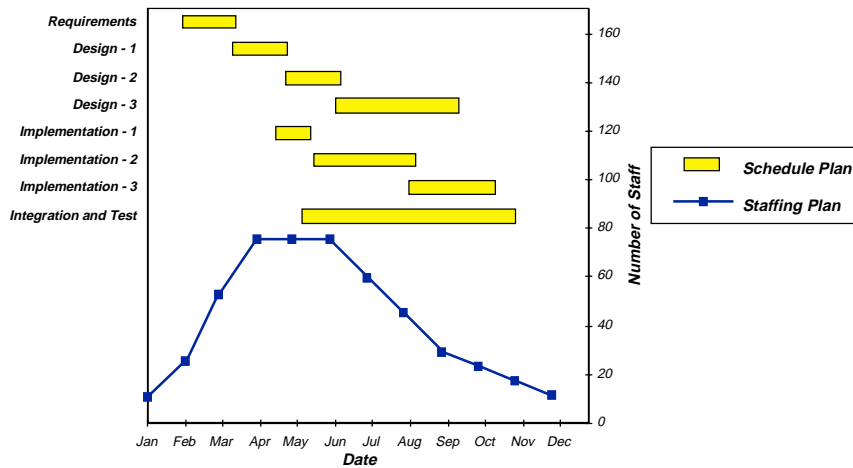
Feasibility Analysis Checklist

□ **Single Plan Issues:**
- *Are important activities missing on schedules?*
- *Is the overlap between project activities reasonable?*
- *Are holidays, vacations, etc. considered in plans/schedules?*
- *Is the rate of planned progress (I.e., slope) reasonable?*
- *Is planned performance consistent with past performance?*

□ **Plan Integration Issues:**
- *Do totals (I.e. total number of units, total effort) match?*
- *Do summary figures match more detailed breakdowns?*
- *Do dates, milestones, and timeframes match?*
- *Does the effort allocated match workload?*
- *Does the effort allocated match cost/budget plans?*
- *Does any other Project information contradict plans?*

Performance Analysis

□ *Analysis conducted to determine whether* *software development is meeting the plans*, *assumptions, and targets; should be conducted periodically once a Project has committed to a plan.*

□ *Looks at:*
- *Leading, Basic, and Supplemental indicators*
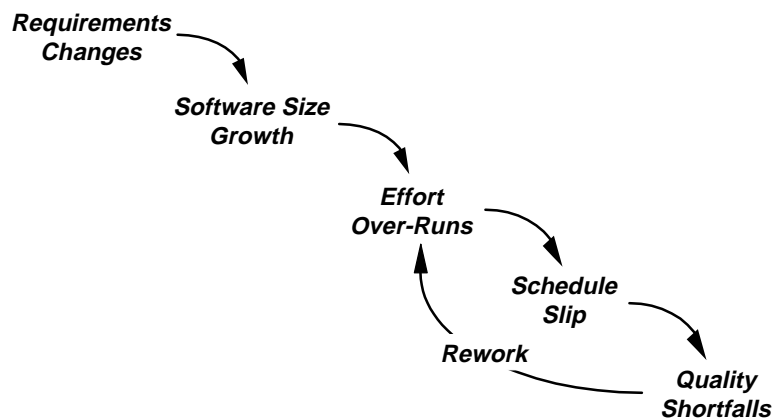- *Critical path items*
- *Inconsistent trends*

Indicator - Types

□ *Leading* - **Predicts the future situation with respect to an issue.**
- • *For example, requirements changes may be a leading indicator for development effort. Changes in requirements usually result in a need for increased effort.*

□ *Basic* - **Describes the current situation with respect to an issue.**
- • *For example, staffing level describes the developer effort currently being expended by the project.*

□ *Supplemental* - **Provides a more detailed view an an issue.**
- • *Triggered when other analyses point to a problem that needs to be investigated. Used to help find root cause of a problem.*
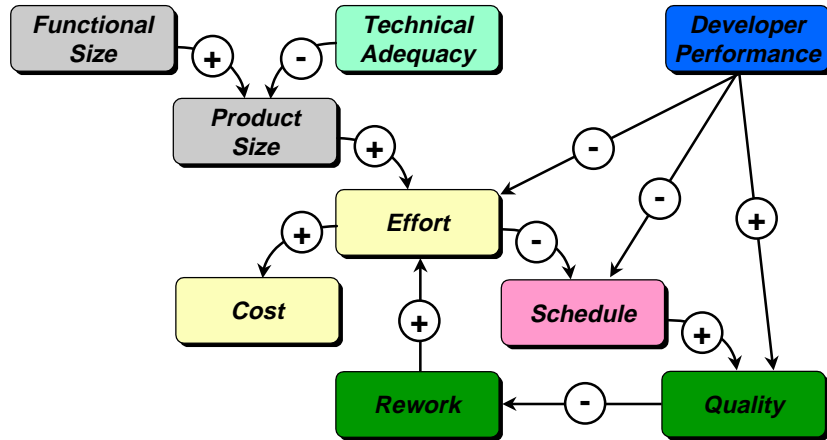

Typical Pattern of Software Problems

Requirements Changes

Software Size Growth

Effort Over-Runs

Schedule Slip

Rework

Quality Shortfalls

Performance Analysis "Road Map"

Performance Analysis Examples
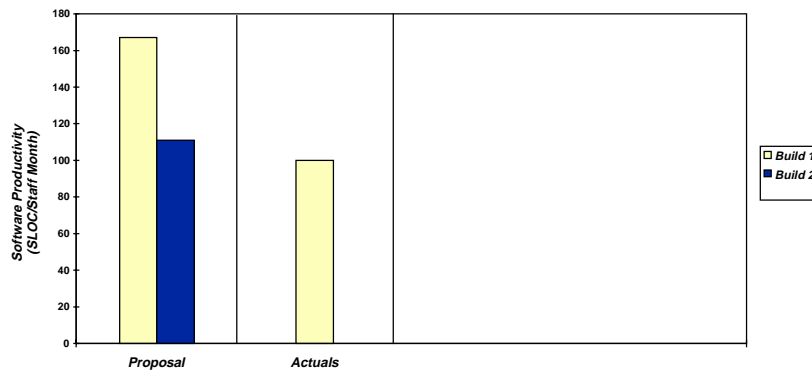
Required Software Productivity
By Build

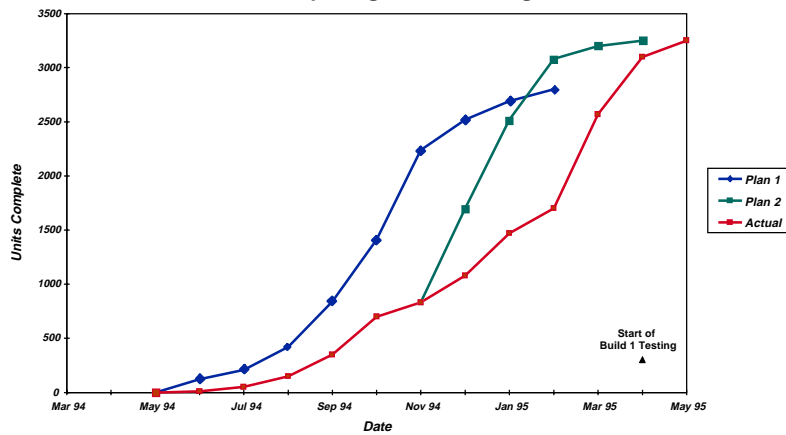# Performance Analysis Examples

Required Software Productivity
By Build
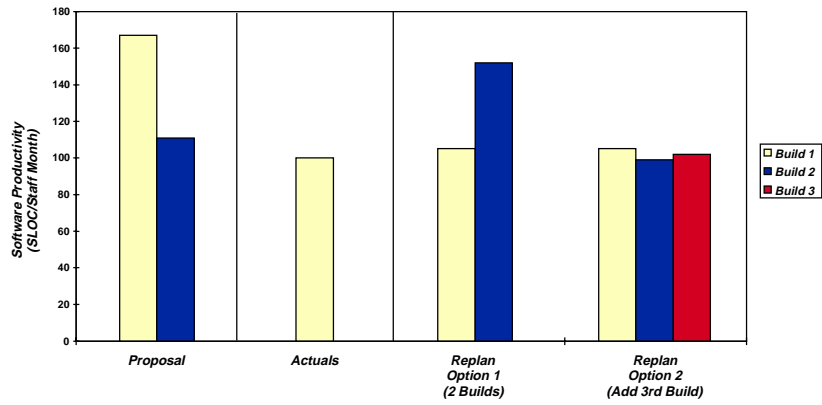
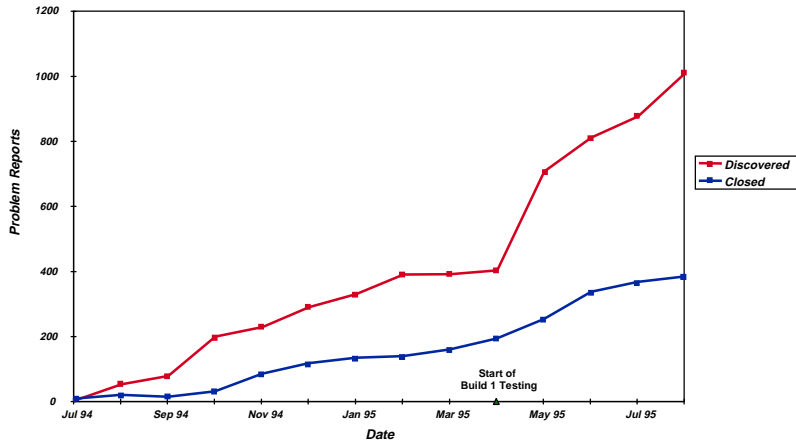# Performance Analysis Examples

Software Development Progress - Build 1
Units Completing Detailed Design
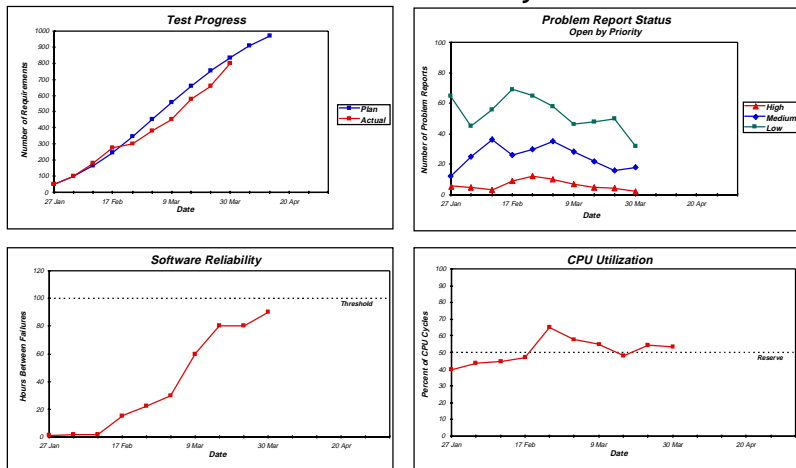
Performance Analysis Examples

Software Problem Reports
Discovery and Closure Trends - Build 1

Integrated Analysis Example

Readiness for Delivery

Performance Analysis Checklist

□ **Single Indicator Issues:**
- *Do actual trends correspond to planned trends (e.g., progress, growth, expenditures, etc.)? How big is the variance?*
- *Does the variance appear to be gradually growing each month?*
- *Are actual values exceeding planned limits (e.g., open defects, changes, resource utilization, etc.)?*
- *Are outliers or other anomalies affecting the results?*

□ **Integrated Indicator Issues:**
- *Is the source of the problem evident?*
- *Are growing problems in one area a leading indicator of other problems later in the project ?*
- *Do multiple indicators lead to similar conclusions?*
- *Does other project information contradict performance results?*

Reporting Analysis Results

□ *The Measurement Results Must be Clearly Understood by the Decision-Maker*

□ *The Results should Address:*
- *Evaluation of Project Status*
- *Specific Problems*
- *Recommendations*
- *Potential New Issues*

□ *Make Results Available Throughout the Organization*

Taking Action

> *Action Must be Taken to Realize any Benefit from Measurement!*

- *Actions May Include:*
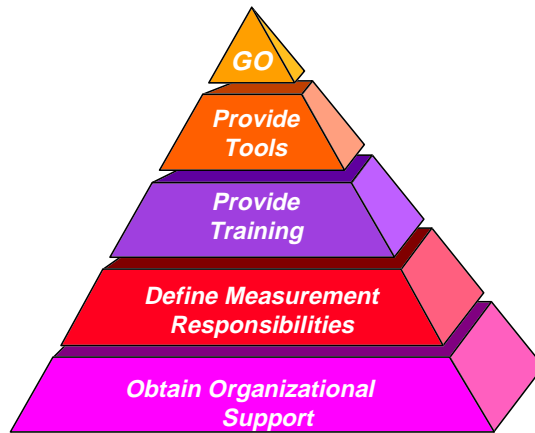 - *Extend schedule to maintain quality*
  - *Add resources to stay on schedule*
  - *Delete capabilities to control costs*
  - *Change the process to improve performance*
  - *Reallocate resources to support key activities*
- *Desired Actions May Not be Possible - May Have to Optimize Within Project Constraints*
- *Effects of Actions Should be Tracked*

Tips for Getting Started

Implementing A Measurement Process

```
            GO
       Provide
        Tools
       Provide
       Training
   Define Measurement
    Responsibilities
   Obtain Organizational
        Support
```

Obtain Organizational Support

❑ *Ensure that All Levels of the Organization Understand How Measurement Results Will be Used*

❑ *Show How Measurement Benefits each Level of the Organization*
- *Executive Manager*
- *Project Manager*
- *Measurement Analyst*
- *Development Team*

❑ *Directly Address the "Cultural" Impacts of Implementing Measurement*

Define Responsibilities

Executive Manager
- *Uses measurement results to make decisions affecting the entire organization*

Project Manager
- *Identifies and manages project issues*
- *Uses measurement results to make project decisions*

Measurement Analyst
- *Tailors measures to address project issues*
- *Collects and analyzes measurement data and reports results*

Development Team
- *Uses measurement results to guide software engineering efforts*
- *Provides measurement data*

Provide Training

- ❐ *Measurement Principles*
- ❐ *Measurement Methodology Training*
- ❐ *Measurement Technique Training (e.g., Cost Models, FPs, etc.)*
- ❐ *Exploratory Data Analysis Techniques*
- ❐ *How to Interpret Graphs (Managers)*
- ❐ *Using Quantiative Information to Make Decisions (Managers)*
- ❐ *Measurement Tool Training*

Provide Tools

- *Database, Graphing, and Reporting*
- *Schedule and Project Management*
- *Financial Management*
- *Software Analysis and Modeling*
- *Software Product Analysis*
- *Software Data Collection*
- *Office Automation*
- *Measurement "Workstations"*

Implementation Lessons Learned

Getting Started

Communicate the goals

Start small

Don't collect what you don't need

Use simple tools initially

Begin analyzing as soon as you can

Using the Results

Don't evaluate individual performance

Make measurement information accessible

Listen to 'bad news'

Don't try to influence measurement results

Pro-actively report project status

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