Practical Software and Systems Measurement

Objective Information for Decision Makers

PSM Overview

Department of Defense

US Army

Scope and Audience

- Addresses Acquisition, Development, and Maintenance of Software and System Projects
- For Project Managers, Technical Leads, and Measurement Analysts
- Limited to Measurement for Project Management Purposes

References

PSM Book

- "Practical Software Measurement: Objective Information for Decision Makers"
- J. McGarry, D. Card, C. Jones, B. Layman, E. Clark, J. Dean, F. Hall
- Addison-Wesley, Boston, 2002

Guidebook

- "Practical Software and Systems Measurement: A Foundation for Objective Project Management"
- Version 4.0b, October 2000

How Measurement Helps

- Objective Insight into Project Performance
- Objective Information to Identify and Manage Risk
- Early Detection and Resolution of Problems
- Objective Team and Organizational Communications
- Ability to Assess Organizational Performance
- Ability to Defend and Justify Decisions

Overview Outline

- PSM Approach
- Plan Measurement
- Perform Measurement
- Summary and Resources

PSM Approach

PSM Key Concepts

- Measurement Is a Process - Not a Pre-Defined List of Graphs or Reports
- Both Data Collection and Analysis Must Be Planned
- PSM Is Flexible - Adapted to Meet Specific Project Information Needs
- PSM Supports the Integrated Information Needs of Both Acquirer and Supplier Organizations
- PSM Addresses the Relationships and Tradeoffs Between Project Objectives

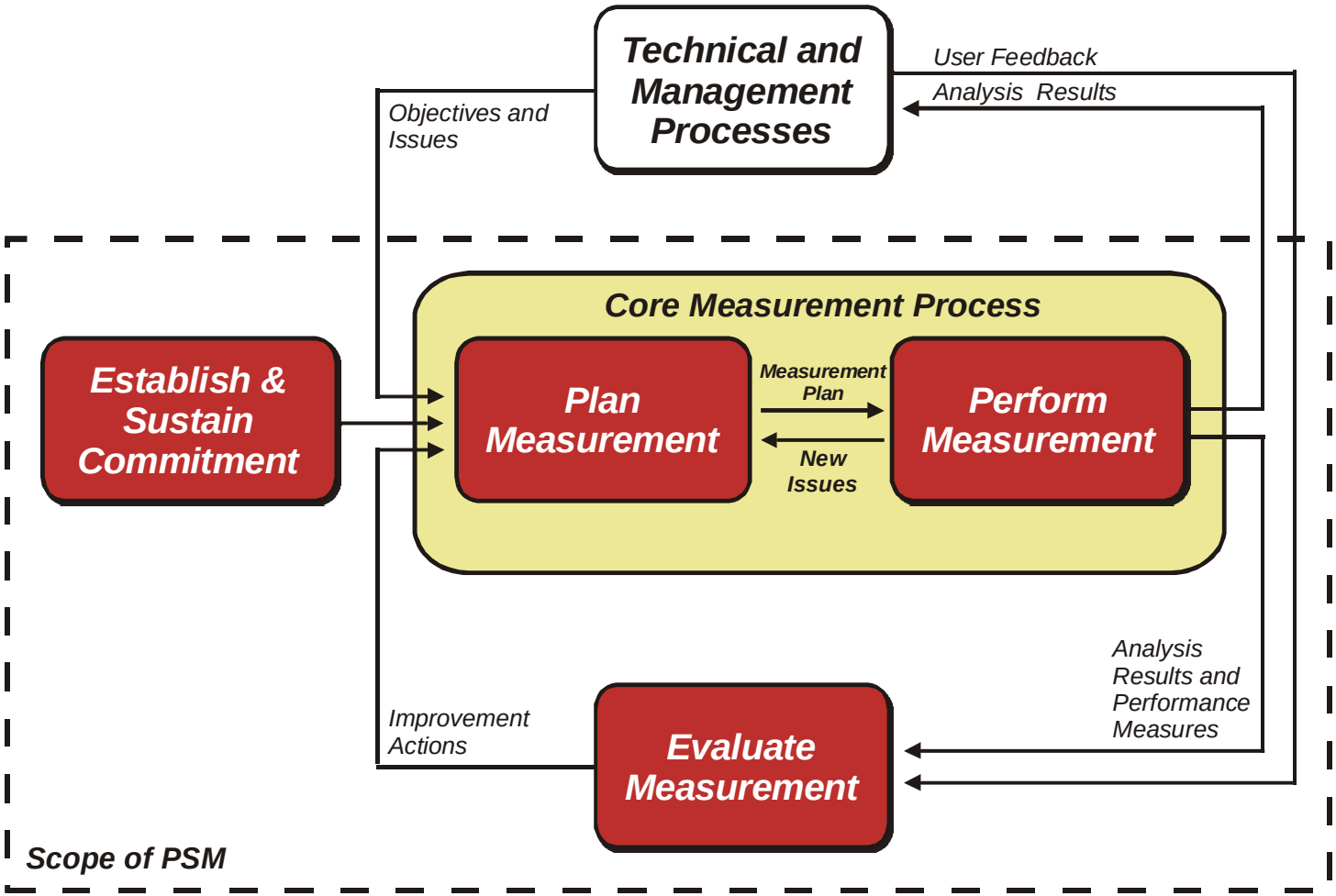
Measurement Principles

- Use Information Needs and Objectives to Drive the Measurement Requirements
- Define and Collect Measures Based on the Technical and Management Processes
- Collect and Analyze Data at a Level of Detail Sufficient to Identify and Isolate Problems
- Implement an Independent Analysis Capability

Measurement Principles (continued)

- Use a Systematic Analysis Process to Trace the Measures to the Decisions
- Interpret the Measurement Results in the Context of Other Project Information
- Integrate Measurement into the Project Management Process Throughout the Life Cycle
- Use the Measurement Process as a Basis for Objective Communications
- Focus Initially on Project-Level Analysis

Measurement Activities



PSM Approach Summary

- Measurement Must Address the Specific Information Needs of Each Unique Project
- The PSM Principles Define an Effective Measurement Process
- PSM Can Be Applied to All Projects
- PSM Is Based on Actual Experience from DoD, Government, and Industry Programs

Plan Measurement

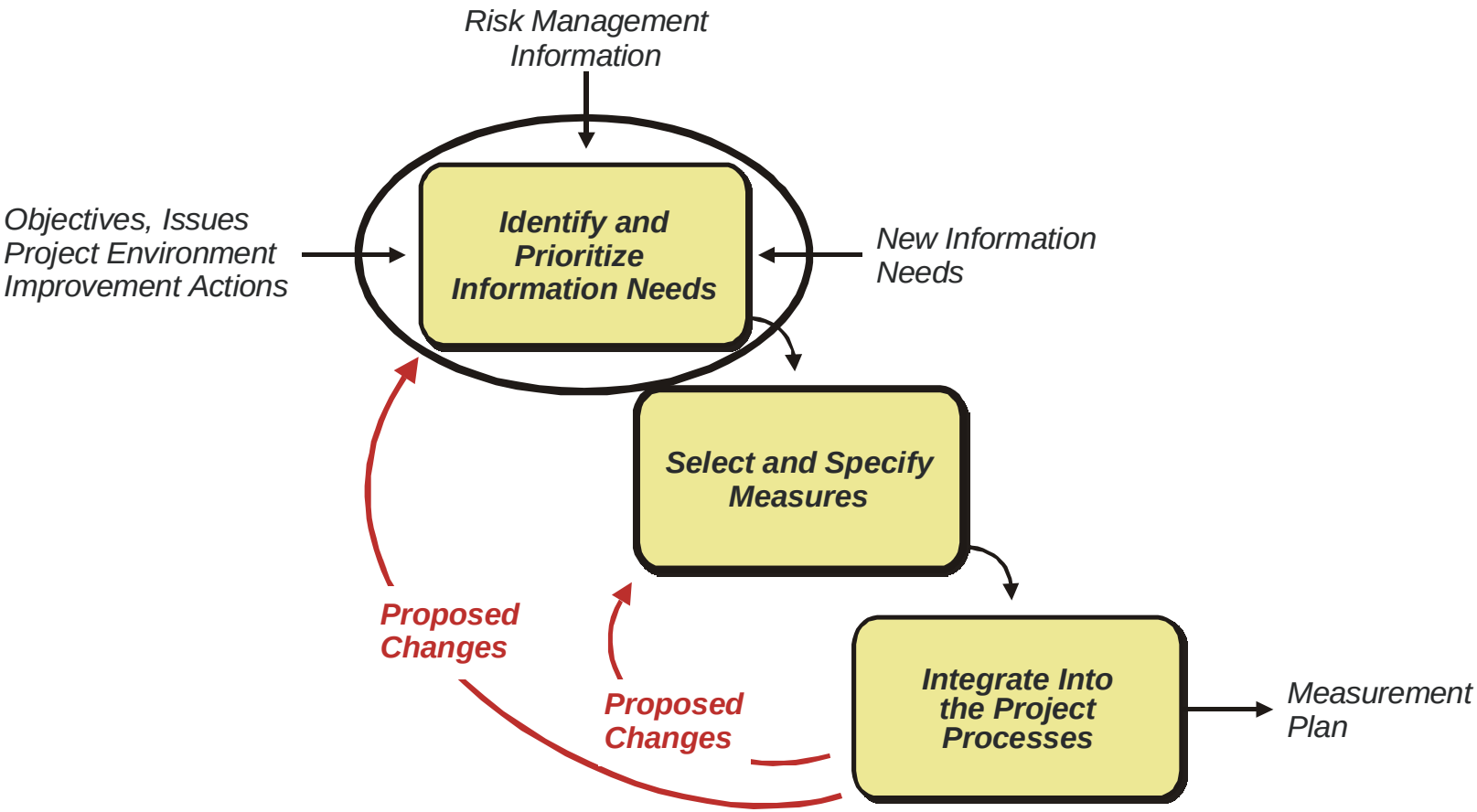
Plan Measurement - Key Concepts

- Each Project Is Described by a Unique Set of Information Needs
- Unique Project Information Needs Usually Can Be Grouped into Seven Common "Information Categories"
- The Project Information Needs Drive the Selection of Measures
- The Measurement Definitions and Methods Are Determined by the Project Processes

Information Needs

- Objective - A Project Goal or Requirement
- Obstacle - An Area of Concern that Could Impact the Achievement of an Objective
  - Risk - concern that may occur
  - Problem - concern that has occurred
  - Lack of Information - inadequate data

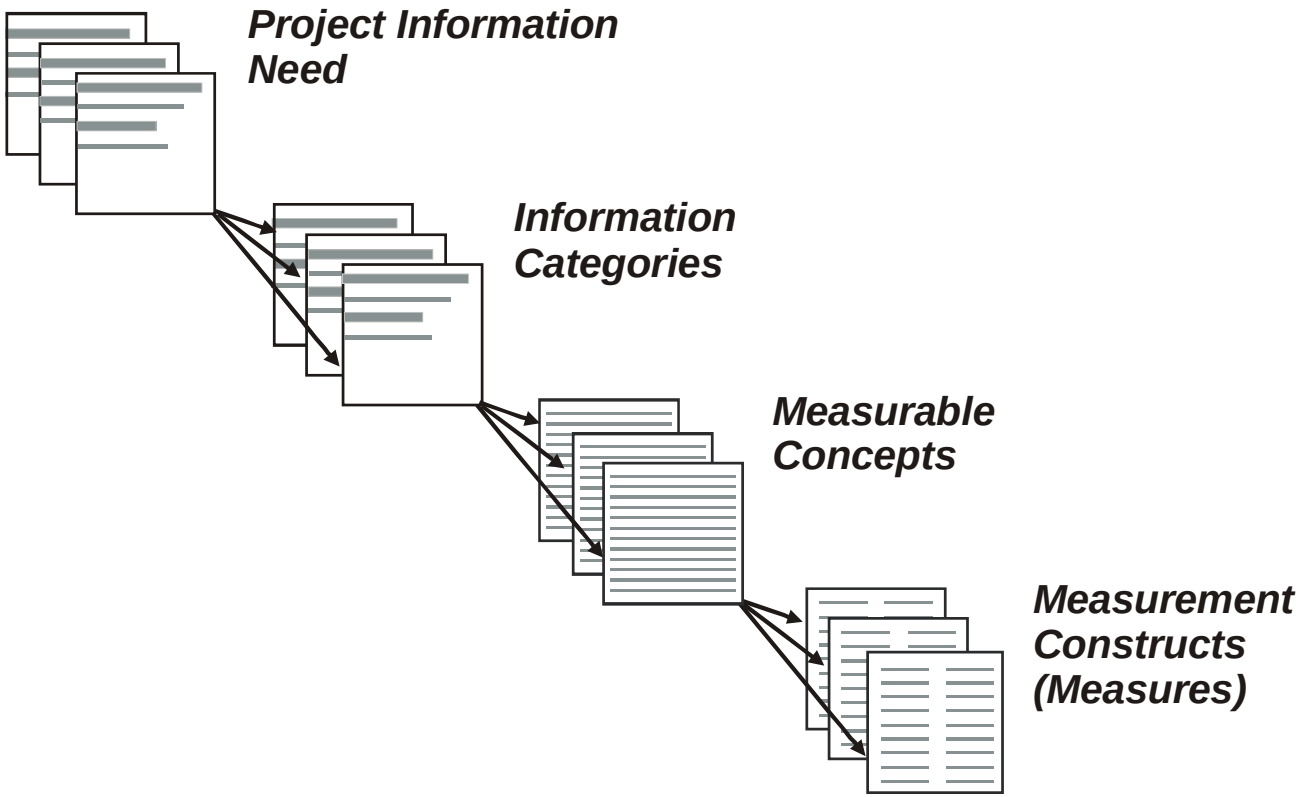
Plan Measurement



Sources for Defining and Prioritizing Project Information Needs

- Risk Analysis Results
- Project Constraints and Objectives
- Leveraged Technologies
- Product Acceptance Criteria
- External Requirements
- Experience
- Planned-Decision Points

PSM Measurement Hierarchy



Information Categories

- Schedule and Progress
- Resources and Cost
- Product Size and Stability
- Product Quality
- Process Performance
- Technology Effectiveness
- Customer Satisfaction

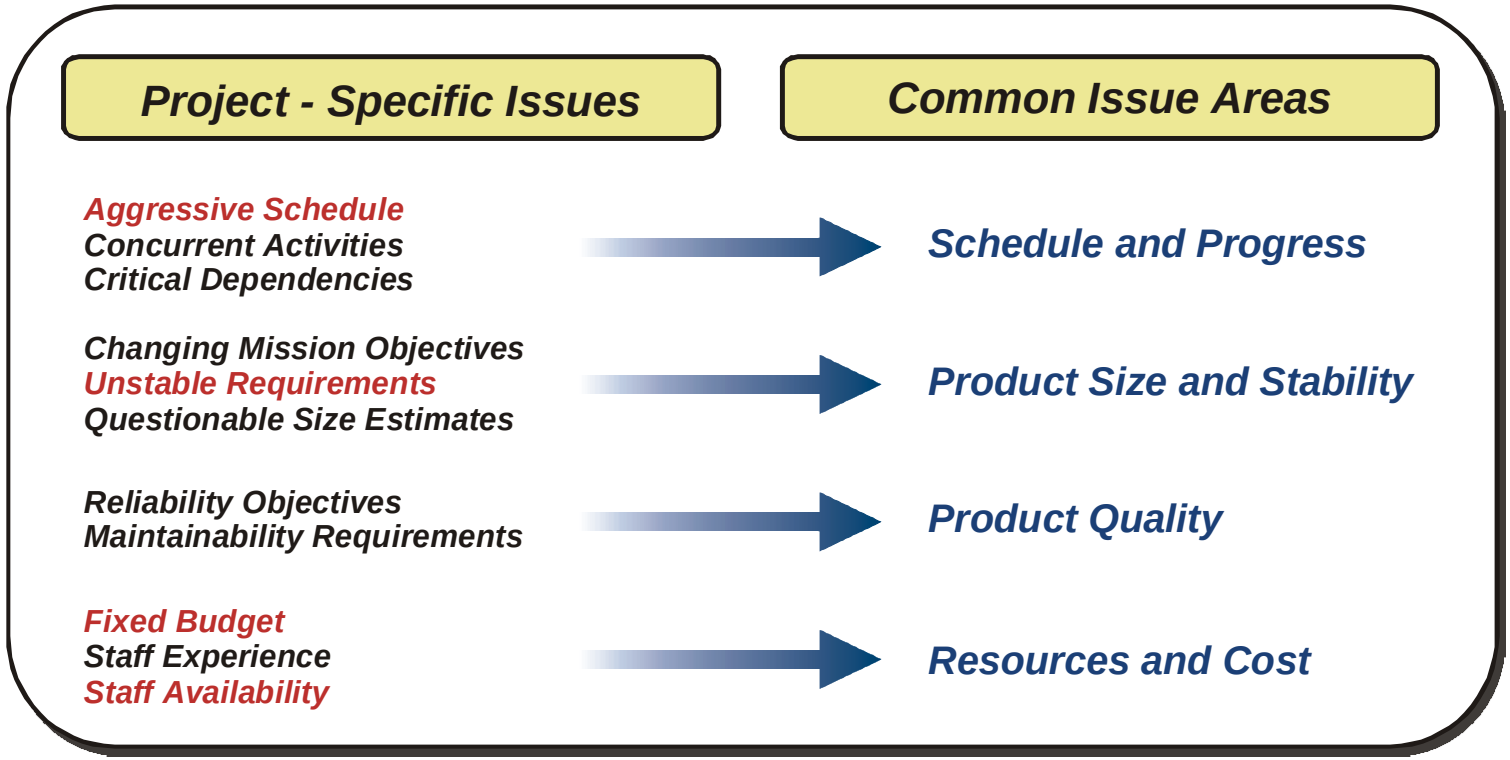
PSM Mapping of Information Categories, Concepts, and Measures

Information Category - Measurable Concept - Measure		
Information Categories	**Measurable Concepts**	**Prospective Measures**
Schedule and Progress	Milestone Completion	Milestone Dates
	Critical Path Performance	Slack Time
	Work Unit Progress	Requirements Traced Requirements Tested Problem Reports Opened Problem Reports Closed Reviews Completed Change Requests Opened Change Requests Resolved Units Designed Units Coded Units Integrated Test Cases Attempted Test Cases Passed Action Items Opened Action Items Completed
	Incremental Capability	Components Integrated Functionality Integrated
Resources and Cost	Personnel Effort	Staff Level Development Effort Experience Level Staff Turnover
	Financial Performance	BCWS, BCWP, ACWP Budget Cost
	Environment and Support Resources	Quantity Needed Quantity Available Time Available Time Used
Product Size and Stability	Physical Size and Stability	Database Size Components Interfaces Lines of Code
	Functional Size and Stability	Requirements Functional Changes Function Points

PSM Mapping of Information Categories, Concepts, and Measures (continued)

Information - Category - Measure Mapping		
Information Categories	**Measurable Concepts**	**Prospective Measures**
Product Quality	Functional Correctness	Defects Age of Defects Technical Performance Level
	Supportability-Maintainability	Time to Restore Cyclomatic Complexity
	Efficiency	Utilization Throughput Response Time
	Portability	Standards Compliance
	Usability	Operator Errors
	Dependability-Reliability	Mean Time to Failure
Process Performance	Process Compliance	Reference Maturity Rating Process Audit Findings
	Process Efficiency	Productivity Cycle Time
	Process Effectiveness	Defects Contained Defects Escaping Rework Effort Rework Components
Technology Effectiveness	Technology Suitability Technology Volatility	Requirements Coverage Baseline Changes
Customer Satisfaction	Customer Feedback	Satisfaction Ratings Award Fee
	Customer Support	Requests for Support Support Time

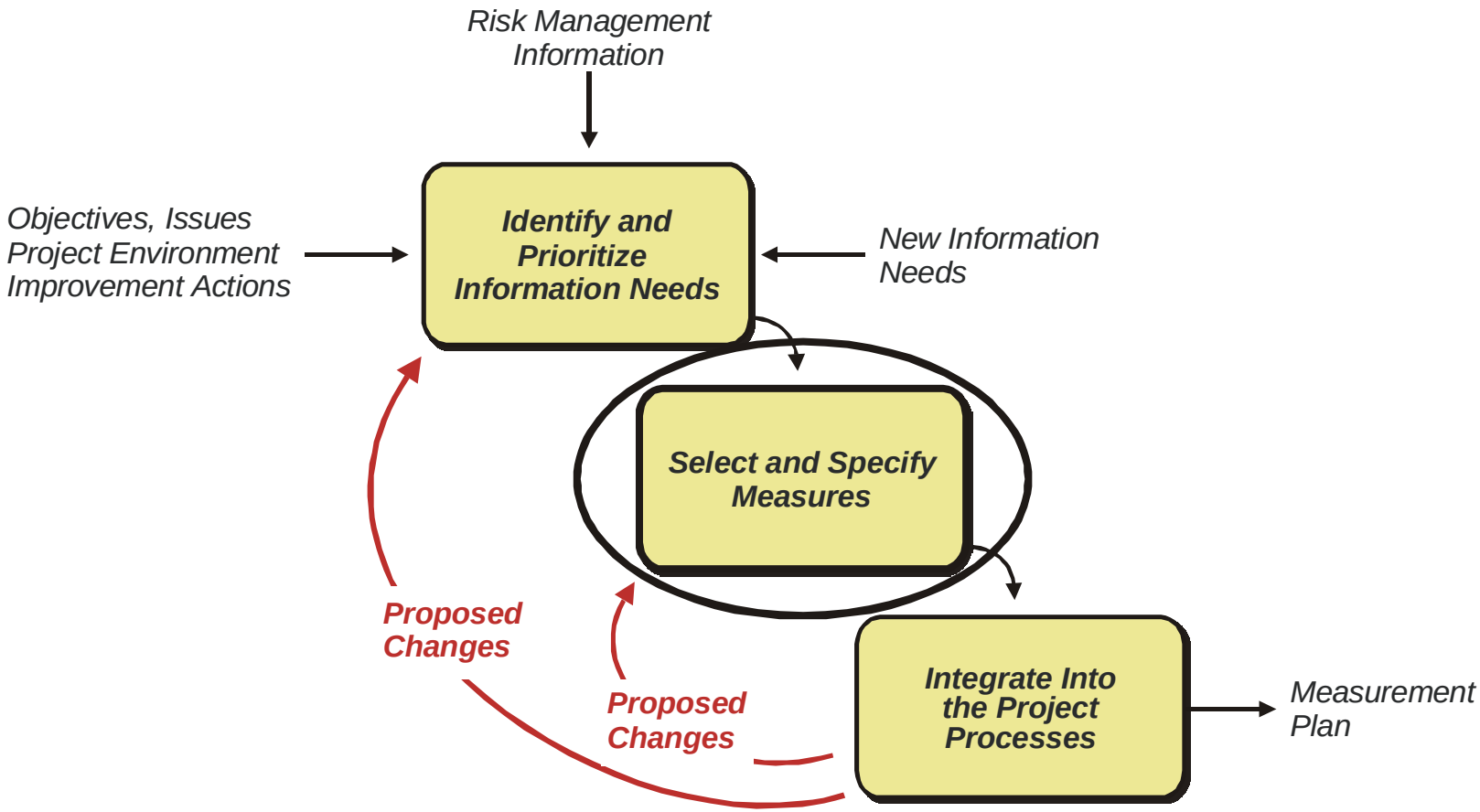
Example of Mapping Project Information Needs



Prioritize Information Needs

- Rank Information Needs Based on Priority at the Current Time
- Ranking May Be Set Through a Measurement Planning Workshop With Participant Consensus
  - Involve acquirer, supplier, PM, test, SW, etc.
- Priorities May Change in Each Phase as Different Issues Arise
  - Measurement program needs to be revised when this occurs

Plan Measurement



Characterize Project Context

- Application Domain
- Life-Cycle Model or Activity Structure
- Product Structure
- Current Measurement Activities
- System and Software Processes and Technology
- Planned Sources of Components (e.g. new, reused, COTS)
- Process Maturity

Information Categories - Measurable Concepts

Schedule and Progress
- Milestone Completion
- Critical Path Performance
- Work Unit Progress
- Incremental Capability

Product Size and Stability
- Physical Size and Stability
- Functional Size and Stability

Product Quality
- Functional Correctness
- Supportability* - Maintainability
- Efficiency
- Portability
- Usability
- Dependability* - Reliability

Resources and Cost
- Personnel Effort
- Financial Performance
- Environment and Support Resources

Process Performance
- Process Compliance
- Process Efficiency
- Process Effectiveness

Technology Effectiveness
- Technology Suitability
- Technology Volatility

Customer Satisfaction
- Customer Feedback
- Customer Support

*Systems Engineering

Measurable Concept

- An Idea About How an Information Need Can Be Satisfied:
  - Possible entities and attributes to be measured
  - Potential use of results in decision making
- May Be Implemented in Many Different Ways
- Each Measurable Concept Involves a Different Question
- PSM-Defined Measurable Concepts Are Widely Used

Entity - Attribute

Entities and Attributes are the basic elements of a measure.

- An **Entity** is the object that is measured
  - Entities include processes, products, projects, and resources
- A Measurable **Attribute** is a distinguishable property or characteristic of the Entity
  - Attributes are either quantitative or qualitative - examples include hours, problems, source lines of code, and design units, e.g. classes

Concepts Relate to Key Questions

Information Category	Measurable Concept	Questions Addressed
Schedule and Progress	Milestone Completion	Is the project meeting scheduled milestones? Are critical tasks or delivery dates slipping?
	Work Unit Progress	How are specific activities and products progressing?
	Incremental Capability	Is capability being delivered as scheduled in incremental builds and releases?
Resources and Cost	Personnel Effort	Is effort being expended according to plan? Is there enough staff with the required skills?
	Financial Performance	Is project spending meeting budget and schedule objectives?
	Environment and Support Resources	Are needed facilities, equipment, and materials available?
Product Size and Stability	Physical Size and Stability	How much are the product's size, content, physical characteristics, or interfaces changing?
	Functional Size and Stability	How much are the requirements and associated functionality changing?
Product Quality	Functional Correctness	Is the product good enough for delivery to the user? Are identified problems being resolved?
	Supportability - Maintainability	How much maintenance does the system require? How difficult is it to maintain?
	Efficiency	Does the target system make efficient use of system resources?
	Portability	To what extent can the functionality be re-hosted on different platforms?
	Usability	Is the user interface adequate and appropriate for operations? Are operator errors within acceptable bounds?
	Dependability - Reliability	How often is service to users interrupted? Are failure rates within acceptable bounds?

Concepts Relate to Key Questions (continued)

Information Category	Measurable Concept	Questions Addressed
Process Performance	Process Compliance	How consistently does the project implement the defined processes?
	Process Efficiency	Are the processes efficient enough to meet current commitments and planned objectives?
	Process Effectiveness	How much additional effort is being expended due to rework?
Technology Effectiveness	Technology Suitability	Can technology meet all allocated requirements, or will additional technology be needed?
	Technology Volatility	Does new technology pose a risk due to too many changes?
Customer Satisfaction	Customer Feedback	How do our customers perceive the performance on this project? Is the project meeting user expectations?
	Customer Support	How quickly are customer support requests being addressed?

Criteria for Selecting Prospective Measures

- Match with Information Need
- Measurement Effectiveness
- Nature of the Entities (i.e., processes and products) to Be Measured
- Cost and Availability of Data
- Life-Cycle Coverage
- External Data Requirements

Selecting Measures

Schedule and Progress

- Milestone completion
- Critical path performance
- Work unit progress
- Incremental Capability

Prospective Measures

- Requirements traced
- Requirements tested
- Requirements status
- Problem reports opened
- Problem reports closed
- Reviews completed
- Change requests opened
- Change requests resolved
- Units designed
- Units coded
- Units integrated
- Test cases attempted
- Test cases passed
- Action item opened
- Action item completed

Measurement Construct

- *A Specification of a Prospective Measure*
- *A Specific Method for Implementing a Measurable Concept:*
  - *Specific entities and attributes*
  - *Pre-planned analyses*
- *Consists of Base Measures, Derived Measures, and Indicators*
- *The Information Product Is Comprised of a Collection of Measurement Constructs with Interpretations*
- *Multiple Constructs May Be Specified for a Single Concept and Information Need*

Specify Measurement Constructs

- Information Need
- Information Category
- Indicator
  - Analysis Model
  - Decision Criteria
  - Base/Derived Measures
- Derived Measure(s)

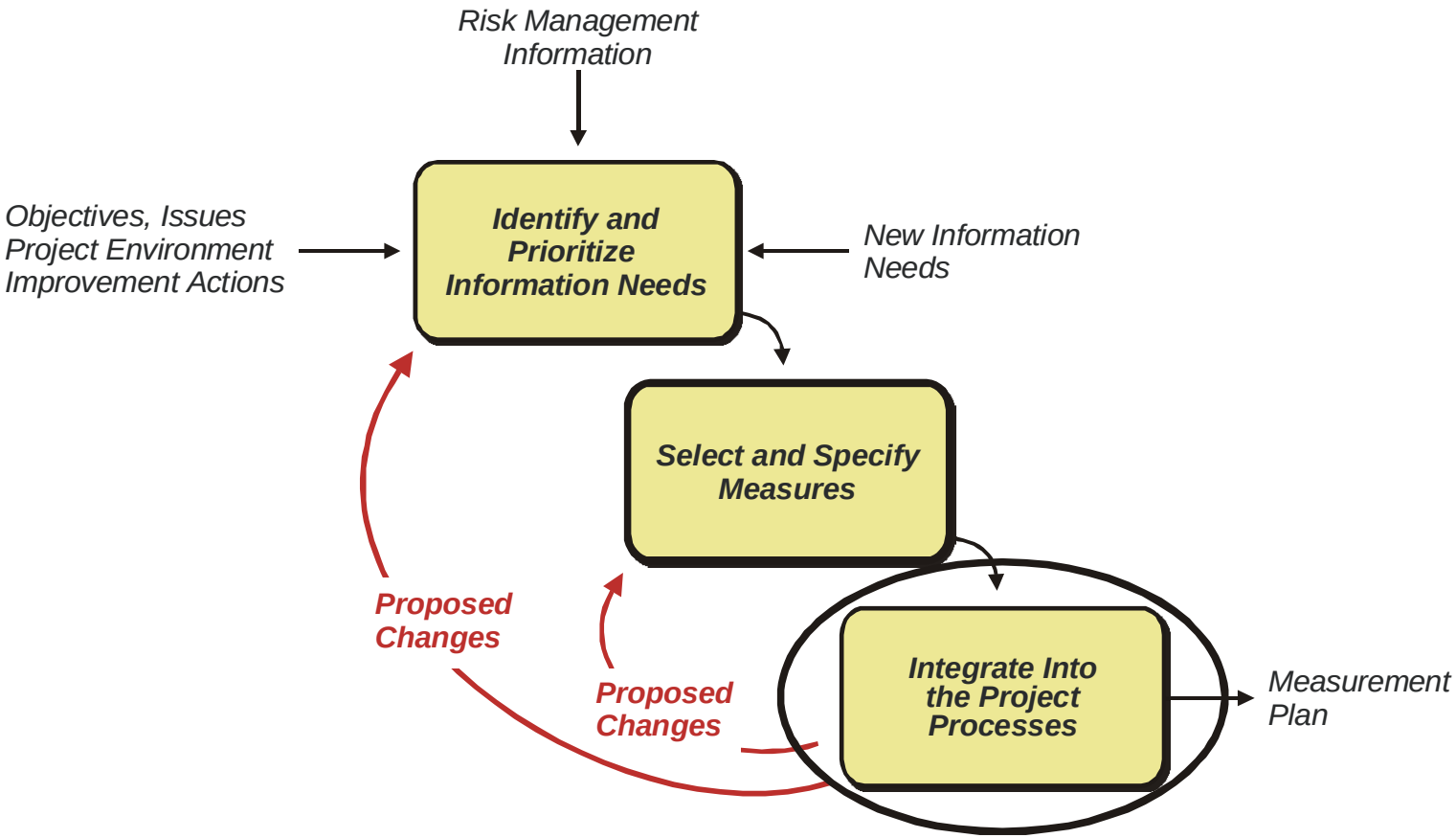
NOTE: details will be defined in the next section, Measurement Information Model

- For Each Derived Measure:
  - Measurement Function
  - Base Measure(s)
- For Each Base Measure:
  - Measurement Method
  - Type of Method
  - Scale
  - Type of Scale
  - Unit of Measurement
  - Relevant Entity
  - Attribute

Measurement Construct Examples

- Four Major Components:
  - Description
  - Specification table
  - Additional analysis guidance
  - Implementation considerations
- Last Two Components Used in Developing Measurement Procedures
- See Appendix A of the PSM Book
- Similar Information Is Contained in the PSM Guidebook, Version 4.0b, Parts 3 and 5

Plan Measurement



Identify Measurement Opportunities

- **Take Advantage of Existing Tools and Measurement Activities:**
  - Problem report databases
  - Configuration management systems
  - Project cost and schedule control systems
  - Design tools
- **Consider Three Types of Data:**
  - Historical results (previous projects)
  - Planning information
  - Actual performance

Develop Measurement Procedures

- Define the Specific Operations, Tools, and Responsibilities for Measurement Activities
- Address Both:
  - Data collection and storage
  - Data analysis and reporting
- Further Considerations Are Discussed in the Perform Measurement Section

Document Measurement Plan

- Purposes of Plan Include:
  - Integrate analysis and reporting into decision-making processes
  - Integrate data collection into data-generating processes
  - Provide a central source for definitions of measures and analyses
- Establish a Concise Working Document Subject to Change

Measurement Plan Content

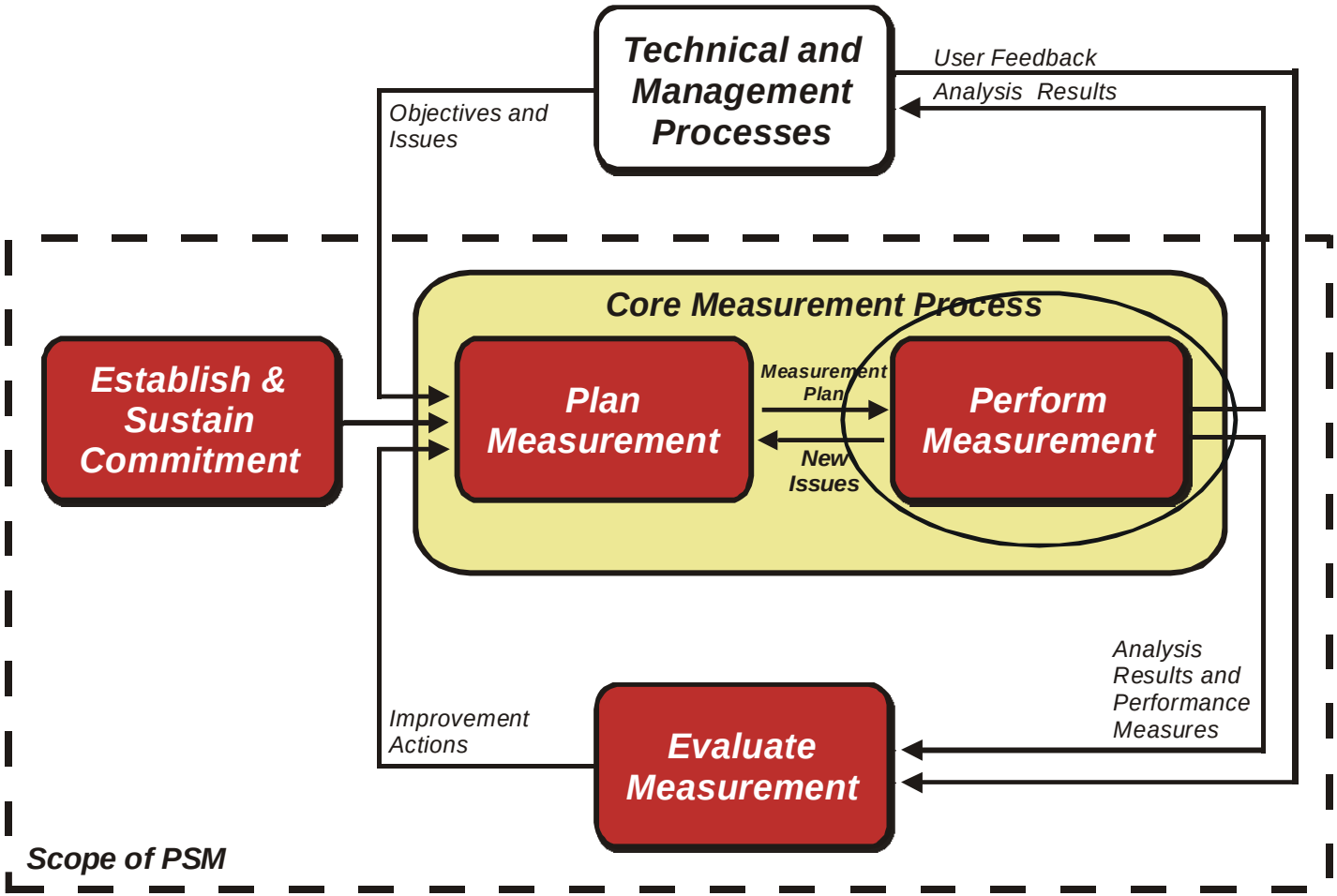
- Introduction
- Project Description
- Measurement Roles, Responsibilities, and Communications
- Description of Project Information Needs
- Definition of Measurement Constructs
- Project Aggregation (Roll-Up) Structures
- Data Collection and Analysis Procedures
- Measurement Evaluation Criteria

Plan Measurement Summary

- The Planning Activity Is Dynamic - Project Information Needs and Processes Are Always Changing
- Success Depends on the Integration of the Measurement Process into the Project Processes
- An Effective Measurement Process Is Designed to Meet the Information Needs of Both Supplier and Acquirer Organizations
- PSM Provides a Systematic Approach for Planning a Measurement Process

Perform Measurement

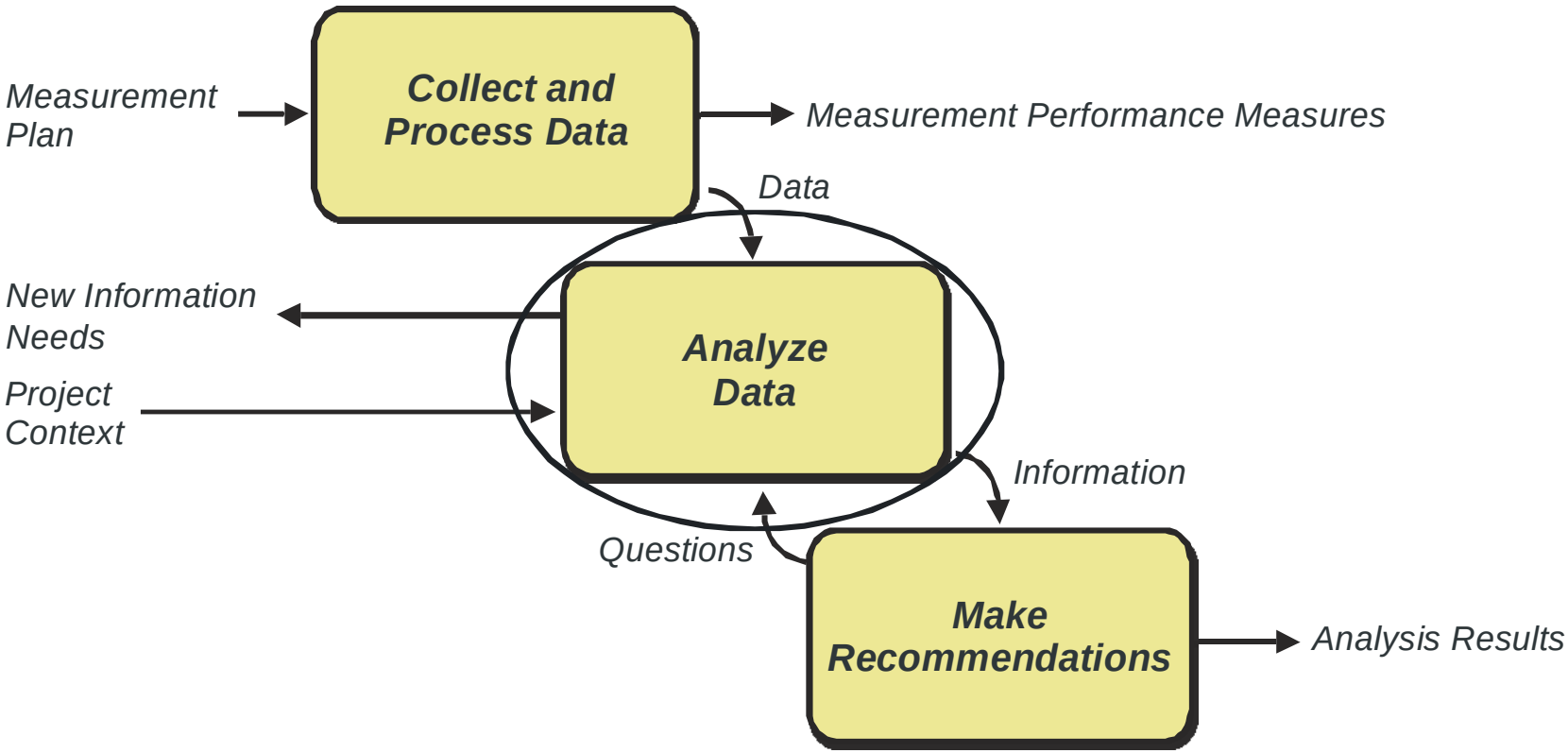
Measurement Activities



Perform Measurement - Key Concepts

- This Activity Provides a Systematic Method for Converting Data into Usable Information
- Like Planning, Performing Must Be Flexible to Adapt to Changing Information Needs
- Analysis Is the Primary Task of This Activity - It Includes Estimating, Assessing Feasibility of Plans, and Tracking Performance Against Plans

Perform Measurement



Analyze Data

- **Indicators Are Systematically Generated, Analyzed, Interpreted, and Reported to:**
  - Produce an assessment relative to known Information Needs
  - Identify new Information Needs (problems, risks, lack of information)

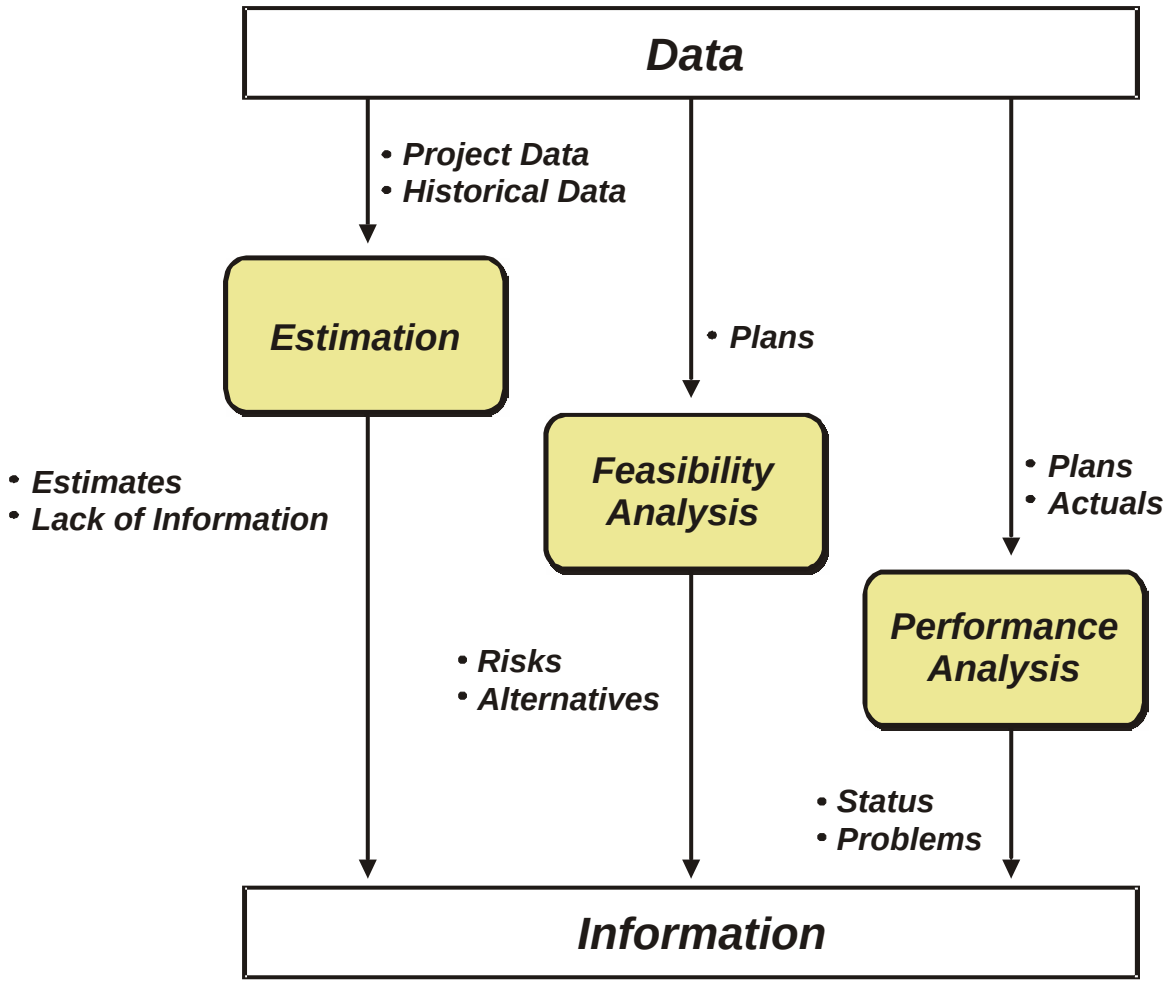
Generate Indicators

- *"Standard" Indicators:*
  - *Pre-defined in measurement plan*
  - *Produced regularly*
  - *May be organized into "sets"*
- *"Special" Indicators:*
  - *Usually created as needed*
  - *May be decompositions of indicators to localize problems*
  - *May be new indicators that respond to new questions*

Generating Useful Indicators

- Use Consistent Conventions
- Keep It Simple; Keep the Message Clear
- Unique Titles Should Reflect 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 Analysis



Estimation Analysis

- Conducted to Establish Target Values or Numerical Expectations for Subsequent Activities and Parameters, Based on Currently Available Data
- Employs Special Types of Indicators (estimators), Adjusted by Performance Factors
- Predicts Values Such as:
  - Product size
  - Effort
  - Schedule
  - Quality

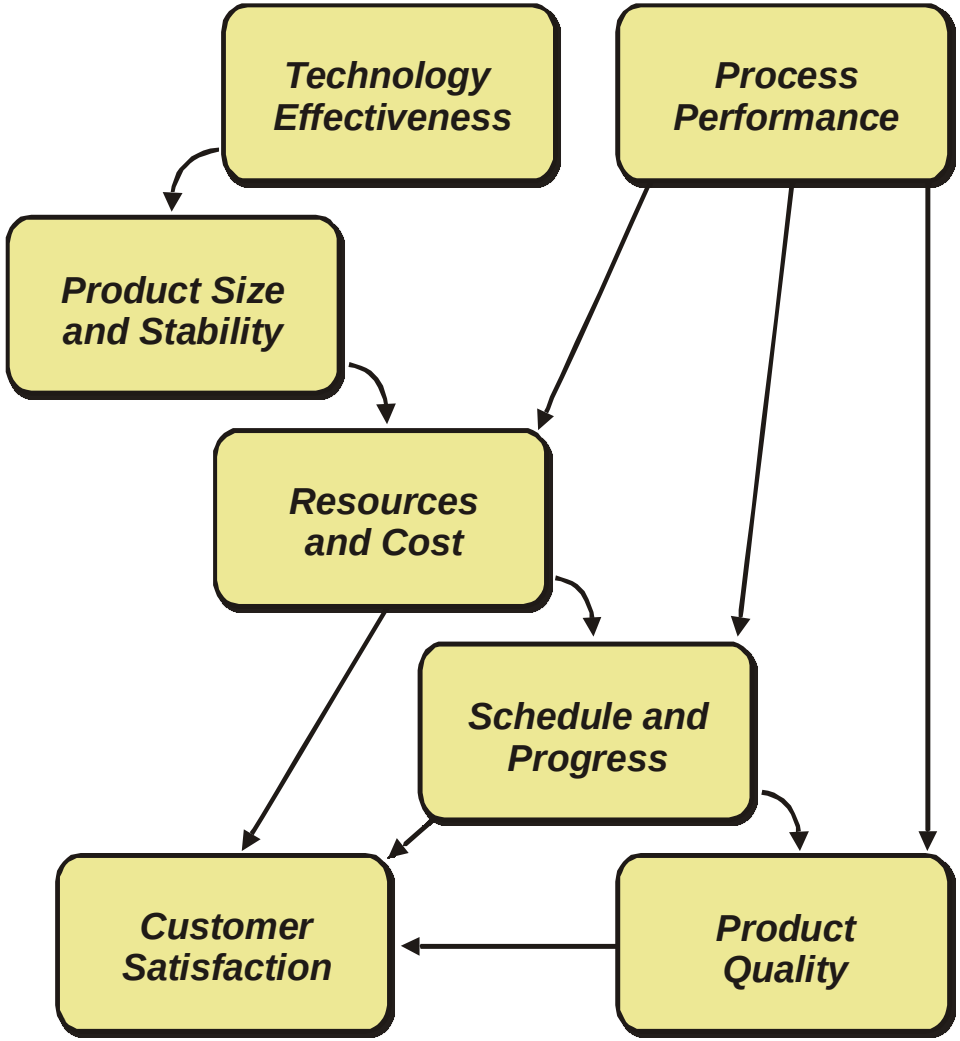
Feasibility Analysis

- Conducted to Determine Whether Plans and Targets Are Realistic and Achievable
- Conducted During the Initial Planning Activity and at All Subsequent Replans
- Looks at:
  - Basis for estimate
  - Realism of adjustments
  - Confidence in process
  - Changes in assumptions or environment
  - Comparisons of project parameters

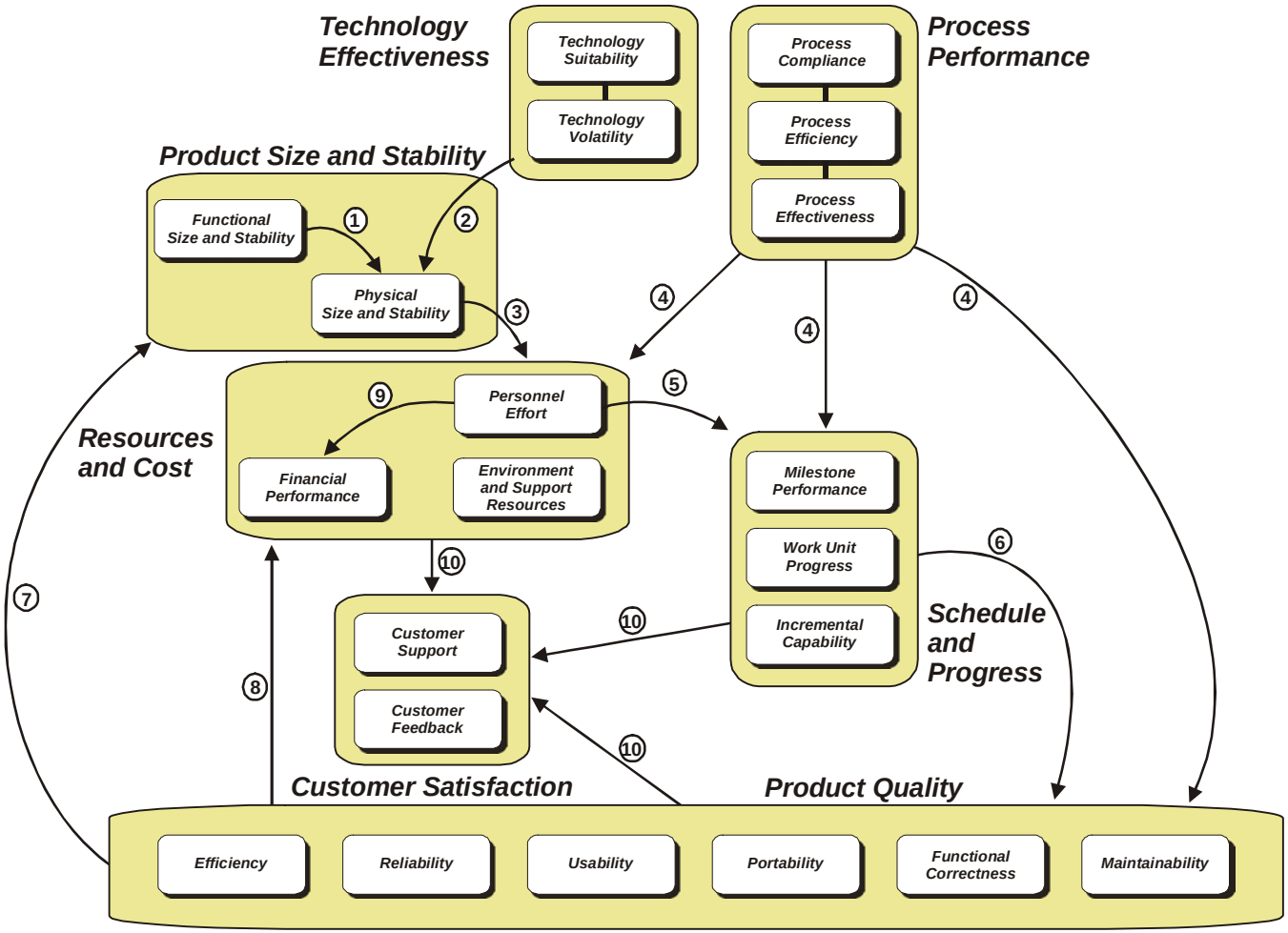
Performance Analysis

- Conducted to Determine Whether Development is Meeting the Plans, Assumptions, and Targets
- Conducted Periodically Once a Project has Committed to a Plan
- Looks at:
  - Leading indicators
  - Critical path items
  - Inconsistent trends

PSM Analysis Model



Details of the PSM Analysis Model

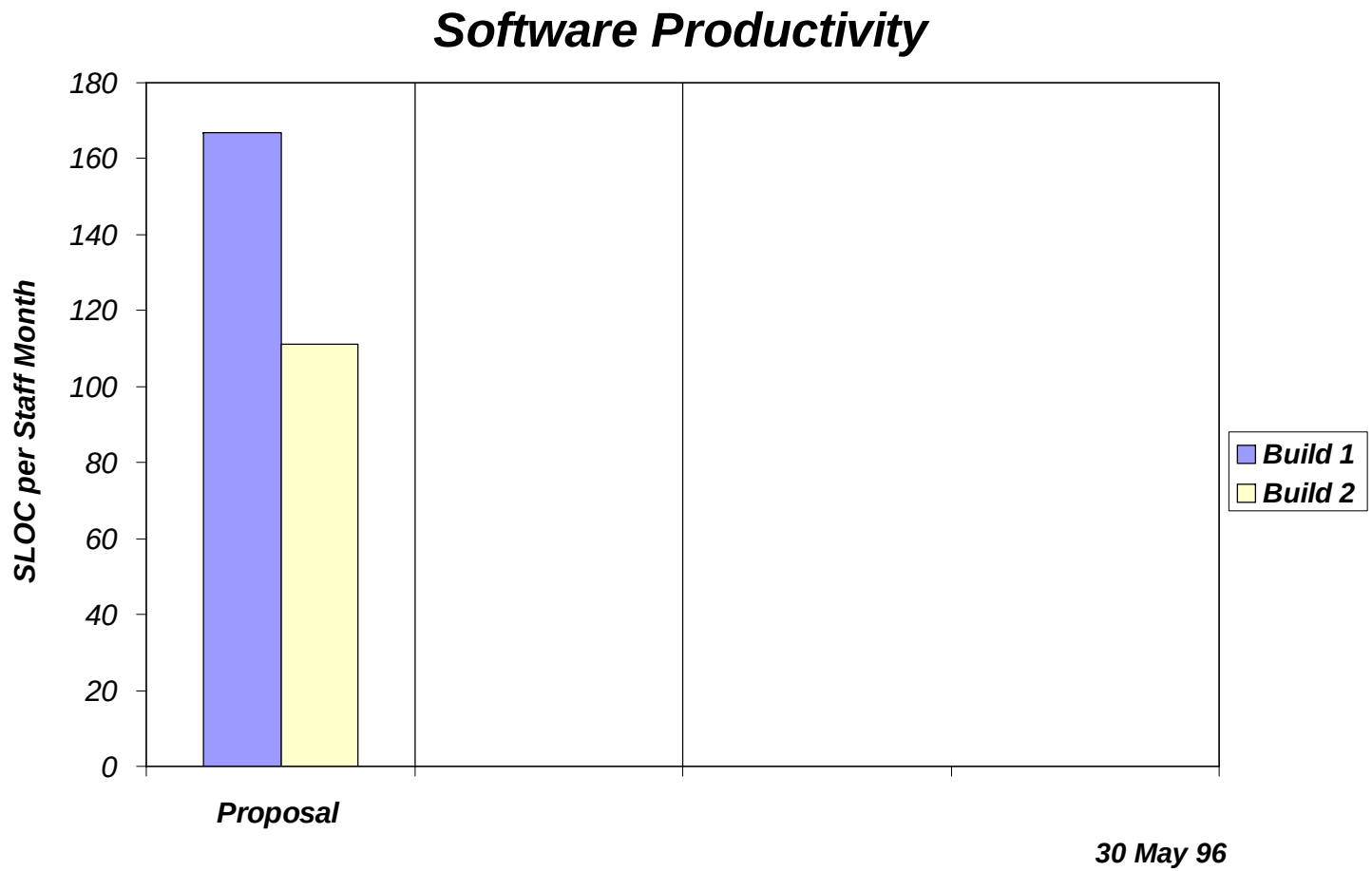


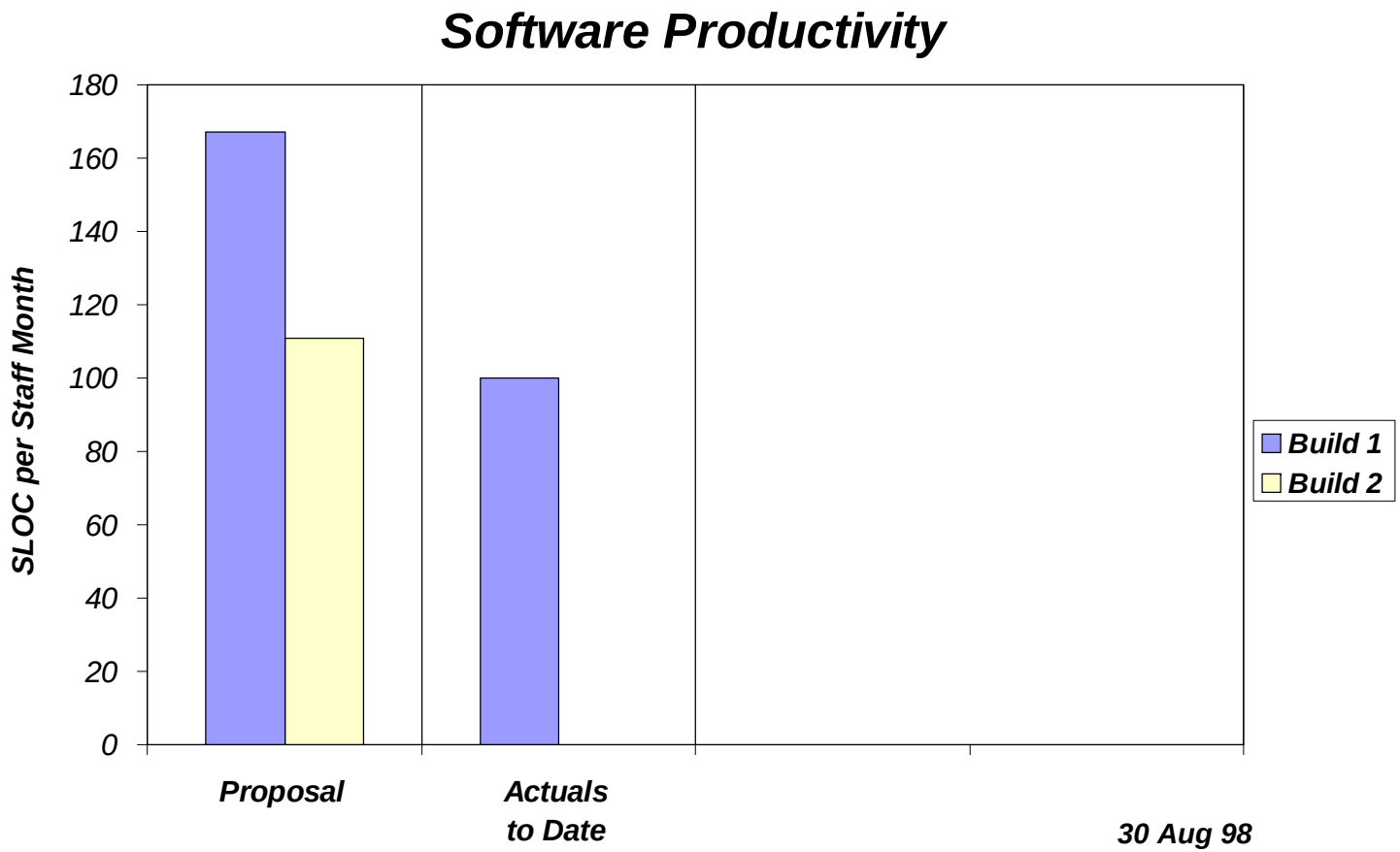
Using the PSM Analysis Model for Performance Analysis

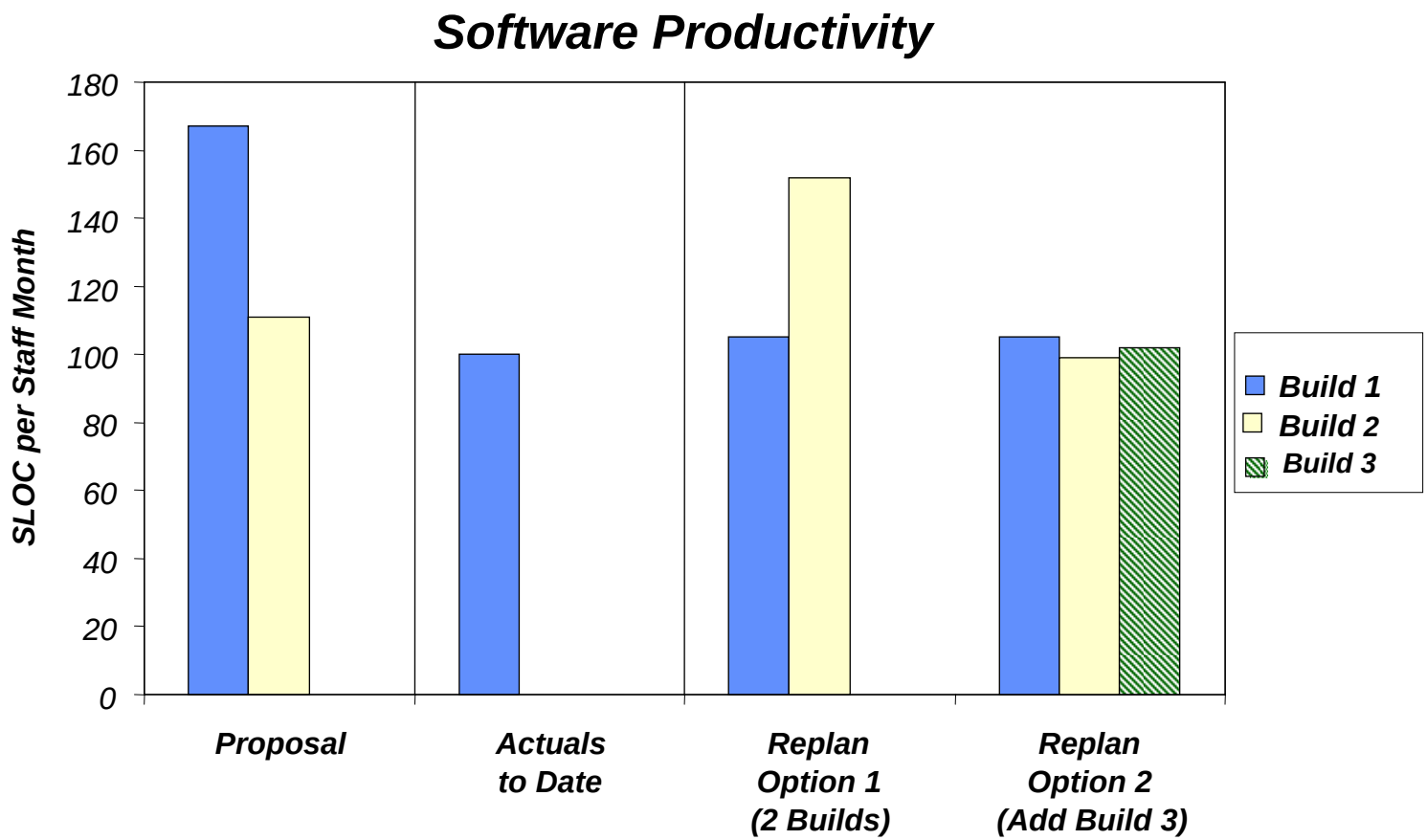
- Relates Information Categories in Terms of Cause and Effect
- Helps Address the Difficult Management Questions:
  - Is there really a problem?
  - What is causing the risk?
  - What are the related Information Needs?
  - What corrective action should be taken?
- Requires Multiple Measures - Indicators

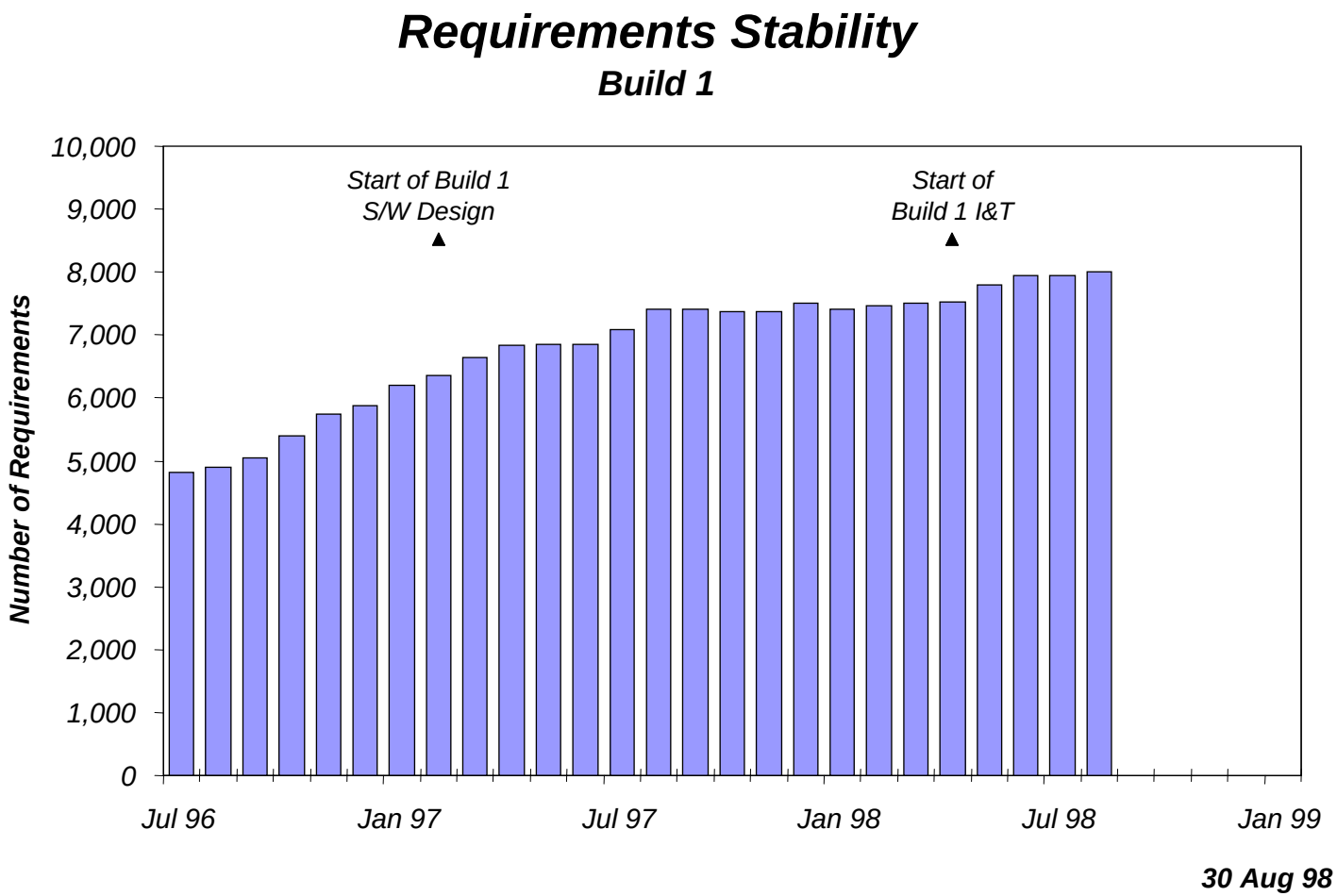
Performance Analysis Example

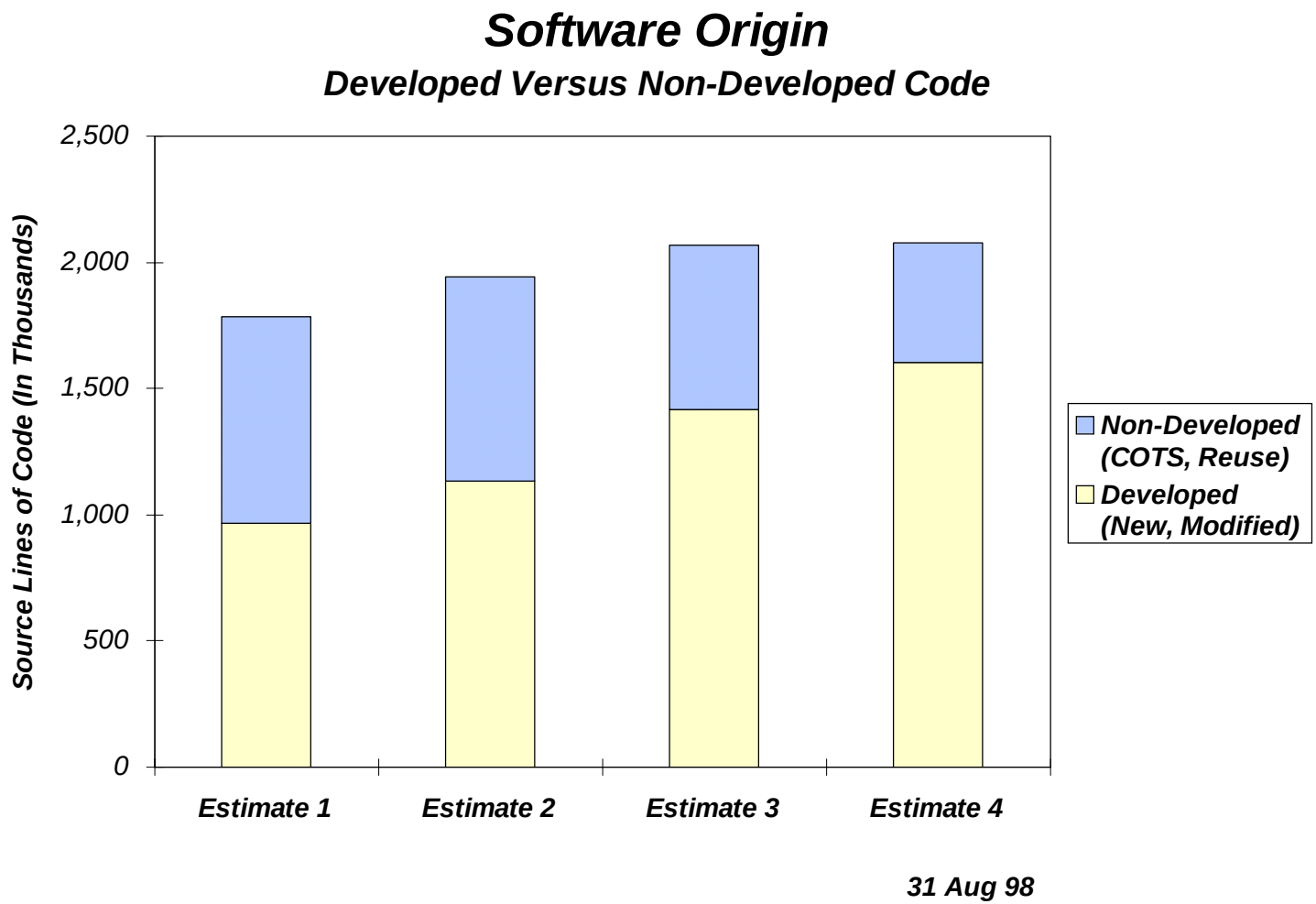
- Real-Time System
- 2M + Source Lines of Code
- Multiple Suppliers
- Average Software Process Maturity
- New and Non-Developed Code (COTS/Reuse)
- Incremental Development Approach
- Key Issues and Objectives:
  - Meet platform deployment schedule
  - High product quality (reliability)
  - Successfully implement new technology

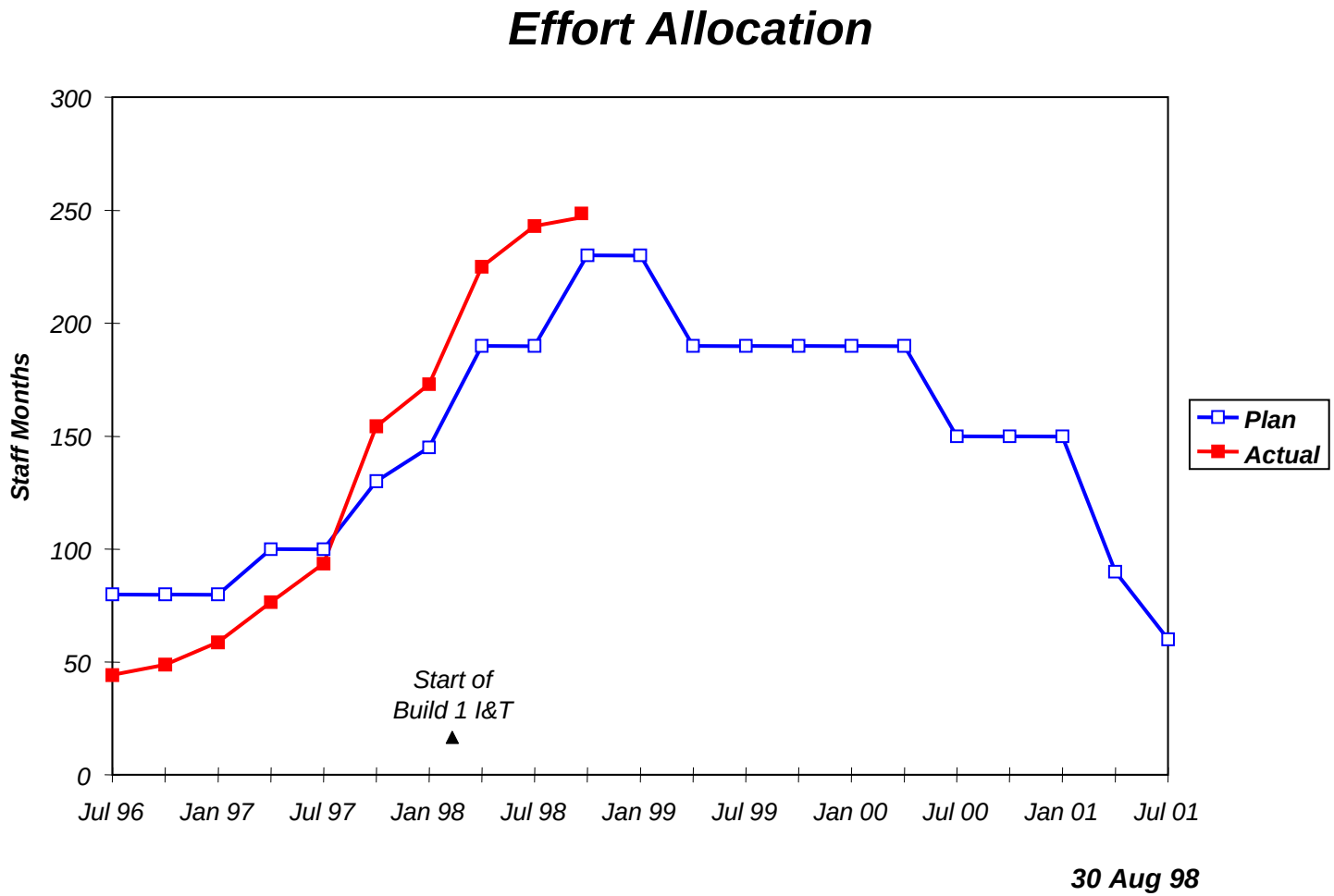


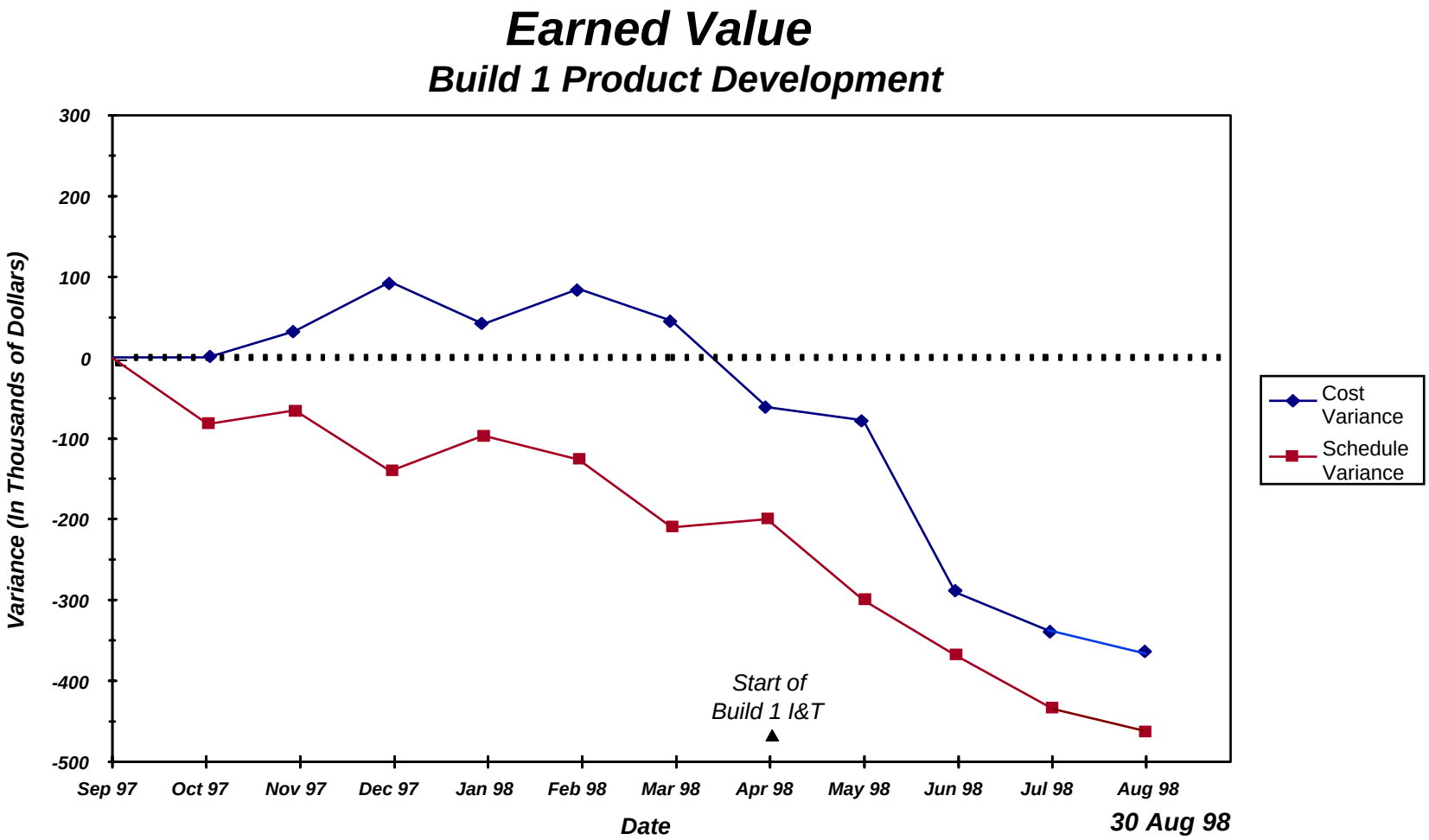


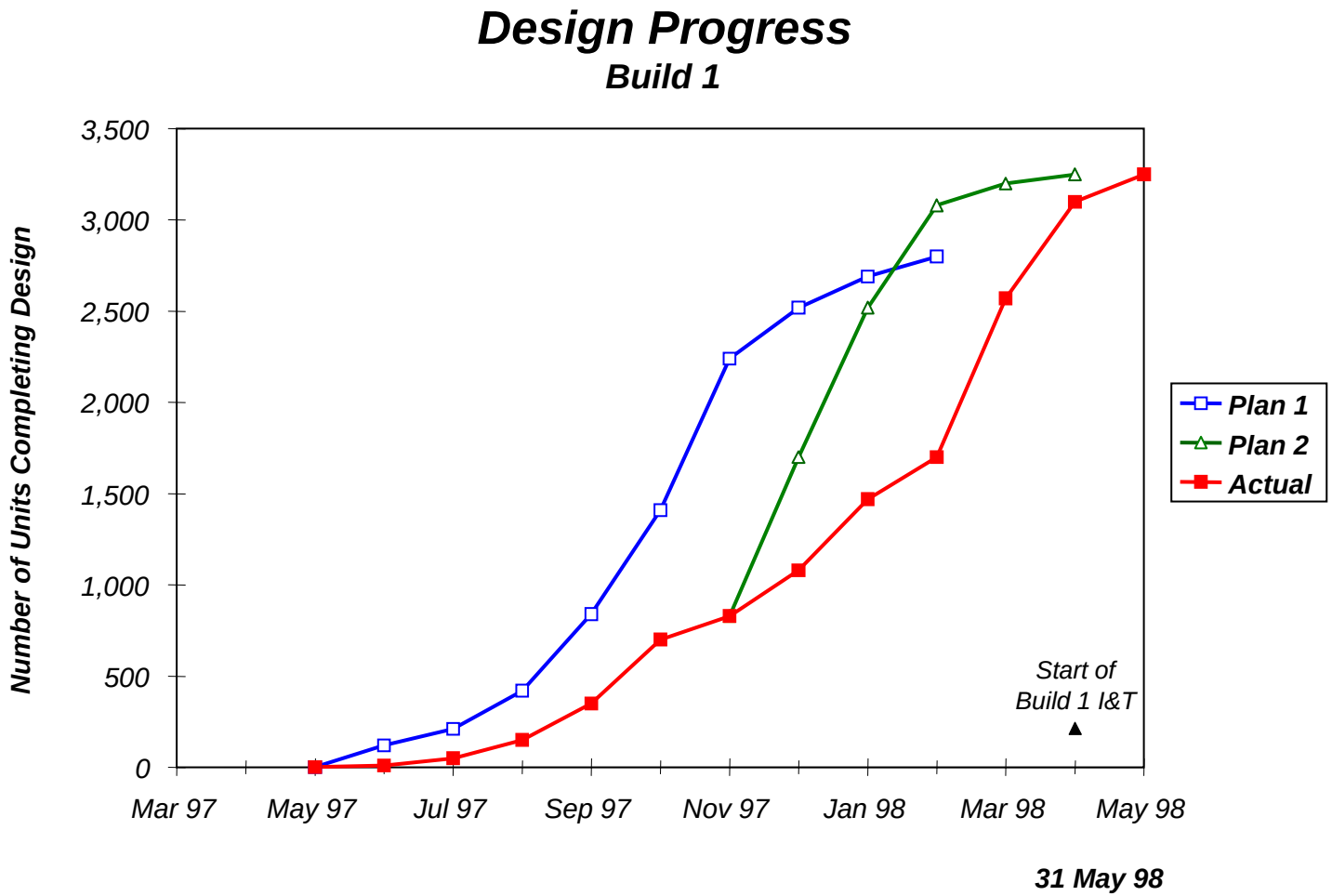


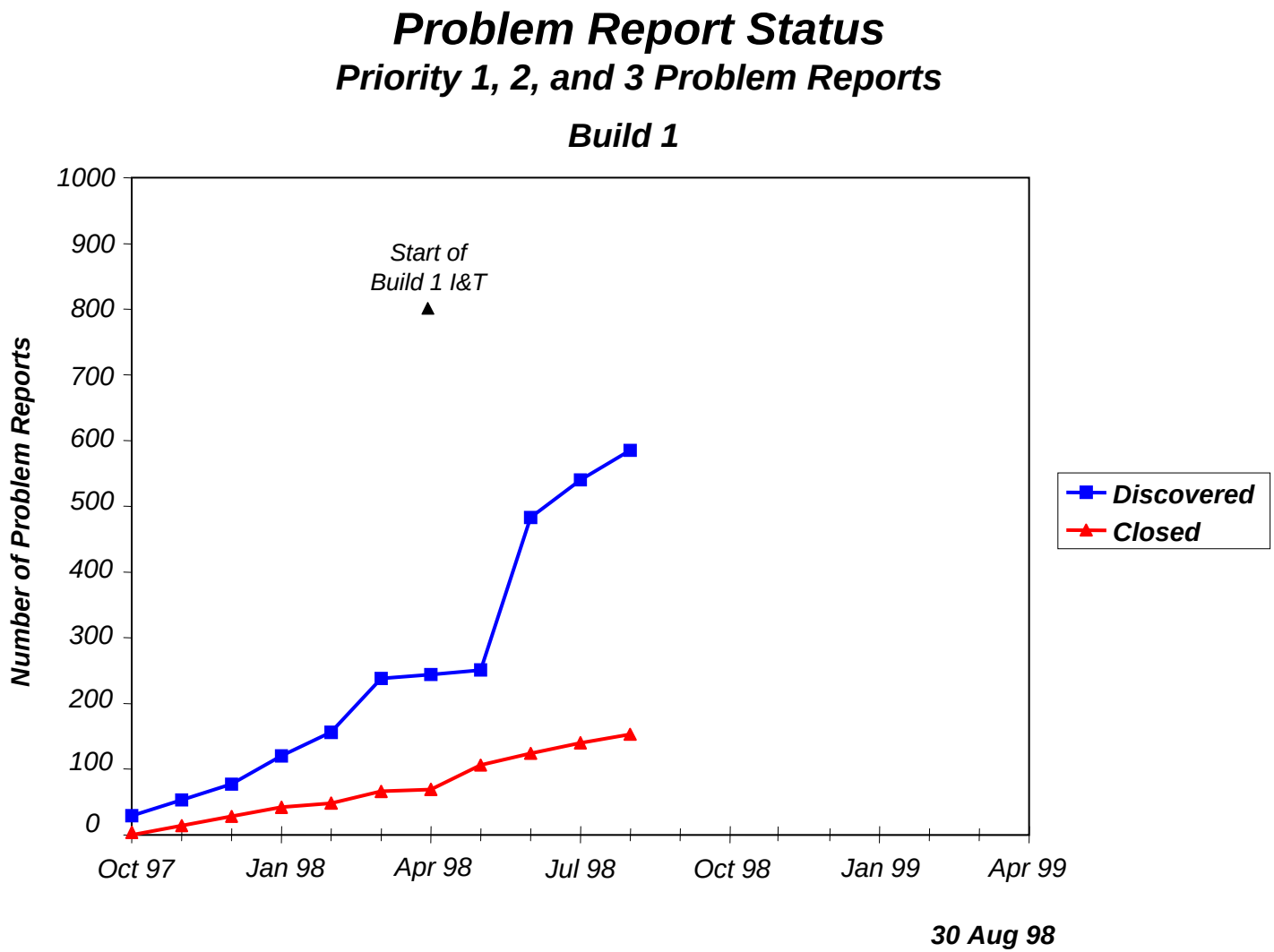


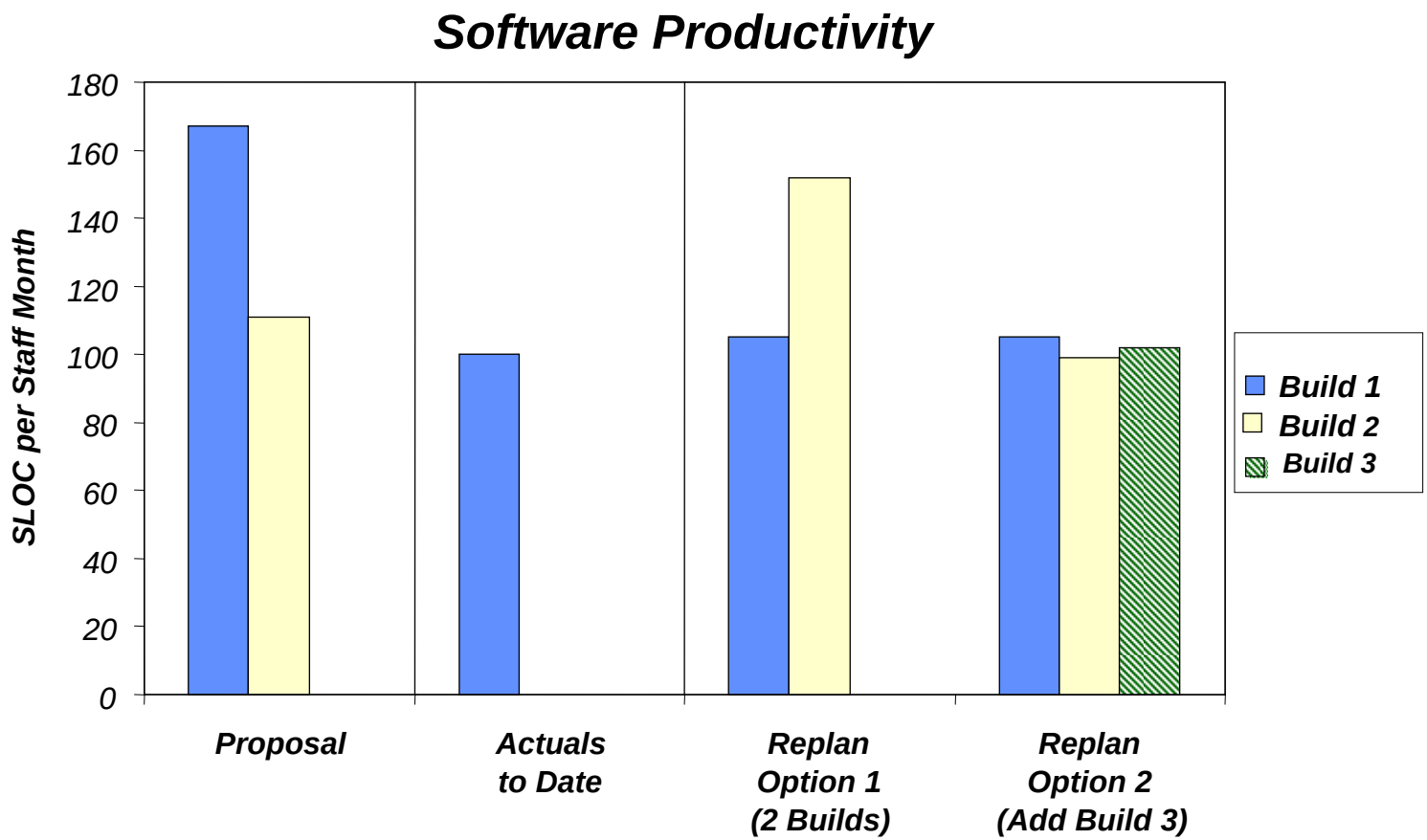












Performance Analysis Summary

- Problems Detected Using Measurement (low productivity)
- Underlying Causes Localized (requirements growth, low staffing, and code source)
- Alternative Replan Strategies Evaluated
- Measurement Supported an Informed Decision

Perform Measurement Summary

- Analysis Is Dynamic - Analysis Must Respond to New and Changing Questions
- The PSM Analysis Model Links Information Needs and Measurement Results
- Both Quantitative and Qualitative Data Should Be Used
- Measurement Results Are the Basis for Risk Resolution, Financial Performance Analysis, and Performance Assessment

Summary and Resources

Summary

- **PSM Is an Effective Measurement Approach that Includes:**
  - Measurement based on project Information Needs
  - A systematic method of defining measures through the information model
  - A defined process for planning, performing, evaluating, and establishing a measurement program

PSM Project Strategy

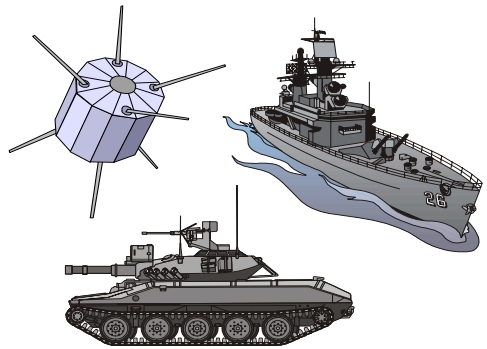
Government - Industry – Academia Team

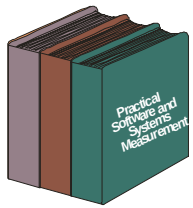
Technical Consensus of Best Practices

Incremental Product Development and Improvement

Integrated With Other Initiatives

Software and Systems Projects

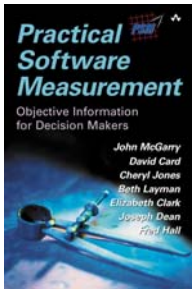




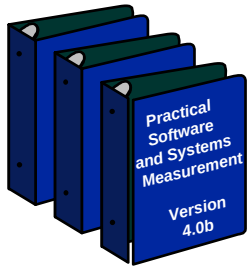
Proven Measurement Technical Guidance and Tools

Comprehensive Transition Support

PSM Products and Services



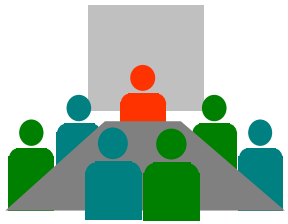
PSM Book



Technical Guidance
(Guidebook V4.0b)

PSM Insight

Training Courses



Measurement Planning Workshops

Project Support

For More Information

Cheryl Jones
US Army TACOM-ARDEC
AMSTA-AR-QAT-A
Building 62
Picatinny Arsenal, NJ 07806

PSM Support Center
4 Old Station Rd.
Severna Park, MD 21146

(973) 724-2644 (Voice)
(973) 724-2382 (FAX)

(973) 724-5638 (Voice)
(410) 280-0576 (FAX)

psm@pica.army.mil
PSM Home Page: www.psmsc.com

www.q-labsusa.com