PART THREE

Measurement Selection and Specification Tables

Part 1 of *Practical Software and Systems Measurement: A Foundation for Objective Project Management* provides an overview of the measurement tailoring process. Part 2 describes the tailoring process in detail.

The material in this part of the Guide represents a starting point for selecting and specifying measures for a specific project. Augment and modify the tables to meet individual project requirements.

This part of the Guide is organized into two chapters:

- **Chapter 1, How to Use the Tables,** explains how to use the detailed PSM measurement selection and specification tables in Chapter 2.
- **Chapter 2, Detailed Measurement Selection and Specification Tables**, provides sample tables to help choose measurement categories and individual measures for a project. The tables also provide specification guidance for each measure to help define associated data and implementation requirements.
- **Chapter 3, Adding Issues, Categories, and Measures,** describes how to document new issues, categories, and measures in the format used in this guide.

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1

How to Use the Tables

This chapter provides information on using the measurement tables in Chapter 2. PSM provides two types of Measurement Tables: Measurement Category Tables and Measurement Description Tables. The tables provide examples of measurement categories and measures to help select and specify measures for a specific project. The tables are grouped by the seven PSM Common Issue Areas.

1.1 How To Use the Measurement Tables

The PSM selection and specification approach is based on the direct relationship between project issues, information needs, and the measures that support the required information. To implement this approach, PSM maps Common Issue Areas to related Measurement Categories, and then to measures in each category. This mapping is depicted in Figure 3-1. The structure of the Measurement Tables in this chapter follows this mapping. The table structure provides guidance in selecting measurement categories and measures that address the project issues. The tables also help in tailoring and specifying the data and implementation requirements for each measure.

Issue - Category - Measure Mapping		
Common Issue Area	**Measurement Category**	**Measures**
Schedule and Progress	Milestone Performance	Milestone Dates
	Work Unit Progress	Critical Path Performance Requirements Status Problem Report Status Review Status Change Request Status Component Status Test Status Action Item Status
	Incremental Capability	Increment Content - Components Increment Content - Functions
Resources and Cost	Personnel	Effort Staff Experience Staff Turnover
	Financial Performance	Earned Value Cost
	Environment and Support Resources	Resource Availability Resource Utilization
Product Size and Stability	Physical Size and Stability	Database Size Components Interfaces Lines of Code Physical Dimensions
	Functional Size and Stability	Requirements Functional Change Workload Function Points
Product Quality	Functional Correctness	Defects Technical Performance
	Supportability - Maintainability	Time to Restore Cyclomatic Complexity Maintenance Actions
	Efficiency	Utilization Throughput Timing
	Portability Usability Dependability - Reliability	Standards Compliance Operator Errors Failures Fault Tolerance
Process Performance	Process Compliance	Reference Model Rating Process Audit Findings
	Process Efficiency	Productivity Cycle Time
	Process Effectiveness	Defect Containment Rework
Technology Effectiveness	Technology Suitability Impact Technology Volatility	Requirements Coverage Technology Impact Baseline Changes
Customer Satisfaction	Customer Feedback	Survey Results Performance Rating
	Customer Support	Requests for Support Support Time

Figure 3-1. Issue-Category-Measure Table

The PSM measurement selection and specification guidance is designed to simplify the mapping of project issues to applicable measures. The PSM I-C-M Table in Figure 3-1 maps the PSM common issue areas to sample measurement categories and measures. Many measures provide insight into more than one common issue; however, the I-C-M Table lists these measures under a single issue for simplicity.

The Measurement Tables are not intended to represent an exhaustive or required set of project management measures. However, these measures have repeatedly proven to be effective over a wide range of projects. The Measurement Table information represents the best practices for addressing issues faced by most project managers. Augment and tailor the list of measures based on your own experience and requirements. PSM provides guidance for tailoring any measure, whether or not it is included in the Measurement Tables. No project should implement all of the measures listed in Chapter 2.

1.2 Measurement Category Tables

The Measurement Category Tables help to determine if the measures in a specific category provide the information required to address a specific project issue. Review these tables for each Common Issue Area that is relevant to the project. If the category provides required information, review the Measurement Description Tables within that category to help select and tailor specific measures. In most cases, the Measurement Category Tables and the Measurement Description Tables should be reviewed concurrently.

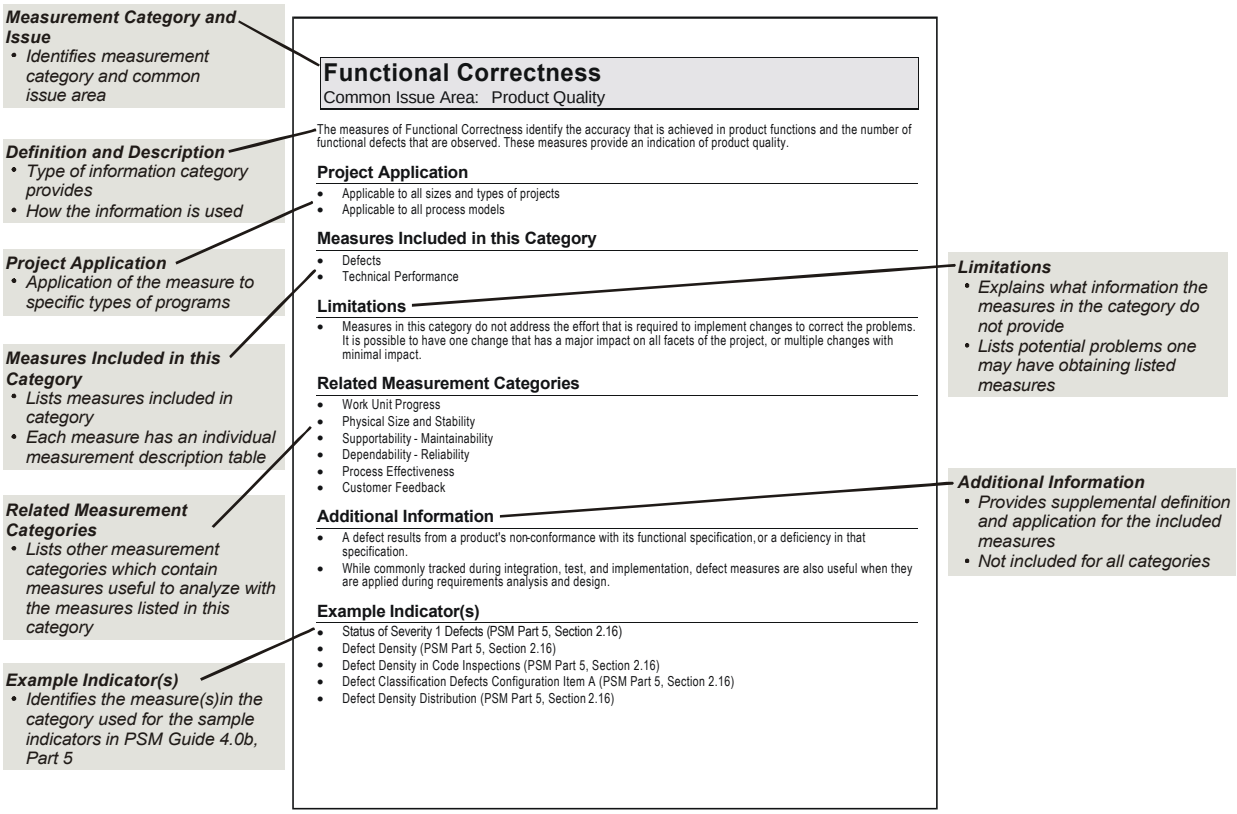

Figure 3-2. Measurement Category Table Roadmap

Figure 3-2 is a "roadmap" to the information in a Measurement Category Table. The following statements describe the type of information in each section of the table. The information in each section of the Measurement Category Table applies to all measures within that category.

- **Measurement Category and Issue -** the Measurement Category and the corresponding Common Issue Area
- **Definition and Description -** a description of the types and uses of measurement information provided by the measures in the Measurement Category
- **Project Application -** information that identifies specific types of projects to which the measures apply. The information addresses the functional domain and the project size
- **Measures Included in this Category -** the measures that are relevant to the Measurement Category. In some cases, this is a single measure.
- **Limitations -** the limitations of the measures in this category
- **Related Measurement Categories -** references to other PSM Measurement Categories that can be used in conjunction with the measures in this category. These related categories support a more complete analysis of the issue in question.
- **Additional Information -** supplementary information that applies to the measures in the Measurement Category. This information may define concepts or terms used in the measures, or may amplify selection guidance. This information is not included for all Measurement Category Tables.
- **Example Indicator(s) -** references specific indicators found in Part 5 of PSM. These include sample graphs of indicators derived from selected measures.

1.3 Measurement Description Tables

The Measurement Description Tables provide two types of information. The first type of information is **selection guidance**, used to determine if a measure will effectively address an identified issue. Selection guidance also helps to determine if the measure is applicable to the project and its associated management and technical processes. The second type of information is **specification guidance**, used to define specific data and implementation requirements for each measure.

Some specification guidance is common to all measures. Rather than repeat this information in every Measurement Description Table, it is summarized in a single General Measurement Specification Table found at the beginning of Chapter 2. This table should be used with each of the individual Measurement Description Tables when specifying measurement data and implementation requirements.

Figure 3-3 is a "roadmap" to the information contained in a Measurement Description Table.

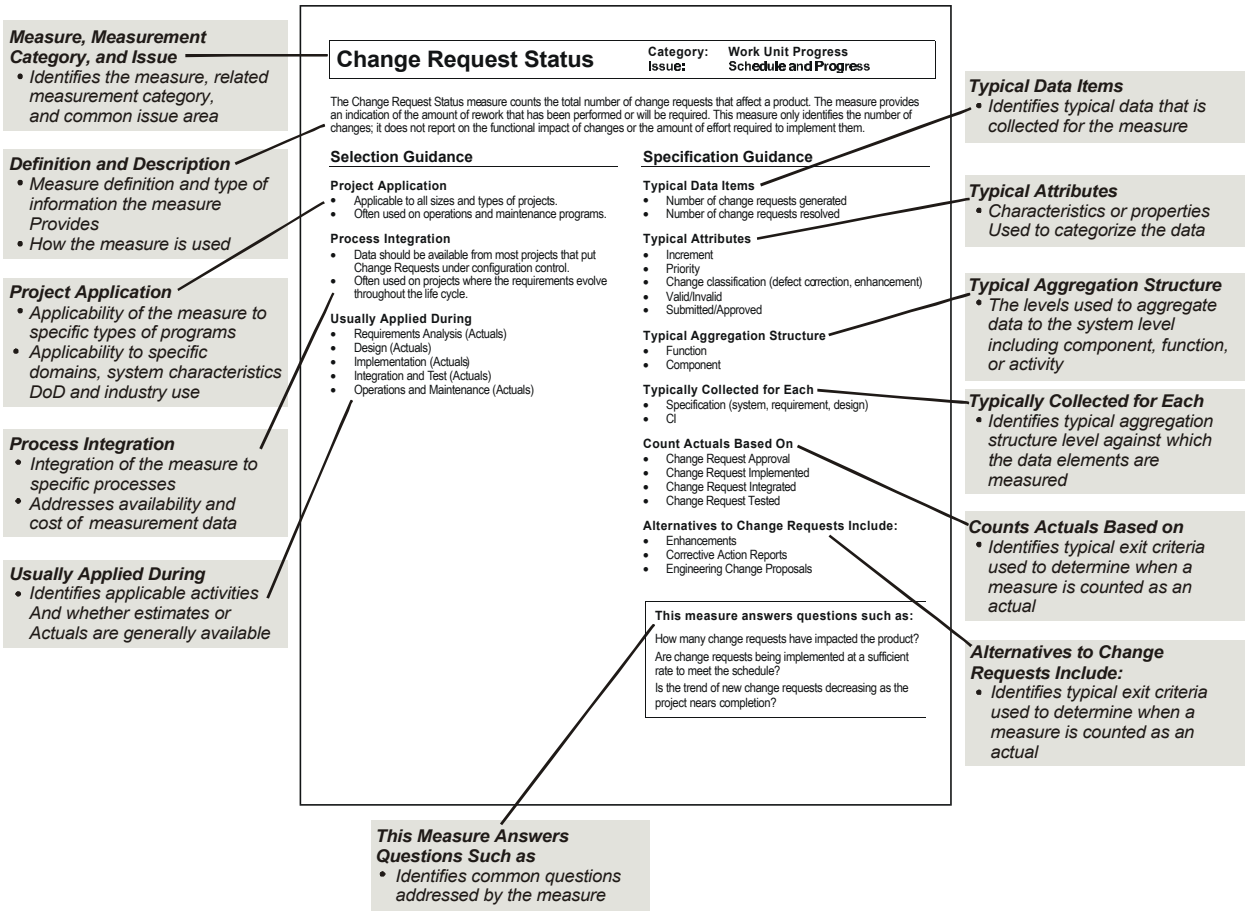

Figure 3-3. Measure Description Table Roadmap

The following is a summary of the type of information in the header and footer sections of the table:

- **Measure, Measurement Category, and Issue -** the specific Measure, the associated Measurement Category, and the corresponding Common Issue Area

- **Definition and Description -** the definition of the measure and a description of its measurement information. It also explains how the measure is used and how effective it is in addressing the issues.

Selection Guidance

The following portions of the Measurement Description Tables help to determine if the measure should be selected:

- **Project Application** – This information helps to determine if the measure is applicable to specific types of projects. The information considers the functional domain, and the size, scope, type, and origin (new, reused, COTS, etc.) of the software or system. This section specifically addresses applying the measure to real-time, data-intensive systems. It also identifies the overall use of the measure within government and industry.

- **Process Integration -** This section helps determine the measure's applicability to different project and technical management processes. The information addresses particular program management practices, availability and cost of data, and other process characteristics. Any considerations unique to software engineering or systems engineering are also described. It also includes software and systems engineering unique considerations. Any software or systems engineering unique considerations are also discussed.

- **Usually Applied During -** This information defines the applicability of the measure to various process activities, including project planning, requirements analysis, design, implementation, integration and test, operations and maintenance. These activities are not sequential, but can occur during any phase of the life cycle, or concurrently during the same phase. This item also lists the type of data (estimates or actuals) that is generally available for the identified activities.

Specification Guidance

The following portions of the Measurement Description Tables help to specify the data and implementation requirements for selected measures:

- **Typical Data Items -** the data items that are usually measured and collected. These data items are the fundamental values collected for a measure. For example, the Effort measure includes the data item, Number of Labor Hours.

- **Typical Attributes -** information on data item properties that are used to sort and correlate the project data. For example, the Number of Labor Hours data item includes attributes of organization, labor category, and increment.

- **Typical Aggregation Structure -** the structure by which data is organized and accumulated to the project level. The aggregation structures in this Guide are based on either activities (such as requirements analysis, design, implementation, integration and test), components (such as CI or component), or functions. The Work Breakdown Structure (WBS) is a combination of activity and component structures.

- **Typically Collected for Each** - the activity or component level at which the supplier typically collects data items for the measure. This is a specific level defined in the measure's Typical Aggregation Structure. For example, if data is collected within a component aggregation structure, data may be collected for each component (the second level in the structure).

- **Data Items - Additional Information (Optional)** - This section provides more information to specify the data items for the measure, or alternatives to the specified data items.

- **Count Actuals Based On -** typical activities or exit criteria for the listed data components. This information determines when a measure is counted as an actual, or when an activity or event is complete. Normally only one of these options is used.

- **This Measure Answers Questions Such As -** typical questions addressed by the measure

1.4 General Measurement Specification Table

The General Measurement Specification Table should be used in conjunction with the individual Measurement Description Tables when specifying data and implementation requirements for selected measures. The specification guidance applies to all measures and summarizes general requirements for the sample measures that are presented in the Guide. The General Measurement Specification Table is the first table in Chapter 2.

1.5 Additional Guidance

Most of the measures listed in the Measurement Description Tables quantify a single characteristic. Some of the measures (such as those under the common issue areas of Product Quality and Process Performance) are composite measures, derived from other measures. For example, Productivity is a composite Process Performance measure. This measure is calculated using (1) a size measure under the Product Size and Stability issue, and (2) the Effort measure under the Resources and Cost issue.

Measures in the Technology Effectiveness issue generally track technologies that are highly "leveraged," or heavily relied on for the project's success. Many of the measures in the Technology Impact category are derivatives of measures categorized under other common issue areas. For example, a project's planned cost and schedule may be based on large increases in productivity due to a substantial amount of reused software. In this case, a measure may be defined that provides information on the relative growth of reused versus newly developed code. Growth in the development of new code, with concurrent reductions in reused code, may indicate a problem: the reused code may not satisfy the requirements, or actual productivity may be less than anticipated.

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2

Detailed Measurement Selection and Specification Tables

The first table in Chapter 2 is the General Measurement Specification Table, applicable to all other tables in this section.

The following measurement tables are grouped by the seven Common Issue Areas defined in this Guide. Each issue includes a Measurement Category Table and associated Measurement Description Tables defined by the Issue-Category-Measure (I-C-M) mapping structure in Figure 3-1. The pertinent Measurement Description Tables immediately follow each Measurement Category Table.

General Measurement Specification Table

Common Issue Area: All

This table provides measurement specification guidance that is applicable to all measures. It augments the specification guidance in the individual Measurement Description Tables. It helps to define overall data and implementation requirements for all sample measures in this Guide.

Specification Guidance

- **Data Types** - Measurement data representing plans, changes to plans, and actual values should be collected and reported for each measure. Update plans and estimates on a regular basis.
- **Measurement Definitions** - Identify the actual measurement definitions and methods used for each measure. If these change during the project, the definitions and interpretations should be updated and provided to the project office. Differences in estimation methods and the way that actuals are counted should also be identified, including the "exit" criteria for counting actuals.
- **Data Dates** - For each measure, identify both the date that the measurement data was collected, and the date that it is reported. The data should be provided in a timely manner. The difference between the collection date and the delivery date should be minimized.
- **Measurement Organization** - If more than one organization is involved in developing the system for a project, measurement data should be collected from each organization and identified by source. Identify different definitions for the same measures.
- **Project Phase** - Measures that are selected and integrated into the project are applied to all life-cycle phases; include project planning, development, and operations and maintenance. Throughout all project phases, measurement plans and estimates should be continually updated and reported.
- **Collection Periodicity** - Measurement data should be collected on a periodic basis (not event-driven). Most projects collect measurement data monthly, but the frequency can be adjusted as necessary. The periodicity for selected measures may be modified to meet process constraints.
- **Data Reporting Mechanisms** - Identify the reporting mechanisms for delivering data to the project office. Every effort should be made to establish the resources necessary to transfer the data electronically on a periodic basis.

Schedule and Progress Measurement Tables

- Milestone Performance
- Work Unit Progress
- Incremental Capability

Milestone Performance

Common Issue Area: Schedule and Progress

The Milestone Performance measures provide basic schedule and progress information for key development activities and events. The measures also help to identify and assess dependencies among development activities and events. Monitoring schedule changes helps to assess the risk in achieving future milestones.

Project Application

- Applicable to all sizes and types of projects
- Applicable to all process models

Measures Included in this Category

- Milestone Dates
- Critical Path Performance

Limitations

- The measures in this category do not address the degree of individual activity completion, or the amount of effort to complete a scheduled activity or task.
- These measures do not address the relative importance of key activities, except for the identification of critical path activities.

Related Measurement Categories

- Work Unit Progress
- Incremental Capability

Additional Information

- An important objective in tracking milestone performance is to determine if schedule changes are realistic. This assessment is usually based on a comparison of planned versus actual dates, and an evaluation of the time allocated to complete future activities.

Example Indicator(s)

- Development Milestone Schedule (PSM Part 5, Section 2.1)
- Milestone Progress - Maintenance Activities (PSM Part 5, Section 2.1)

Milestone Dates

Category: Milestone Performance
Issue: Schedule and Progress

Milestone Dates measures the start and end dates for activities, events, and products. The measure provides an easy-to-understand view of scheduled activities and events. Comparison of plan and actual milestone dates provides insight into significant and repetitive schedule changes at the activity level.

Selection Guidance

Project Application
- Applicable to all sizes and types of projects.
- Included in most government and industry measurement practices.

Process Integration
- Required data is generally obtained from project scheduling systems and/or documentation. Data should be focused on major activities and events, particularly key items affecting the critical path performance or risk items.
- Detailed milestones provide a better indication of progress and allow earlier identification of problems.
- If dependency data is collected, slips in related activities can be projected and assessed.
- If activities or events are re-planned to occur at a different time, the original dates should be retained (with a unique plan identifier) to observe planned schedule changes.
- Some operations and maintenance projects are considered level-of-effort tasks and may not have detailed milestones. Such projects may only track increment release date and change request closure dates.

Usually Applied During
- Project Planning (Estimates)
- Requirements Analysis (Estimates and Actuals)
- Design (Estimates and Actuals)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Estimates and Actuals)

Specification Guidance

Typical Data Items
- Start date of activity or event
- End date of activity or event

Typical Attributes
- Activity or event name
- Version of the plan
- Increment
- Organization

Typical Aggregation Structure
- Component
- Activity

Typically Collected for Each
- CI or equivalent
- Key activity

Count Actuals Based On
- Customer sign-off
- Action items closed
- Documents baselined
- Milestone review held
- Successful completion of tasks

This measure answers questions such as:

Is the current schedule realistic?

How many activities are concurrently scheduled?

How often has the schedule changed?

What is the projected completion date for the project?

What activities, events, or products are on time, ahead of schedule, or behind schedule?

Critical Path Performance

Category: Milestone Performance
Issue: Schedule and Progress

Critical Path Performance measures the variance between projected and actual schedule performance for project components with direct and immediate impact on schedule baseline and completion goals. The measure provides information on components having the greatest impact on schedules and end-state schedule performance. The measure also assesses the earliest possible completion dates for all activities, based on the longest dependent path in the schedule. Dependent schedule paths are defined as activity strings.

Selection Guidance

Project Application
- Applicable to all sizes and types of projects.
- Often used for projects with schedule constraints and key activities.

Process Integration
- Requires identification of all schedule dependencies between activities. Requires definition of the underlying assumptions and the causes of dependency between activities.
- A good estimate of schedule risk is required to evaluate stability of schedule.
- Schedule dependencies determine the critical path of activities.
- The number of integrated activities, and schedule dependencies often determine the level of program risk.
- Environmental consideration (such as delays in senior level approvals, reorganizations, and funding variances) can impact program efficiencies and the ability to meet schedule targets.
- The “waterfall” software development model typically contains many critical path dependencies. Other software development models (spiral, prototyping, incrementl/release) reduce schedule dependencies between activities.

Usually Applied During
- Project Planning (Estimates)
- Requirements Analysis (Estimates and Actuals)
- Design (Estimates and Actuals)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Estimates and Actuals)

Specification Guidance

Typical data items
- Start and end dates of activity or event
- Dependent activities
- Length of time to complete each activity or event
- Days of slack time for each activity or event

Typical Attributes
- Activity or event name
- Version of the plan
- Increment
- Organization
- Degree of schedule dependency between activities (complete, partial, unknown)
- Cause of dependency (information needed, resource limitation, management directive)

Typical Aggregation Structure
- Component
- Activity

Typically Collected for Each
- CI or equivalent
- Activity

Count Actuals Based On
- Customer sign-off
- Action items closed
- Documents baselined
- Milestone review held
- Successful completion of tasks

This measure answers questions such as:

Has the critical path been altered? What actions should be taken due to changes in the critical path?

What critical path activities are being impacted?

Which critical activities are most prone to schedule slips?

Has there been a change in the amount of slack time?

Work Unit Progress

Common Issue Area: Schedule and Progress

Work Unit Progress measures address progress, based on the completion of hardware or software work units that combine incrementally into a complete activity or product. If objective completion criteria are defined, Work Unit Progress measures are very effective for assessing progress at any point in the project. They can be used to project activity or product completion dates.

Project Application

- Applicable to all sizes and types of projects
- Applies to all product-oriented process models

Measures Included in this Category

- Requirements Status
- Problem Report Status
- Review Status
- Change Request Status
- Component Status
- Test Status
- Action Item Status

Limitations

- These measures do not weigh difficult or critical activities or products. All activities are assumed to be equally important.

Related Measurement Categories

- Milestone Performance
- Personnel
- Financial Performance
- Physical Size and Stability
- Functional Size and Stability

Additional Information

- Components may be defined differently for each project and discipline. Components can be elements, units, configuration items (CIs), objects, interfaces, screens, reports, packages, icons, machines, circuit boards, documents, or other measurable product structures.
- Problem reports and change requests are sometimes considered components, especially on maintenance activities during the operations and maintenance phase. COTS/GOTS and other non-developed or reusable products can also be counted as components.
- Some components can be aggregated to form higher-level components, such as units to CIs to increments. These may be referred to as sub-components.
- In the remaining tables, a CI to unit breakdown of the components is assumed.
- Activity status is usually determined relative to the project's Work Breakdown Structure.

Example Indicator(s)

- Problem Report Status (PSM Part 5, Section 2.2)
- Problem Report Aging - Open Problem Reports (PSM Part 5, Section 2.2)
- Problem Report Status - Open by Priority (PSM Part 5, Section 2.2)
- Problem Report Status - Open by Priority 1 and 2 by Configuration Item (PSM Part 5, Section 2.2)
- Problem Report Status - Open by Priority 1 and 2 by Type (PSM Part 5, Section 2.2)
- Design Progress With Replan (PSM Part 5, Section 2.3)
- Subsystem Acceptance Status (PSM Part 5, Section 2.3)
- Action Item Status (PSM Part 5, Section 2.4)

Requirements Status

Category: Work Unit Progress
Issue: Schedule and Progress

The Requirements Status measure is derived from the Requirements measure in the Functional Size and Stability measurement category. It counts the number of requirements that have been defined and allocated to hardware and software components. It also counts the number of defined requirements that have been allocated to test cases, and the number that have been successfully tested. The measure is an indication of product design and test progress. When used to measure test status, the measure is used to evaluate whether required functionality has been successfully demonstrated against the specified requirements, and the amount of testing that has been performed. The measure provides excellent test coverage and is also known as "Breadth of Testing."

Selection Guidance

Project Application
- Generally applicable to all sizes and types of projects with a requirements or design activity.

Process Integration
- Requires disciplined requirements traceability and testing processes for successful implementation. Allocated requirements should be testable and mapped to test sequences. If an automated design tool is used, the data is more readily available.
- Can be applied for each unique test sequence, such as CI, integration, system, and regression test, including "dry-runs."
- One of the more difficult Work Unit Progress measures to collect since requirements may not map directly to components, test cases, and test procedures. It is sometimes difficult to objectively determine if a requirement has been successfully tested.
- Early in a project, the requirements baseline is limited to high-level specifications. Later in a project, the requirements baseline expands and measurement data is traceable to components and test cases.
- Some requirements may not be testable until late in the testing process. Others are not directly testable. Some may be verified by inspection.
- Software requirements are allocated from system requirements and organization imposed requirements.
- Track which requirements are allocated to hardware and which are allocated to software.

Usually Applied During
- Requirements Analysis (Estimates)
- Design (Estimates and Actuals)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)

Specification Guidance

Typical Data Items
- Total number of requirements
- Number of requirements traced to detailed specifications
- Number of requirements traced to hardware or software components
- Number of requirements traced to test specifications
- Number of requirements tested successfully

Typical Attributes
- Increment
- Category of requirement (stated, derived)
- Type of requirement (user, system, component, software, etc.)
- Specification reference
- Test sequence reference

Typical Aggregation Structure
- Function

Typically Collected for Each
- Requirement specification

Count Actuals Based On
- Completion of specification review
- Baselining of specifications
- Baselining of requirements traceability matrix
- Successful completion of all tests in the appropriate test sequence

This measure answers questions such as:

Have all of the requirements been allocated to hardware or software components?

Are the requirements being tested as scheduled?

Is implementation of the requirements behind or ahead of schedule?

Problem Report Status

Category: Work Unit Progress
Issue: Schedule and Progress

Problem Report Status counts the number of hardware or software problems reported and resolved. This measure provides an indication of product maturity and readiness for delivery. The rates at which problem reports are written and resolved can be used to estimate product completion. This measure can also indicate the quality of the problem resolution process, based on the average age of reported problems and the average time to resolve them.

Selection Guidance

Project Application
- Applicable to all sizes and types of projects.

Process Integration
- Many projects have acceptance criteria based on the number of open problem reports, by priority. This measure is useful in tracking those requirements.
- The level of test activity has a significant impact on this measure. Test personnel generally alternate between testing and fixing problems. It may be necessary to normalize this measure using some measure of Test Progress.
- Data is generally available, since most projects have an established problem reporting system. Data is easier to collect when an automated problem tracking system is used.
- On development projects, data is generally available during integration and test. Problem report data is more difficult to collect earlier (during requirements analysis, design, and implementation) because a formal problem reporting system is usually not in place and enforced. When this data is available, it provides good progress information. An inspection or peer review can provide this information.
- More advanced projects may track the phase or source where the problem was injected and detected.

Usually Applied During
- Requirements Analysis (Estimates)
- Design (Estimates and Actuals)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items
- Number of problem reports reported
- Number of problem reports resolved
- Average age of problems
- Average time to resolve

Typical Attributes
- Increment
- Priority
- Problem report status (open, closed)
- Category (requirement, documentation, design, software, hardware, or other)
- Valid/Invalid

Typical Aggregation Structure
- Component

Typically Collected for Each
- CI or equivalent

Count Actuals Based On
- Problem report reported
- Problem report implemented
- Problem report integrated
- Problem report tested

This measure answers questions such as:

Are open problem reports being closed at a sufficient rate to meet the test completion date?

Is the product maturing? (Is the problem report discovery rate going down?)

When will testing be complete?

What components have the most open problem reports?

Review Status

Category: Work Unit Progress
Issue: Schedule and Progress

The Review Status measure counts the number of reviews successfully completed, including both supplier and acquirer reviews. The measure provides an indication of progress in completing review activities.

Selection Guidance

Project Application
- Used on medium to large projects.

Process Integration
- Easy to collect if formal reviews are a part of the development process.

Usually Applied During
- Requirements Analysis (Estimates and Actuals)
- Design (Estimates and Actuals)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)

Specification Guidance

Typical Data Items
- Number of reviews
- Number of reviews completed successfully
- Cumulative time spent in reviews

Typical Attributes
- Type of review
- Component being reviewed
- Increment

Typical Aggregation Structure
- Component
- Activity

Typically Collected for Each
- CI or equivalent
- Activity

Alternatives to Reviews Include
- Inspections
- Walkthroughs

Count Actuals Based On
- Completion of review
- Resolution of all associated action items

This measure answers questions such as:

Are development review activities progressing as scheduled?

What components have failed their review?

Change Request Status

Category: Work Unit Progress
Issue: Schedule and Progress

The Change Request Status measure counts the total number of change requests that affect a product. The measure provides an indication of the amount of rework that has been performed or will be required. This measure only identifies the number of changes; it does not report on the functional impact of changes or the amount of effort required to implement them.

Selection Guidance

Project Application
- Applicable to all sizes and types of projects.
- Often used on operations and maintenance programs.

Process Integration
- Data should be available from most projects that put Change Requests under configuration control.
- Often used on projects where the requirements evolve throughout the life cycle.

Usually Applied During
- Requirements Analysis (Actuals)
- Design (Actuals)
- Implementation (Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items
- Number of change requests generated
- Number of change requests resolved

Typical Attributes
- Increment
- Priority
- Change classification (defect correction, enhancement)
- Valid/Invalid
- Submitted/Approved

Typical Aggregation Structure
- Function
- Component

Typically Collected for Each
- Specification (system, requirement, design)
- CI

Count Actuals Based On
- Change Request Approval
- Change Request Implemented
- Change Request Integrated
- Change Request Tested

Alternatives to Change Requests Include:
- Enhancements
- Corrective Action Reports
- Engineering Change Proposals

This measure answers questions such as:

How many change requests have impacted the product?

Are change requests being implemented at a sufficient rate to meet the schedule?

Is the trend of new change requests decreasing as the project nears completion?

Component Status

Category: Work Unit Progress
Issue: Schedule and Progress

The Component Status measure counts the number of hardware or software components that complete a specific activity. A comparison of plans and actuals helps assess the status of development progress. Early in the development activity, planning changes should be expected. Later in the process, an increase in the planned number of components that are scheduled for a specific activity may indicate unplanned or excessive growth.

Selection Guidance

Project Application

- Usually used on medium to large projects.

Process Integration

- Easier to collect if formal reviews, inspections, or walkthroughs are included in the development process.
- Data is sometimes available from configuration management systems or development tools.
- Data is generally available if there is a mature and disciplined development process.
- Component status during test activities requires a disciplined testing process with separate tests per component(s) allocated to defined test sequences.
- Component status during test activities can be applied for each unique test sequence, including "dry-runs."
- Component status during system test activities is generally one of the more difficult Work Unit Progress measures to collect since most integration and test activities are based on requirements or functions instead of components.
- For software components, the most common unit is a source code component.

Usually Applied During

- Requirements Analysis (Estimates)
- Design (Estimates and Actuals)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Estimates and Actuals)

Specification Guidance

Typical Data Items

- Total number of components
- Number of components completed successfully

Typical Attributes

- Increment
- Type of activity or process

Typical Aggregation Structure

- Component

Typically Collected for Each

- CI or equivalent

Additional Information

- Progress can be measured for individual processes such as preliminary design, detailed design, implementation, component test, and CI test

Count Actuals Based On

- Completion of component reviews, inspections, or walkthroughs
- Successful completion of specified test
- Release to configuration management
- Resolution of action items

This answers questions such as:

Are components completing development activities as scheduled?

Is the planned rate of completion realistic?

What components are behind schedule?

Test Status

Category: Work Unit Progress
Issue: Schedule and Progress

The Test Status measure counts the number of test cases that have been attempted and the number that have been completed successfully. This measure can be used with the Requirement Status measure to evaluate test progress. This measure helps assess product quality based on the proportion of attempted test cases that have been successfully executed.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects.
- Especially important to those projects with high reliability requirements, security implications, or catastrophic failure potential.

Process Integration

- Disciplined test planning and tracking processes are needed to implement this measure successfully.
- Can be applied for each unique test sequence, such as component, integration, system, and regression test, including "dry-runs."
- There should be a mapping between defined test cases and requirements to analyze which functions are passing test and which ones are not.
- Easy to collect if projects define and allocate a quantifiable number of test cases to each product test sequence.
- Can utilize design or architecture information, concentrating on interfaces among components or configuration items.

Usually Applied During

- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Estimates and Actuals)

Specification Guidance

Typical Data Items

- Total number of test cases
- Number of test cases attempted
- Number of test cases passed

Typical Attributes

- Increment
- Test sequence
- Test environment
- Test configuration

Typical Aggregation Structure

- Component

Typically Collected for Each

- CI

Count Actuals Based On

- Successful completion of each test case in the appropriate test sequence

Alternatives to Test Cases Include:

- Test procedures
- Test threads
- Logical paths

This measure answers questions such as:

Is test progress sufficient to meet the schedule?
Is the planned rate of testing realistic?
What functions have been tested or are behind schedule ?

Action Item Status

Category: Work Unit Progress
Issue: Schedule and Progress

The Action Item Status measure reports the number and status of action items for technical and management activities. This measure provides information on the total number of open action items, as well as the number opened or closed during the reporting period. Analyzing trends of opened and closed items is effective in evaluating plans.

Selection Guidance

Project Application

- Useful to any project that identifies specific action items.

Process Integration

- Requires a process for identifying, handling, and tracking action items.
- Data is usually available. An automated tracking system or database simplifies data collection and improves timely analysis. Otherwise, data may be collected manually from staff members, meeting minutes, or other management reports.

Usually Applied During

- Requirements Analysis (Estimates and Actuals)
- Design (Estimates and Actuals)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Estimates and Actuals)

Specification Guidance

Typical Data Items

- Number of action items reported
- Number of action items resolved
- Average age of action items
- Average time to resolve

Typical Attributes

- Priority
- Source
- Scope
- Impact

Typical Aggregation Structure

- Activity
- Component

Typically Collected for Each

- Key activity
- Project

Count Actuals Based On

- Action items identified
- Action items verified
- Action items resolved

Alternatives to Action Items Include

- Project issues

This measure answers questions such as:

Are high priority action items being resolved quickly?

Incremental Capability

Common Issue Area: Schedule and Progress

Incremental Capability measures count the cumulative functions or product components associated with a product at a given time. An increment is a predefined group of work units, functions, or product components. An increment may be a product shipped to a customer or an internal increment delivered to the next phase of development. These measures determine whether the capability is being developed as scheduled or delayed to future deliveries. The measures can also support a decision on an early product release.

Project Application

- Measurement category applicable to projects that have multiple deliveries
- Applies to all process models that are based on incremental deliveries.

Measures Included in this Category

- Increment Content - Components
- Increment Content - Functions

Limitations

- Incremental development often results in the release of products with incomplete functions. It is sometimes difficult to determine if all of the planned capability is completed in any given increment. It is easier to assess completion with defined exit criteria.
- Measures in this category require a straight forward mapping of functions to the capability achieved. It is often difficult to define the capability of the increments. It is helpful to express program schedules in terms of capabilities achieved.

Related Measurement Categories

- Milestone Performance
- Work Unit Progress
- Physical Size and Stability
- Functional Size and Stability
- Process Efficiency
- Process Effectiveness

Example Indicator(s)

- Incremental Content (PSM Part 5, Section 2.5)

Increment Content - Components

Category: Incremental Capability
Issue: Schedule and Progress

The Increment Content - Components measure identifies the components that are included and assembled into increments. An increment represents a version of the final end capability or product. The measure indicates progress in producing the increment. Increment content is often deferred or removed to preserve the scheduled delivery date. It is easier to track incorporation of capability by component (rather than by function) since it is relatively easy to detect whether or not a component has been completed and integrated.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects that develop products in increments.

Process Integration

- Requires a formal, detailed list of content by increment defined at the component level.
- Easy to collect, especially if the project has a detailed tracking mechanism.
- To effectively use this measure the lower level components that comprise the increment must have defined exit criteria.

Usually Applied During

- Design (Estimates)
- Implementation (Estimates)
- Integration and Test (Estimates and Actuals)
- Operations And Maintenance (Estimates and Actuals)

Specification Guidance

Typical Data Items

- Number of components
- Number of components successfully integrated

Typical Attributes

- Increment

Typical Aggregation Structure

- Component

Typically Collected for Each

- CI or equivalent

Count Actuals Based On

- Successful integration
- Successful testing

This measure answers questions such as:

Are components being incorporated as scheduled?
Will each increment contain the specified components?
What components have been deferred or eliminated?
What components have been added?

Increment Content - Functions

Category: Incremental Capability
Issue: Schedule and Progress

The Increment Content-Functions measure identifies the functional content of increments. The measure indicates progress in incremental functionality based on the requirements of the final end capability or product. Increment content is often deferred or removed to preserve the scheduled delivery date.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects that develop products in increments.

Process Integration

- Requires a formal, detailed list of functions and requirements by increment.
- Feasible to collect if the project has an automated traceability mechanism among components and functions. Easier to collect if use cases or functional threads are defined.
- It is often difficult to identify whether a function is incorporated in its entirety. A considerable amount of testing and analysis must be done to determine if all aspects of a function are incorporated.
- It is easier to monitor the functional content if the requirements allocation and requirements traceability activities are well defined.

Usually Applied During

- Requirement Analysis (Estimates)
- Design (Estimates)
- Implementation (Estimates)
- Integration and Test (Estimates and Actuals)
- Operations And Maintenance (Estimates and Actuals)

Specification Guidance

Typical Data Items

- Number of functional requirements
- Number of functional requirements successfully implemented

Typical Attributes

- Increment

Typical Aggregation Structure

- Function

Typically Collected for Each

- Function or equivalent

Count Actuals Based On

- Successful integration
- Successful testing

This measure answers questions such as:

Is functionality being incorporated as scheduled?

Will each increment contain the specified functionality?

What functionality has been deferred?

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Resources and Cost Measurement Tables

- Personnel
- Financial Performance
- Environment and Support Resources

Personnel

Common Issue Area: Resources and Cost

Personnel measures characterize the amount of effort that is planned and expended by defined activities or products. These measures may also describe the number and experience of personnel assigned to a project and may evaluate the rate at which people are added to and removed from a project. Personnel measures can be used to assess the adequacy of planned effort and to analyze the actual allocation of labor. They are essential to evaluating development productivity. Personnel measures are especially critical for a software project, since it is a labor-intensive process.

Project Application

- Applicable to all sizes and types of projects
- Applicable to all process models

Measures Included in this Category

- Effort
- Staff Experience
- Staff Turnover

Limitations

- The utility and timeliness of the measures are generally limited by the structure and capabilities of the financial system, which may be difficult to change.
- Measures are not always available at lower levels of product and activity detail.
- All actual effort (especially uncompensated overtime) may not be reported.
- Measures may not capture the total effort applied to a project if they do not distinguish between full and part-time personnel.
- Measures may not be available from subcontractors.

Related Measurement Categories

- Milestone Performance
- Work Unit Progress
- Process Efficiency
- Process Effectiveness

Additional Information

- Software and systems engineering activities may include system design, software design, documentation, coding, component test, CI integration and test, increment integration and test, software integration and test, system integration and test, project management, configuration management, quality assurance, and IV&V.

Example Indicator(s)

- Effort Allocation With Replan (PSM Part 5, Section 2.6)
- Effort Allocation by Development Activity (PSM Part 5, Section 2.6)
- Staffing Level (PSM Part 5, Section 2.6)
- Staff Experience (PSM Part 5, Section 2.7)

Effort

Category: Personnel
Issue: Resources and Cost

The Effort measure counts the number of labor hours or number of personnel applied to all tasks. This is a straightforward, easily understood measure. It can be categorized by activity as well as by product. This measure usually correlates directly with cost, but can also address other common issue areas including Schedule and Progress, and Process Performance.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects. Projects with fixed staffing levels may not track this measure.
- Included in most government and industry measurement practices.

Process Integration

- Data should be available from most projects at the system level.
- Data is usually derived from a financial accounting and reporting system and/or separate time card system.
- All labor hours should be collected (including overtime) whether or not it is compensated. The overtime data is sometimes difficult to collect.
- This measure is most effective when financial accounting and reporting systems are directly tied to individual products and activities at a WBS component level of detail. Counting personnel may be difficult if they are not allocated to the project on a full-time basis or if they are assigned to more than one WBS component.
- If labor hours are not explicitly provided, data may be approximated from staffing and/or cost data. Labor hours are sometimes considered proprietary data.
- Planning data is usually based on estimation models, historical data, or engineering judgment.

Usually Applied During

- Project Planning (Estimates)
- Requirements Analysis (Estimates and Actuals)
- Design (Estimates and Actuals)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Estimates and Actuals)

Specification Guidance

Typical Data Items

- Number of labor hours (days, months, etc.)
- Number of personnel

Typical Attributes

- Organization
- Labor category
- Increment

Typical Aggregation Structure

- Activity/Component

Typically Collected for Each

- WBS Component

Count Actuals Based On

- Financial reporting criteria

This measure answers questions such as:

Are development resources being applied according to plan?

Are certain tasks or activities taking more or less effort than expected?

Staff Experience

Category: Personnel
Issue: Resources and Cost

The Staff Experience measure counts the total number of experienced personnel in defined areas. The measure determines whether sufficient experienced personnel are available. The experience factors are based on the requirements of each individual project, such as environment or application. Experience is usually measured in years.

Selection Guidance

Project Application

- Applicable to projects that require particular expertise and level of experience to complete.

Process Integration

- Requires a personnel database that includes experience data.
- Difficult to collect and keep up-to-date as people are added to or removed from a project. Generally has to be maintained manually.
- A matrix of project skill requirements versus current personnel skills and availability may help to track this measure and identify necessary training areas.
- Experience factor may be defined for software language, system engineering discipline, domain, hardware, application, platform, and length of time together as a team.

Usually Applied During

- Project Planning (Estimates)
- Requirements Analysis (Actuals)
- Design (Actuals)
- Implementation (Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Number of personnel
- Number of years of experience

Typical Attributes

- Experience factor
- Organization

Typical Aggregation Structure

- Activity

Typically Collected for Each

- Project

Count Actuals Based On

- Major staff changes

This measure answers questions such as:

Are sufficient experienced personnel available?

Will additional training be required?

Staff Turnover

Category: Personnel
Issue: Resources and Cost

The Staff Turnover measure counts staff losses and gains. Excessive turnover impacts learning curves, productivity, and the ability of the supplier to implement the system with the resources provided within cost and schedule. This measure is most effective when used in conjunction with the Staff Experience measure. Loss of key and experienced personnel is critical.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects.

Process Integration

- Difficult for the acquirer to obtain on contractual projects, since most suppliers consider this proprietary information. May be more readily available on internal projects.
- It is useful to categorize the number of personnel lost into planned and unplanned losses, since most projects plan to add and remove personnel at various stages of the project.

Usually Applied During

- Requirements Analysis (Actuals)
- Design (Actuals)
- Implementation (Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Number of personnel
- Number of personnel gained (per period)
- Number of personnel lost (per period)

Typical Attributes

- Experience factor
- Organization

Typical Aggregation Structure

- Activity

Typically Collected for Each

- Project

Count Actuals Based On

- Financial reporting criteria
- Organization restructuring or new organizational charts

This measure answers questions such as:

How many people have been added or have left the project?

How are the experience levels being affected by the turnover rates?

What areas are most affected by turnover?

Financial Performance

Common Issue Area: Resources and Cost

Financial Performance measures report the difference between budgeted and actual cost for a specific product or activity. These measures are used to assess whether the project can be completed within cost and schedule constraints, and to identify potential cost overruns.

Project Application

- Applicable to all sizes and types of projects
- Required for major government projects
- Applicable to all process models

Measures Included in this Category

- Earned Value
- Cost

Limitations

- Cost and schedule performance systems can be difficult to establish for software and systems engineering projects. A detailed WBS must be developed that includes quantifiable exit criteria.
- Cost is generally not the best measure of performance due to insufficient detail in the WBS and associated problems with reporting actual progress.

Related Measurement Categories

- Personnel
- Environment and Support Resources

Example Indicator(s)

- Cost and Schedule Variance (PSM Part 5, Section 2.8)
- Planned Cost Profile (PSM Part 5, Section 2.9)
- Cost Profile With Actual Costs (PSM Part 5, Section 2.9)

Earned Value

Category: Financial Performance
Issue: Resources and Cost

The Earned Value measure compares the cost of work performed to the budget, based on dollars budgeted for each component of the Work Breakdown Structure (WBS). The measure can also identify cost overruns and underruns early in a project.

Selection Guidance

Project Application

- Applicable to any project that uses a cost and schedule system, such as a Cost/Schedule Control System Criteria (C/SCSC), or an earned value accounting system.

Process Integration

- On most large government contracts, earned value data is required and is readily available. This data should be based on a validated cost accounting system. If this data is not required, then the cost measure can be used instead.
- This can be difficult to track without an automated system tied to the accounting system.
- This data tends to lag behind other measurement information due to formal reporting requirements.
- Limited in applicability if costs are planned and expended on a level of effort basis.
- Most useful if the earned value system is consistent with the WBS.
- Software WBS components must be product-based and have measurable criteria for this measure to be effective.

Usually Applied During

- Project Planning (Estimates)
- Requirements Analysis (Estimates and Actuals)
- Design (Estimates and Actuals)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Budgeted cost of work scheduled (BCWS)
- Budgeted cost of work performed (BCWP)
- Actual cost of work performed (ACWP)
- Estimated cost at completion (EAC)
- Budgeted cost at completion (BAC)

Typical Attributes

- Organization
- Increment

Typical Aggregation Structure

- Activity/Component

Typically Collected for Each

- WBS component

Count Actuals Based On

- WBS component complete to defined exit criteria

This measure answers questions such as:

Are project costs in accordance with budgets?

What is the projected completion cost?

What WBS components or tasks have the greatest variance?

Can the project be completed on time?

Cost

Category: Financial Performance
Issue: Resources and Cost

The Cost measure counts budgeted and expended costs. The measure provides information about the amount of money spent on a project or a product, compared to budgets.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects.
- Used to evaluate costs for those projects that do not use an Earned-Value cost accounting system such as Cost/Schedule Control System Criteria (C/SCSC).

Process Integration

- Data should come from an automated accounting system. This data tends to lag behind other measurement information due to formal reporting requirements.
- Should be relatively easy to collect at a high level. But not all projects detail WBS components sufficiently.
- Data should be more readily available for hardware components.
- Data should be separated into direct and indirect costs associated with each WBS component.
- This measure does not address the amount of work completed for the costs incurred.

Usually Applied During

- Project Planning (Estimates)
- Requirements Analysis (Estimates and Actuals)
- Design (Estimates and Actuals)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Estimates and Actuals)

Specification Guidance

Typical Data Items

- Cost (dollars)

Typical Attributes

- Organization

Typical Aggregation Structure

- Activity/Component

Typically Collected for Each

- WBS component

Count Actuals Based On

- WBS component complete to defined exit criteria

This measure answers questions such as:

Are project costs in accordance with budgets?

Will the target budget be achieved, or will there be an overrun or surplus?

Environment and Support Resources

Common Issue Area: Resources and Cost

Environment and Support Resources measures address the availability and utilization of tools, spare parts, and facility resources. They do not include Personnel. Resources may include measures for development, integration and test, file build, operations and maintenance. These measures address the adequacy of resources and are recommended for projects where key resources are shared with other projects, or are suspected to be inadequate.

Project Application

- Applicable to all projects with resource constraints
- Applies to all process models

Measures Included in this Category

- Resource Availability
- Resource Utilization

Limitations

- These measures do not address whether the resources are used most effectively.

Related Measurement Categories

- Financial Performance
- Supportability - Maintainability
- Process Efficiency
- Process Effectiveness

Example Indicator(s)

- Resource Utilization - Test Facilities (PSM Part 5, Section 2.10)

Resource Availability

Category: Environment and Support Resources
Issue: Resources and Cost

The Resource Availability measure tracks the availability of key development, test environment, and renewable resources. The measure is used to determine if key resources are available when needed. It can be integrated into the Milestone Dates measure. Personnel resources are not included in this measure (they are tracked with Effort or Staff Experience).

Selection Guidance

Project Application

- Applicable to all sizes and types of projects.
- More important for projects with constrained resources.

Process Integration

- Required data is generally obtained from project scheduling systems or documentation.
- Resources may include software, hardware, integration and test facilities, tools, other equipment, or office space. Normally only key resources are tracked.
- Be sure to consider all resources including those furnished by the acquirer, supplier, and third party vendors.
- Quantity needed and quantity available may be expressed as number of resources or percent of resources.

Usually Applied During

- Project Planning (Estimates)
- Requirements Analysis(Estimates and Actuals)
- Design (Estimates and Actuals)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Estimates and Actuals)

Specification Guidance

Typical Data Items

- Availability date
- Quantity needed
- Quantity available
- Date no longer needed or available (delivered or canceled)

Typical Attributes

- Type of resource
- Organization

Typical Aggregation Structure

- Activity

Typically Collected for Each

- Key resource

Count Actuals Based On

- Start of key activity
- Availability of resource

This measure answers questions such as:

Are key resources available when needed?

Is the availability of support resources impacting progress?

Resource Utilization

Category: Environment and Support Resources
Issue: Resources and Cost

The Resource Utilization measure counts the hours of resource time requested, allocated, scheduled, available (after maintenance downtime or other problems), and used. Resource Utilization is relevant to projects that have resource constraints and is usually focused only on key resources. This measure provides an indication of whether key resources are sufficient and if they are used effectively.

Selection Guidance

Project Application

- More important for projects with constrained resources. Especially important during integration and test activities.

Process Integration

- Relatively easy to collect at a high level. Easier to collect if a resource monitor or resource scheduling system is in place.
- Resources may include software, hardware, integration and test facilities, tools, and other equipment. Normally only key resources are tracked.
- Be sure to consider all resources including those furnished by the acquirer, supplier, and third party vendors.
- In some cases it may be simpler to track the time or number of resources that are unavailable instead of available.

Usually Applied During

- Project Planning (Estimates)
- Requirements Analysis (Estimates and Actuals)
- Design (Estimates and Actuals)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Estimates and Actuals)

Specification Guidance

Typical Data Items

- Number of hours/units requested
- Number of hours/units allocated
- Number of hours/units scheduled
- Number of hours/units available
- Number of hours/units used

Typical Attributes

- Type of resource
- Organization

Typical Aggregation Structure

- Activity

Typically Collected for Each

- Key resource

Count Actuals Based On

- End of reporting period
- Key milestone events

This measure answers questions such as:

Are sufficient resources available?

How efficiently are resources being used?

Is the availability of resources impacting progress?

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Product Size and Stability Measurement Tables

- Physical Size and Stability
- Functional Size and Stability

Physical Size and Stability

Common Issue Area: Product Size and Stability

Physical Size and Stability measures quantify the physical size of a system or product. Size is a critical factor for estimating development schedules and costs. These measures also provide information on the amount and frequency of change to products, which is especially critical late in product development.

Project Application

- Applicable to all sizes and types of projects
- Measures in this category are usually selected based on domain characteristics
- Applicable to all process models

Measures Included in this Category

- Database Size
- Components
- Interfaces
- Lines of Code
- Physical Dimensions

Limitations

- Physical size measures do not always map directly to the amount of functionality in the system.
- Measures in this category do not generally address product quality, complexity, or difficulty.
- Accurate estimates are dependent on the availability of good historical data or engineering experience.
- Reported changes of physical size often occur too late to correct the underlying problems. Measuring requirements or design changes provides early warnings of related problems.

Related Measurement Categories

- Work Unit Progress
- Functional Size and Stability

Additional Information

- The physical components of a system or product may be defined differently for each project. They might be described as units, elements, objects, interfaces, screens, reports, packages, icons, primitives, or other measurable product structures.
- Problem reports and change requests are sometimes considered components, especially for maintenance activities during the operations and maintenance phase. COTS/GOTS and other non-developed or reusable products can also be counted as components.
- Some components can be aggregated to form higher-level components (for example, units to CIs to increments). These can be referred to as sub-components.

Example Indicator(s)

- Interface Stability (PSM Part 5, Section 2.11)
- Software Size by Configuration Item (PSM Part 5, Section 2.12)
- Software Size - Lines of Code (PSM Part 5, Section 2.12)
- Electrial Power Budget (PSM Part 5, Section 2.13)

Database Size

Category: Physical Size and Stability
Issue: Product Size and Stability

The Database Size measure counts the number of words, records, or tables in each database. The measure indicates how much data must be handled by the system.

Selection Guidance

Project Application

- Applicable to all domains. Often used on information system software projects.
- Used for any project with significant database processing. Especially important for those with performance constraints.

Process Integration

- In order to estimate the size of a database, a data model and an operational profile must be developed. This is generally a manual process that can be difficult.
- Actuals are relatively easy to collect.
- For software components, database size is often collected. For hardware components, storage device size is often collected.

Usually Applied During

- Requirements Analysis (Estimates)
- Design (Estimates)
- Implementation (Estimates and Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Number of tables
- Number of records or entries
- Number of words or bytes

Typical Attributes

- Increment
- Database identifier

Typical Aggregation Structure

- Component

Typically Collected for Each

- CI or equivalent

Count Actuals Based On

- Schema design released to configuration management
- Schema implementation released to configuration management

This measure answers questions such as:

How much data has to be handled by the system?

How many different data types have to be addressed?

Components

Category: Physical Size and Stability
Issue: Product Size and Stability

The Components measure counts the number of elementary components in a system or product, and the number that are added, modified, or deleted. The total number of components defines the size of the system. Changes in the number of estimated and actual components indicate risk due to product size volatility and additional work that may be required. Reporting the number of components provides size information earlier than other size measures, such as lines of code or system interfaces.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects.
- Applicable to all application domains, generally with different component definitions.

Process Integration

- Requires a well-defined and consistent component allocation structure.
- Required data is generally easy to obtain from design tools, configuration management tools, or documentation.
- Counts of deleted and added components are relatively easy to collect. Modified components are sometimes not tracked.
- Volatility in the planned number of components may represent instability in the requirements or in the design of the system or product.

Usually Applied During

- Requirements Analysis (Estimates)
- Design (Estimates and Actuals)
- Implementation (Estimates and Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Number of units
- Number of units added
- Number of units deleted
- Number of units modified

Typical Attributes

- Increment
- Source (new, reused, NDI, GOTS, or COTS)
- Language (if software)
- Delivery status (deliverable, non-deliverable)
- End-use environment (operational, support)

Typical Aggregation Structure

- Component

Typically Collected for Each

- CI or equivalent

Count Actuals Based On

- Release to configuration management
- Passing unit test
- Passing inspection

This measure answers questions such as:

How many components need to be implemented and tested?

How much has the approved system baseline changed?

Have the components allocated to each increment changed? Is functionality slipping to later increments?

Interfaces

Category: Physical Size and Stability
Issue: Product Size and Stability

The Interfaces measure counts the number of shared physical and logical boundaries between discrete system or software components (internal interfaces) and external to the system. This measure is particularly useful when allocating functions during architecture development, to quantify the number of pair-wise relationships between components. This measure also counts the number of interfaces that are added, modified, or deleted. Changes in the number of estimated and actual interfaces indicate risk due to requirements, architectural, or design volatility and may result in additional work.

Selection Guidance

Project Application

- Applicable to all application domains.
- Applicable to all sizes and types of projects, generally with different interface definitions.

Process Integration

- Requires a definition of the component level where interfaces must be counted.
- Requires a well-defined and consistently detailed architecture or design.
- Required data is generally easy to obtain from design tools, configuration management tools, or documentation.
- Counts of deleted and added interfaces are relatively easy to collect; counts of modified interfaces are more difficult to obtain.
- Applicable at all levels of system and software design.
- Include interfaces between system components that may not be physically adjacent to one another, e.g., the logical interface(s) between two computers communicating over a network.
- It may be useful to measure the number of interfaces internal to a CI during design and implementation.

Usually Applied During

- Requirements Analysis (Estimates)
- Design (Estimates and Actuals)
- Implementation (Actuals)
- Integration and Test (Actuals)

Specification Guidance

Typical Data Items

- Number of interfaces
- Number of interfaces added
- Number of interfaces deleted
- Number of interfaces modified

Typical Attributes

- Increment
- Component boundary
- Nature of interface (e.g., data, control signals, mechanical action)
- Type (physical or logical)

Typical Aggregation Structure

- Component

Typically Collected for Each

- CI or equivalent

Count Actuals Based On

- Release to configuration management
- Passing an integration test

This measure answers questions such as:

How many interfaces need to be implemented and tested?

How much has the approved system or software baseline changed?

Have the interfaces allocated to each increment changed?

Lines of Code

Category: Physical Size and Stability
Issue: Product Size and Stability

The Lines of Code measure counts the total amount of source code and the amount that has been added, modified, or deleted. Lines of code is a well-understood software measure that helps in estimating project cost, required effort, schedule, and productivity. Changes in the number of lines of code indicate development risk due to product size volatility, and possible additional work.

Selection Guidance

Project Application

- Used for projects of all sizes. Less important for projects where little code is generated, such as those using automatic code generation and visual programming environments.
- Applicable to all domains. Commonly used in weapons applications.
- Included in most government and some commercial measurement practices.
- Most effective for traditional high-order languages such as Ada, FORTRAN, and COBOL.
- Not usually tracked for COTS software unless changes are made to the source code.

Process Integration

- Define lines of code for each language. Lines of code from different languages are not equivalent.
- It may be necessary to calculate an effective or equivalent SLOC count based on source. New and modified lines would count at 100% while reused code would count at a lower percentage (to address the effort required to integrate and test the reused code).
- It is sometimes difficult to generate accurate estimates early in the project, especially for new types of projects.
- Estimates should be updated on a regular basis.
- Actuals can easily be counted using automated tools.
- A consistent methodology should be used for counting.

Usually Applied During

- Project Planning (Estimates)
- Requirements Analysis (Estimates)
- Design (Estimates)
- Implementation (Estimates and Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Number of lines of code (LOC)
- Number of LOC added
- Number of LOC deleted
- Number of LOC modified

Typical Attributes

- Increment
- Source (new, reused, NDI, GOTS, or COTS)
- Language
- Delivery status (deliverable, non-deliverable)
- End-use environment (operational, support)

Typical Aggregation Structure

- Component

Typically Collected for Each

- Unit or equivalent

LOC Definition May Include

- Logical lines
- Physical lines
- Comments
- Executables
- Data declarations
- Compiler directives

Count Actuals Based On

- Release to configuration management
- Passing unit test
- Passing inspection

This measure answers questions such as:

How accurate was the project size estimate on which the schedule and effort plans were based?

How much has the project size changed? In what components have changes occurred?

Has the size allocated to each increment changed?

Physical Dimensions

Category: Physical Size and Stability
Issue: Product Size and Stability

The Physical Dimensions measure quantifies the tangible properties of a product, and changes to those properties including physical size, weight, and power. The measure may include a physical dimension that is required for the project to meet requirements or design specifications. The specific data items in the Physical Dimensions measure depend on the physical characteristics and application domain of the system. Physical dimensions can be measured during successive phases of development to show progress in achieving plans.

Selection Guidance

Project Application

- Applicable to all products with physical constraints or requirements.
- Not usually tracked for COTS hardware unless the physical dimensions or modifications may impact the system's application or performance.

Process Integration

- Required data is obtained through the application of measurement tools, instruments, or personal observation.

Usually Applied During

- Project Planning (Estimates)
- Requirements Analysis (Estimates)
- Design (Estimates and Actuals)
- Implementation (Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Length, width, height, perimeter, circumference, curvature, volume
- Weight, mass
- Temperature
- Pressure
- Electrical resistance, capacitance, inductance, voltage, current, power

Typical Attributes

- Product type (model, prototype, first article, production component)
- Product model identifier
- Increment
- Operational state (off, initializing, stand-by, fully operational, shutdown)
- Component identifier (serial number)
- Source (new, reused, NDI, GOTS, COTS)

Typical Aggregation Structure

- Component

Typically Collected for Each

- CI or equivalent

Count Actuals Based On

- Completion of engineering review or formal evaluation
- Observations

This measure answers questions such as:

Do the system components meet the physical requirements or design specifications?

How much variance is there between a system component and its physical requirements or design specifications?

Will a change to volume or weight exceed allocated limits?

Functional Size and Stability

Common Issue Area: Product Size and Stability

Functional Size and Stability measures quantify the functionality of a system or product. Functional size may be used to estimate development schedule and cost. These measures also provide information about the amount and frequency of change to the system's functionality, which is critical late in development. Functional changes generally correlate to effort, cost, schedule, and product size changes.

Project Application

- Applicable to all sizes and types of projects
- Applicable to all process models

Measures Included in this Category

- Requirements
- Functional Change Workload
- Function Points

Limitations

- Functional size does not generally address the quality of the product or system measured.
- System-level functional size measures do not always map directly to the effort required to build the system (especially when NDI/COTS/GOTS is used).
- Functional size is hard to measure consistently. Clear counting standards are required (such as the IFPUG Counting Practices manual).

Related Measurement Categories

- Work Unit Progress
- Physical Size and Stability

Example Indicator(s)

- Requirements Stability (PSM Part 5, Section 2.14)
- Requirements Stability by Type of Change (PSM Part 5, Section 2.14)
- Multiple Indicators for Change Requests (PSM Part 5, Section 2.15)
- Change Requests by Priority (PSM Part 5, Section 2.15)

Requirements

Category: Functional Size and Stability
Issue: Product Size and Stability

The Requirements measure counts the number of requirements in the system or product specifications. It also counts the number of requirements that are added, modified, or deleted. The measure provides information about the total number of requirements and the development risk due to growth and/or volatility in requirements.

Selection Guidance

Project Application

- Applicable to all domains.
- Useful for any size and type of project that tracks requirements.
- Effective for both non-developed (COTS/GOTS/Reuse) and newly developed components.

Process Integration

- It is sometimes difficult to specifically define discrete requirements. A consistently applied definition makes this measure more effective.
- Requires a good requirements traceability process. If an automated design tool is used, the data is more readily available.
- Count changes against a baseline that is under formal configuration control. Both stated and derived requirements may be included.
- To evaluate stability, a good definition of the impacts of each change is required.
- Organize requirements hierarchically (e.g. user requirements lead to system requirements which are decomposed into software, hardware, operations, and maintenance requirements.

Usually Applied During

- Project Planning (Estimates)
- Requirements Analysis (Estimates and Actuals)
- Design (Actuals)
- Implementation (Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Number of requirements (user, system, component, etc.)
- Number of requirements added
- Number of requirements deleted
- Number of requirements modified

Typical Attributes

- Increment
- Change source (supplier, acquirer, user)
- System component
- Priority (high, medium, low)
- Level of requirement (user, system, software)

Typical Aggregation Structure

- Function

Typically Collected for Each

- Requirement specification

Count Actuals Based On

- Passing requirements inspection
- Release to configuration management
- SCCB Approval

This measure answers questions such as:

Have the requirements allocated to each incremental delivery or increment changed? Are requirements being deferred to later increments?

How much has functionality changed? What components have been affected the most?

Is the number of requirements growing? If so, at what rate?

Functional Change Workload

Category: Functional Size and Stability
Issue: Product Size and Stability

The Functional Change Workload measure counts the number of change requests that affect the functionality of a product. The measure indicates the amount of work that will be required to implement functional changes, and the stability of the system that is supported or enhanced. This measure is often used in the operations and maintenance phase.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects.
- Applicable to all domains.

Process Integration

- Often used on iterative development projects and operations and maintenance projects doing functional upgrades and basic maintenance.

Usually Applied During

- Requirements Analysis (Actuals)
- Design (Actuals)
- Implementation (Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Number of functional change requests written
- Number of functional change requests approved and open
- Number of functional change requests assigned to an increment
- Number of functional change requests resolved

Typical Attributes

- Increment
- Priority
- Valid/Invalid
- Approved/Unapproved
- Change classification (defect correction, enhancement)

Typical Aggregation Structure

- Function

Typically Collected for Each

- Requirement specification
- Design specification

Count Actuals Based On

- Functional change requested
- Functional change impact evaluated
- Functional change approved
- Functional change implemented
- Functional change tested

This measure answers questions such as:

How many functional change requests have been written?

Is the backlog of open functional change requests declining?

Is the rate of new functional change requests increasing or decreasing?

Function Points

Category: Functional Size and Stability
Issue: Product Size and Stability

The Function Points measure provides a weighted count of the number of external inputs and outputs, logical internal files and interfaces, and inquiries for a system. This measure determines the functional size of software to support an early estimate of the required level of effort. It can also be used to normalize productivity measures and defect rates.

Selection Guidance

Project Application

- Applicable to all sizes of projects.
- Applicable to all domains. Commonly used in information system applications.

Process Integration

- Should be based on a defined method, such as the International Function Point Users' Group's function point counting practices manual.
- Usually requires formal training.
- Requires a well-defined set of work products to describe the requirements and design.
- Labor intensive to estimate and count. Automated tools are scarce and have not been validated.

Usually Applied During

- Requirements Analysis (Estimates)
- Design (Estimates and Actuals)
- Implementation (Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Number of function points
- Number of function points added
- Number of function points deleted
- Number of function points modified

Typical Attributes

- Increment
- Source (new, reused, NDI, GOTS, or COTS)

Typical Aggregation Structure

- Function

Typically Collected for Each

- Function

Count Actuals Based On

- Completion of design documentation
- Release to configuration management
- Passing design inspections
- Delivery

This measure answers questions such as:

How big is the software product?

Is the functional size of the software increasing? If so, at what rate?

How much is the required functionality changing over time?

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Product Quality Measurement Tables

- Functional Correctness
- Supportability - Maintainability
- Efficiency
- Portability
- Usability
- Dependability - Reliability

Functional Correctness

Common Issue Area: Product Quality

The measures of Functional Correctness identify the accuracy that is achieved in product functions and the number of functional defects that are observed. These measures provide an indication of product quality.

Project Application

- Applicable to all sizes and types of projects
- Applicable to all process models

Measures Included in this Category

- Defects
- Technical Performance

Limitations

- Measures in this category do not address the effort that is required to implement changes to correct the problems. It is possible to have one change that has a major impact on all facets of the project, or multiple changes with minimal impact.

Related Measurement Categories

- Work Unit Progress
- Physical Size and Stability
- Supportability - Maintainability
- Dependability - Reliability
- Process Effectiveness
- Customer Feedback

Additional Information

- A defect results from a product's non-conformance with its functional specification, or a deficiency in that specification.
- While commonly tracked during integration, test, and implementation, defect measures are also useful when they are applied during requirements analysis and design.

Example Indicator(s)

- Status of Severity 1 Defects (PSM Part 5, Section 2.16)
- Defect Density (PSM Part 5, Section 2.16)
- Defect Density in Code Inspections (PSM Part 5, Section 2.16)
- Defect Classification Defects Configuration Item A (PSM Part 5, Section 2.16)
- Defect Density Distribution (PSM Part 5, Section 2.16)

Defects

Category: Functional Correctness
Issue: Product Quality

The Defects measure quantifies the number, status, and priority of defects reported. It provides useful information on the ability of a supplier to find and fix defects in hardware, software or documentation. The number of defects indicates the amount of rework, and has a direct impact on quality. Arrival rates can indicate product maturity (a decrease should occur as testing is completed). Closure rates are an indication of progress, and can be used to predict test completion. Tracking the length of time that defects have remained open can be used to determine whether progress is being made in fixing defects, or whether rework is being deferred. A Defect Density measure - an expression of the number of defects in a quantity of product - can be derived from this measure. Defect Density can identify components with the highest concentration of defects.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects.
- Applicable to all domains.
- Included in most government and industry measurement practices.

Process Integration

- Requires a well-defined testing and inspection process and a disciplined defect tracking process.
- This measure is generally available during integration and test. It is beneficial to begin defect tracking earlier during requirements, design, development, component inspections, and component test.
- Easy to collect actuals when an automated defect tracking system is used. Many projects do not estimate the number of defects expected. For those that do, projects may estimate total expected defects or defects remaining in the system.
- The number of discovered defects is relative to the amount of discovery activity, such as number of inspections and amount of testing.
- Defect density requires the collection of both defect and size data for each component. Usually only valid, unique defects are included in the defect density calculation.
- Software defects are often logical defects.
- System interface defects are as important as physical defects.

Usually Applied During

- Requirements Analysis (Estimates and Actuals)
- Design (Estimates and Actuals)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Number of defects
- Average age of defects

Typical Attributes

- Increment
- Defect priority
- Defect category (requirements, design, product, documentation)
- Defect status (open, resolved)
- Activity originated
- Activity discovered

Typical Aggregation Structure

- Component

Typically Collected for Each

- CI or equivalent

Count Actuals Based On

- Defects accepted by configuration control board
- Defects validated
- Defect correction successfully tested/inspected
- Defect assessment of readiness for delivery to a field

This measure answers questions such as:

How many (critical) defects have been reported for each component?

Do defect reporting and closure rates support the scheduled completion date of integration and test?

What components have a disproportionate amount of defects, and therefore require additional testing, review, or are candidates for rework?

Technical Performance

Category: Functional Correctness
Issue: Product Quality

The Technical Performance measure is a combination of other measures that are defined by the system's functional and technical requirements. These measures address any functional characteristics that can be quantitatively defined and demonstrated. Various types of functional requirements may be measured including user and mission functions, interoperability of components, security features, accuracy of the system component functions, response time, data handling capability, or signal processing. These measures provide an indication of the overall ability of a system to meet the users' functional requirements.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects.
- Included in all government and industry projects that define specific requirements that must be achieved in products.
- Often used for projects integrating COTS products.

Process Integration

- It is often difficult to generate accurate estimates early in the project, especially for new technologies and new projects.
- Data may not be available until late in a project, when system functional testing is performed.
- Resource and technology limitations may prohibit demonstration and measurement of all technical performance parameters.
- Data may be available from functional test records.
- Modeling and simulation results may be used to estimate functional performance levels.
- Specific measures are defined by the technical requirements of the system, software and components.

Usually Applied During

- Requirements Analysis (Estimates)
- Design (Estimates)
- Implementation (Estimates and Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Specified technical performance level
- Demonstrated technical performance level

Typical Attributes

- Increment
- Source (new, reused, NDI, GOTS, or COTS)
- Technical performance identifier

Typical Aggregation Structure

- Component
- Function

Typically Collected for Each

- CI or Equivalent
- Requirement

Count Actuals Based On

- Passing functional test

This measure answers questions such as:

How accurate was the signal processing function in this release?

Is the system able to read all the required data files in the required time?

Was the system able to perform all required functions within the specified system response time?

Supportability - Maintainability

Common Issue Area: Product Quality

The measures of Supportability - Maintainability quantify the time and level of resources that are required to sustain the useful life of a system and its components through planned restoration and enhancement. Supportability - Maintainability measures also quantify resources that are needed to restore a system to operational status after a failure. These resources include tools, personnel, repair parts, and other assets. Supportability - Maintainability measures help evaluate the users' ability to sustain system operation during the time required to complete a mission or task. These measures are determined by the specific characteristics of the system such as the complexity of components, the number and intricacy of the interfaces, the degree of nesting, and the types of data structures. Complex or tightly coupled components are more difficult to restore or repair after failure. Complex components are generally harder to test and, may contain more defects and more resources to maintain than less complex components.

Project Application

- Applicable to projects with long-term operations and maintenance requirements

Measures Included in this Category

- Time to Restore
- Cyclomatic Complexity
- Maintenance Actions

Limitations

- Software Supportability - Maintainability data may not be available until after a component is coded or tested. Changing the supportability characteristics of software may require significant rework to redesign or recode the software.
- Some components may be complex, to meet specified functional and performance requirements.
- Supportability data on COTS/GOTS and other non-developed or reusable products may not be readily available to determine system support requirements.

Related Measurement Categories

- Functional Correctness
- Portability
- Usability
- Dependability - Reliability

Example Indicator(s)

- System Failures and Restorations (PSM Part 5, Section 2.17)
- Mean Time to Repair or Fix (PSM Part 5, Section 2.17)
- Mean Time to Restore System, With Threshold (PSM Part 5, Section 2.17)
- Software Complexity - CI A (PSM Part 5, Section 2.18)
- Software Complexity - CI A - Units With Complexity > 10 (PSM Part 5, Section 2.18)

Time to Restore

Category: Supportability - Maintainability
Issue: Product Quality

The Time to Restore measure quantifies the time that must be expended to recover from a system failure. Restoring the system may include two tasks: immediate restoration of operational capability and fixing the root cause of the problem. A comprehensive measure includes the elapsed time, effort, and resources needed for system restoration and for problem resolution. This information supports trade-offs between system design and integrated logistics support characteristics. Historical data is used during system design to evaluate alternative solutions to optimize the time to restore system operation. Time to Restore measures are used for integrated logistics support planning to determine adequate maintenance methods that will ensure operational availability.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects.
- Often used for mission critical systems, real time systems, or any other system requiring high operational availability.

Process Integration

- Data collection requires a disciplined failure and maintenance tracking process that records restoration data related to each failure. Data can be gathered from test logs or incident reports. Easier to collect if an automated system is used.
- Time to Restore begins when a failure is observed and continues until a permanent fix is completed, including integration and test.
- If a system is designed for fault tolerance to minimize down time, the Time to Restore measure may only include the time needed to restore system operation after a failure is observed. This may only require automatic switching from a failed component to a redundant component, with minimal down time.
- Operating time to failure may be based on either component operating time or clock time.
- Time to restore software depends on the effort required to determine the cause of a failure, usually limited by the complexity of the code and available tools.
- Time to restore the system's operational functionality may include software, hardware, and operational impact (to people, procedures and training).

Usually Applied During

- Project Planning (Estimates)
- Requirements (Estimates)
- Design (Estimates)
- Implementation (Estimates)
- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Estimates and Actuals)

Specification Guidance

Typical Data Items

- Time at which system failure was observed
- Time at which functionality was restored
- Time at which a permanent fix was completed (including integration and test)
- Number of components affected
- Effort (labor hours) to recover (restore and fix)

Typical Attributes

- System failure identifier
- Increment
- Severity of failure
- Failure cause
- Components affected
- Type of restoration (automated, manual, cold start, hot start, etc.)
- Mode of operation after restoration (full or degraded)

Typical Aggregation Structure

- Component
- Function

Typically Collected for Each

- CI or equivalent
- Function

Count Actuals Based On

- Restoration of system operation after a failure
- Test of fix
- Delivery of fix

This measure answers questions such as:

How long does it take to recover from a failure?

How much effort is required to fix a system component after a failure?

Does the system design support restoration of system operation within resource constraints?

Cyclomatic Complexity

Category: Supportability - Maintainability
Issue: Product Quality

The Cyclomatic Complexity measure is usually applied to count the number of unique logical paths in a software component. However, the concept of Cyclomatic Complexity also can be used to evaluate the complexity of control or information flow in a system. This measure provides an indication of both design quality and the amount of testing required. A high complexity rating is often a leading indicator of a high defect rate. Components with high complexity usually require additional reviews, increased testing, or rewriting. Other component-complexity measures include essential, Halstead, and data flow complexity.

Selection Guidance

Project Application

- Applicable to projects with testability, reliability, or maintainability concerns.
- Not generally used for COTS or reused code. Not generally used on software from automatic code generators or visual programming environments.

Process Integration

- Operational requirements may require efficient, highly complex code.
- The interpretation of complexity is different for each high-order language.
- Estimates are generally not produced, but a desired threshold or expected distribution may be specified, based on experience.

Usually Applied During

- Design (Actuals)
- Implementation (Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Number of decision points (nodes)
- Number of paths (edges)

Typical Attributes

- Increment

Typical Aggregation Structure

- Component

Typically Collected for Each

- Unit or equivalent

Count Actuals Based On

- Passing inspection
- Passing component test
- Release to configuration management

This measure answers questions such as:

How many complex components exist in this project?

What components are the most complex?

What components should be subject to additional testing or reviews?

What is the minimum number of test cases required to test the logical paths through the component?

Maintenance Actions

Category: Supportability - Maintainability
Issue: Product Quality

The Maintenance Actions measure counts the number and impact of discrete maintenance actions that are performed on the system. This measure is most effective when maintenance actions are aggregated by the type of action performed. For example, maintenance actions may be aggregated as preventive/unscheduled/deferred, type of system components impacted, priority, impact on user service, or relative size (hours of labor or cost). This measure can be used to determine whether a change to the system has an effect on supportability.

Selection Guidance

Project Application
- Applicable to all sizes and types of projects.

Process Integration
- Requires explicit definition of a maintenance action.
- Define specific data requirements when establishing a maintenance tracking system to facilitate data collection.

Usually Applied During
- Project Planning (Estimates)
- Requirements Analysis (Estimates)
- Design (Estimates)
- Implementation (Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items
- Date of maintenance action
- Time to perform maintenance action
- Cost (dollars) to perform maintenance action
- Effort (labor hours) to perform maintenance action
- Number of user services unavailable
- Number of users impacted
- Number of system components impacted

Typical Attributes
- Maintenance action identifier
- Category of maintenance action (preventive, unscheduled, deferred)
- Priority
- System components impacted
- Impact on user service
- Type of maintenance action

Typical Aggregation Structure
- Component

Typically Collected for Each
- CI or equivalent

Count Actuals Based On
- Completion of each maintenance action

This measure answers questions such as:

How often must maintenance staff work on the system?

How much does maintenance cost?

Which system components have the highest number of maintenance actions?

Efficiency

Common Issue Area: Product Quality

Efficiency measures are used to assess operational adequacy regarding required resources, output generated, or timing of the system and its components (software and hardware). Efficiency measures have implications for system performance, cost, enhancement, and supportability. During development, measures focus on the reserve capacity of components to ensure adequate performance under stress conditions and to permit future growth from new requirements. Systems with low efficiency (high utilization or low throughput) often require a costly upgrade after deployment and operation.

Project Application

- Applicable to all projects with resource constraints on system components
- Applicable to all process models
- Applicable to all projects with expected high component utilization or system stress conditions

Measures Included in this Category

- Utilization
- Throughput
- Timing

Limitations

- These measures are often difficult to define and collect. Automated system or CASE tools can automatically collect or report certain measures in this category.
- Software and systems that are integrated into shared or legacy systems could be impacted by change beyond the program's control, reducing efficiency in the end state system. This reduction may not be detected during development.

Related Measurement Categories

- Physical Size and Stability
- Supportability - Maintainability
- Usability
- Process Effectiveness
- Impact

Example Indicator(s)

- Response Time - On-Line Functions (PSM Part 5, Section 2.19)
- Response Time During Test - On-Line Functions (PSM Part 5, Section 2.19)

Utilization

Category: Efficiency
Issue: Product Quality

The Utilization measure quantifies the portion of a component resource used or allocated during system operation. A component resource might include CPU, I/O, memory, or storage. The measure indicates whether the resource can support the system's operational requirements. The measure can also be used to determine whether sufficient capacity exists to support operations under conditions of high usage or stress, or if new functionality can be supported.

Selection Guidance

Project Application

- Critical for safety in high performance environments.
- Needed for memory-constrained systems.
- Useful for dedicated processor components.

Process Integration

- The operational profile has a significant impact on this measure. Test cases should include both normal and stress levels of operation.
- Specific operations included in the operational profile may be measured separately to determine utilization by function or task.
- Actual measurement requires a tool that monitors usage based on a defined operational profile during a specific period of time or at defined instances.
- Estimates are difficult to derive and require significant simulation or modeling support. Estimates must be developed early to impact design decisions.
- Actual long-term, static storage utilization is easy to measure and estimates are often based on product size. Dynamic storage or dynamic memory allocation is dependent on how the function is implemented and is often difficult to measure.
- Instrumentation impacts must be accounted for when measuring actual utilization.
- For software components, programming language on utilization should be considered.
- System resources may be insufficient even though individual component resources are adequate.
- Utilization may refer to hardware concepts, such as battery power or mechanical capacity.

Usually Applied During

- Project Planning (Estimates)
- Requirements Analysis (Estimates)
- Design (Estimates)
- Implementation (Estimates and Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Maximum capacity of resource
- Maximum amount of resource established as design limit (utilization target limit)
- Maximum amount of resource established as performance limit (utilization upper limit)
- Date/time of measurement
- Amount of resource used

Typical Attributes

- Resource type
- Increment
- State or mode
- Operational profile
- Function, task or operation measured
- Test sequence

Typical Aggregation Structure

- Component

Typically Collected for Each

- CI or equivalent

Count Actuals Based On

- Integrated system test
- Stress/endurance test

This measure answers questions such as:

Can additional data traffic be accomodated after system delivery?

Do estimates for the resource (e.g. CPU) appear reasonable? Have large increases occurred?

Is the reserve capacity sufficient under all system states?

Throughput

Category: Efficiency
Issue: Product Quality

The Throughput measure provides an estimated or actual value for flow of materials or information (such as processing or data transfer) during a specified period of time. The measure indicates whether the component or system can support its operational requirements. The measure also provides a basis to determine if future enhancement requirements and technology upgrades can be accommodated.

Selection Guidance

Project Application

- Critical for high-traffic systems.
- Useful for dedicated processor and critical timing requirements.

Process Integration

- Actual values can be based on real-time observation or may require a tool that measures usage based on a defined operational profile.
- The operational profile has a significant impact on this measure. Tests should include both normal and stress levels of operation. The operational profile for each test should be provided with the data.
- Estimates are difficult to derive and require significant simulation or modeling support. Estimates must be developed early to impact design decisions.
- The measurement methodology for throughput is critical for meaningful results. In many cases, the measure is based on average throughput for a specified time.
- Care must be exercised to insure instrumentation impacts are accounted for in the throughput calculations.
- System throughput may be insufficient even though individual component throughput is adequate.
- Throughput can refer to the hardware concepts (such as fuel delivery, wire current, or airflow) or network concepts (such as I/O).

Usually Applied During

- Project Planning (Estimates)
- Requirements Analysis (Estimates)
- Design (Estimates)
- Implementation (Estimates and Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Estimates and Actuals)

Specification Guidance

Typical Data Items

- Number of transactions
- Number of transactions completed
- Length of the measured time period
- Number of data packets or units of material
- Number of data packets or units of material successfully initiated
- Number of data packets or units of material successfully completed

Typical Attributes

- Increment
- Operational profile
- Test sequence

Typical Aggregation Structure

- Component

Typically Collected for Each

- CI or equivalent

Count Actuals Based On

- Integrated system test
- Stress/endurance test

This measure answers questions such as:

To what extent do individual components contribute to or adversely impact system throughput?

Where are the bottlenecks?

Do throughput estimates appear reasonable? Have large increases occurred?

Can the design handle the required amount of materials or data in the allocated time?

Can the design handle additional materials or data after delivery?

Will the I/O resources allow increases in data traffic flow?

Timing

Category: Efficiency
Issue: Product Quality

Timing reports the amount of time required to perform a function, such as task completion or request processing. The measure counts the time between initiation and conclusion of an event, such as a request for service. It provides an indication of whether the target or component system responds in a timely manner.

Selection Guidance

Project Application

- Used extensively on projects involving significant user interaction.
- Critical for projects with specified response time requirements; especially critical for real-time systems.
- Critical for systems performing parallel sequences of tasks, such as deployments.

Process Integration

- Actuals can be based on real-time observation or may require a tool that measures request completion based on a defined operational profile.
- The operational profile has a significant impact on this measure. Tests should include both normal and stress levels of operation. The operational profile for each test should be provided with the data.
- This measure should be collected at the lowest appropriate level to best represent the level of service provided.
- User interface response time is often considered an important quality factor.
- Instrumentation used to collect timing data must be non-invasive for the system. This is especially important for real time systems.
- Systems typically have a variety of functions that depend on correct timing (such as component turn-on, mechanical motions, and damping). Each measured function may need a different type of data collection.

Usually Applied During

- Project Planning (Estimates)
- Requirements Analysis (Estimates)
- Design (Estimates)
- Implementation (Estimates and Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Estimates and Actuals)

Specification Guidance

Typical Data Items

- Time that the function was initiated
- Time that the function was completed
- Maximum allowable time for the function

Typical Attributes

- Increment
- Operational profile
- Function, task or operation measured
- Test sequence

Typical Aggregation Structure

- Function

Typically Collected for Each

- Function

Count Actuals Based On

- Integrated system test
- Stress/endurance test

This measure answers questions such as:

Is the target system sufficient to meet response requirements?

How long do certain services or functions take?

Does the system operate efficiently?

Portability

Common Issue Area: Product Quality

Portability measures address the interface and interoperability of a component to determine the feasibility and resources needed to modify the component for use in another application. The measure may help predict and assess the ability to move software applications or hardware components within the system environment or between systems. These measures also assess compliance with recognized standards. The level of open systems compliance and lack of proprietary vendor design characteristics may indicate software portability.

Project Application

- Applicable to all sizes and types of projects
- Applicable to all process models

Measures Included in this Category

- Standards Compliance

Limitations

- Portability is usually evaluated for a component or subsystem.
- Highly portable components do not guarantee project success.
- Determining the level of compliance is subjective.

Related Measurement Categories

- Milestone Performance
- Environment and Support Resources
- Supportability - Maintainability
- Usability
- Dependability - Reliability
- Impact

Example Indicator(s)

- Interface Compliance (PSM Part 5, Section 2.20)
- Validation (PSM Part 5, Section 2.20)

Standards Compliance

Category: Portability
Issue: Product Quality

The Standards Compliance measure quantifies the portability and interoperability of a given architecture and its individual components. The measure helps to ensure consistent interfaces and to identify adherence to documented standards.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects.

Process Integration

- The operational environment and system architecture have a significant impact on this measure.
- Estimates are difficult to derive and require significant analysis.
- Operating environment components and versions, and software component modularity significantly impact this measure.
- Standards compliance impacts the ability to integrate hardware components.

Usually Applied During

- Project Planning (Estimates)
- Requirements Analysis (Estimates)
- Design (Estimates)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Number of interfaces
- Number of interfaces compliant with a specific standard
- Number of interoperability features
- Number of interoperability features compliant with a specific standard

Typical Attributes

- Increment
- Compliance standard

Typical Aggregation Structure

- Component

Typically Collected for Each

- CI or equivalent

Count Actuals Based On

- System level testing

This measure answers questions such as:

How portable is the system?

How easily can functionality be added or changed?

Usability

Common Issue Area: Product Quality

Usability measures predict and assess user satisfaction and system ease of use. The measures are based on factors such as system safety, consistency, reliability, and adequacy of documentation. Usability measures may also assess readiness to deliver.

Project Application

- Applicable to most products that have a user interface
- Applicable to all process models

Measures Included in this Category

- Operator Errors

Limitations

- Determining usability is a subjective process; user perceptions will effect the number of operator errors identified.

Related Measurement Categories

- Functional Correctness
- Supportability - Maintainability
- Dependability - Reliability
- Customer Feedback

Example Indicator(s)

- Problem Reports by Type of Problem Data (PSM Part 5, Section 2.21)
- Operator Error Distribution by Reason (PSM Part 5, Section 2.21)
- Device Complexity Distribution (PSM Part 5, Section 2.21)

Operator Errors

Category: Usability
Issue: Product Quality

The Operator Errors measure quantifies ease of use and system reliability in the operational environment. This measure provides insight into system failures or anomalies attributed to operational causes rather than to hardware or software discrepancies. The Operator Errors measure ensures consistent user interfaces by identifying adherence to documented system requirements and operational profiles.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects.

Process Integration

- Estimates are difficult to derive, and require significant user interaction.
- Can be assessed during training or prototyping.
- Data may be collected for each type of operator error or for each function that a component performs.
- For software components, the focus is predominantly on user display and user interaction.
- For hardware components, the focus is predominately on ergonomics of hardware components.

Usually Applied During

- Implementation (Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Time period over which the task was performed
- Number of operator errors

Typical Attributes

- Task identifier
- Increment
- User interface device
- Priority
- Test sequence
- Category of operator errors
- Operations document identifier

Typical Aggregation Structure

- Component
- Function

Typically Collected for Each

- Human Machine Interface (HMI) component
- Function

Count Actuals Based On

- Test incidence reports

This measure answers questions such as:

Does the product meet its intended use?

Is the system user friendly? Are any specific devices too complex?

Have the operators received adequate training?

What is the quality of the operational documentation?

Dependability - Reliability

Common Issue Area: Product Quality

Dependability - Reliability measures estimate the probability that an item will continue to function for a specified period of time under certain conditions. Reliability is the probability that an item will function without failure for a specified period of time under certain conditions. Availability is related to Dependability - Reliability. Failures that occur during operation either degrade or completely eliminate certain functions, some of which could be mission critical or safety hazards. These measures monitor the quantity and severity of failures, and determine if the expected frequency of failures is acceptable. Estimated probabilities of failures and consequences can be determined through modeling, analysis, and/or testing.

Project Application

- Applicable to all sizes and types of projects
- Applies mostly to systems that have mission critical or safety considerations

Measures Included in this Category

- Failures
- Fault Tolerance

Limitations

- In complex systems, it is difficult to determine all possible failures and associated impacts.
- It may be difficult or prohibitive to test for all possible failures, or all chain of event combinations.

Related Measurement Categories

- Functional Correctness
- Supportability - Maintainability
- Usability

Example Indicator(s)

- MTBF Ranges Based on Historical Data (PSM Part 5, Section 2.22)
- Reliability Growth Tracked With Mean Time to Failure (PSM Part 5, Section 2.22)

Failures

Category: Dependability-Reliability
Issue: Product Quality

The Failures measure is based on the number, criticality, and time interval between failures. A failure is the inability of a system component to perform a required function under certain conditions within a specified time. This measure is used to support indicators of reliability such as historical achievement of system mean time between failures (MTBF) and reliability growth.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects.

Process Integration

- Requires a disciplined failure tracking process, including training of users, operators, and testers. Easier to collect if an automated system is used. Data comes from test logs or incident reports.
- It is useful to categorize failure causes, including failures caused by requirements specification problems, component design, operator error, or documentation errors.
- It is beneficial to categorize failures by the type of corrective and preventive actions necessary, including repair or replacement of the item, or training of test personnel or operators.
- Some projects specify reliability threshold limits, such as an acceptable number of failures over time.
- Operating time to failure may be based on either component operating time or clock time.
- The test environment must be representative of the operational environment. The test environment and input data must thoroughly exercise the system for resulting indicators to be representative of operations.

Usually Applied During

- Design (Estimates)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Estimates and Actuals)

Specification Guidance

Typical Data Items

- Date and time that failure occurred
- Date and time that failure was resolved
- Operating time since the last failure

Typical Attributes

- Failure identifier
- Type of failure
- Severity of failure effect
- Root cause of failure
- Phase of occurrence
- Corrective and preventive actions required
- Test sequence

Typical Aggregation Structure

- Function
- Component

Typically Collected for Each

- Function
- CI or equivalent

Count Actuals Based On

- Failure documented
- Failure validated
- Failure resolved

This measure answers questions such as:

What is the system's operational reliability?

Is the system ready for operation?

How often (and how severely) will the system/component fail during operation of the system?

Will the system, component, or function be available for use when it is needed?

Fault Tolerance

Category: Dependability - Reliability
Issue: Product Quality

Fault Tolerance measures the capability of a system to continue performing its functions despite failures in components. A fault may or may not result in degraded performance of a fault-tolerant system. This measure determines whether the system can operate within reliability, maintainability, availability, and safety requirements after a fault has occurred. This is often achieved through redundancy of components or other design features that allow functional recovery. Fault tolerance measures are used in system planning and development to ensure performance in the operational environment. Achieved fault tolerance must be monitored in the operations and maintenance phase.

Selection Guidance

Project Application

- Applies mostly to systems that have mission critical or safety considerations.
- COTS/NDI components that are integrated into critical systems must be evaluated for the impact on overall system fault tolerance.

Process Integration

- Fault tolerance must be considered in requirements analysis and planning to determine redundancy and its impacts on design and operation.
- Requirements allocation and tradeoff analysis are critical to designing a fault tolerant system.
- Identifying hazards and failure modes is critical to determining fault tolerance of system functions.
- Measures can be taken at the design level, based on interface adequacies.
- Determining failure modes for software is difficult due to all the possible combinations of data input, logic paths, etc.

Usually Applied During

- Project Planning (Estimates)
- Requirements Analysis (Estimates)
- Design (Estimates and Actuals)
- Integration & Testing (Estimates and Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Number of single point failure modes
- Number of identified failure modes
- Number of identified failure modes with fault-tolerant design protection

Typical Attributes

- Failure mode
- Failure effect
- Redundancy level
- Type of fault tolerance (shadow, voting, restart)

Typical Aggregation Structure

- Function
- Component

Typically Collected for Each

- Critical function
- CI or equivalent

Count Actuals Based On

- Design Reviews
- Test completion
- Operational failure experience

This measure answers questions such as:

What is the level of fault tolerance for this system or function?

Are there single point failures for any critical function?

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Process Performance Measurement Tables

- Process Compliance
- Process Efficiency
- Process Effectiveness

Process Compliance

Common Issue Area: Process Performance

Process Compliance measures address compliance of an organization's process to either a standard process assessment model or to the organization's policies and procedures. “Process” describes the people, methods, and tools that are used to generate the organization's products. “Process component” describes any specific procedure or resource that is established within an organization's process and is measured in a process assessment. These measures identify strengths and weaknesses of an organization’s process and monitor progress towards improvement of the process. Although many process assessment models exist, the most common are the Capability Maturity Model (CMM), developed by the Software Engineering Institute and ISO/IEC 15504. Process Compliance measures may also be obtained from the results of audits that are based on the International Organization for Standardization (ISO) 9000 series of Quality Management standards.

Project Application

- Applicable to all sizes and types of projects
- Applicable to all process models
- Useful for process improvement

Measures Included in this Category

- Reference Model Rating
- Process Audit Findings

Limitations

- These measures may be obtained through a formal assessment or an informal self-evaluation. Both methods require significant investment in preparation, training, and conduct of the assessment or evaluation. Formal assessment requires a greater investment due to the use of external evaluators.
- An organization’s process maturity or capability is usually evaluated by assessing selected projects. The Reference Model Rating(s) resulting from a process assessment is assigned to the local organization and may not be applicable to all projects, especially those with significant cost and schedule constraints.
- The Reference Model Rating may help to select a capable supplier, but does not guarantee delivery of a quality product.
- Use of different process assessment models or audit teams may not yield comparable results.

Related Measurement Categories

- Process Efficiency
- Process Effectiveness

Example Indicator(s)

- Reference Model Level - Continuous Type (PSM Part 5, Section 2.23)
- Reference Model Level - Staged Type (PSM Part 5, Section 2.23)
- Process Audit Findings (PSM Part 5, Section 2.24)
- Audit Findings by Reason Code (PSM Part 5, Section 2.24)

Reference Model Rating

Category: Process Compliance
Issue: Process Performance

The Reference Model Rating measure compares the implementation of the organization's defined process with the requirements of an accepted reference model. The rating results from an assessment of the organization's process capabilities. A published process model guides the assessment. With the reference model rating and assessment findings, the organization can identify opportunities for improving processes and can measure progress. This measure is sometimes used during contract source selection to evaluate competing suppliers. Staged-view process models provide a single overall rating for organizational process maturity and a profile of the achieved process components. Continuous-view process models provide a capability rating for each process component that is assessed (rather than a single organizational rating). The quantitative measurement results are limited to the date of the assessment or evaluation and the awarded rating level. However, the most useful assessment information is qualitative, including strengths and weaknesses of various process components.

Selection Guidance

Project Application
- Normally measured at the organizational level.
- Useful for organizations and projects of all sizes.

Process Integration
- Rating may be used by the acquirer as a source-selection criterion or by the supplier as a competitive advantage.
- Applied using a software or systems engineering assessment model.

Usually Applied During
- Project Planning (Actuals)
- Requirements Analysis (Actuals)
- Design (Actuals)
- Implementation (Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items
- Date of assessment
- Reference model rating

Typical Attributes
- Process identifier
- Reference model identifier
- Project assessed
- Organization
- Assessment type (formal or informal)

Typical Aggregation Structure
- Activity

Typically Collected for Each
- Organization

Count Actuals Based On
- Completion of assessment

This measure answers questions such as:

What is the current process maturity or capability rating of the organization?

What process components are established and practiced?

What management and technical practices can be improved?

Does the supplier meet the minimum process maturity or capability requirements?

Process Audit Findings

Category: Process Compliance
Issue: Process Performance

The Process Audit Findings measure indicates how well the project is following the process defined by the organization. This measure counts the number of defined process components (often documented in a checklist) that were reviewed and the number that pass the audit. Generally, passing an audit means that the organization actually follows the procedures that are defined for that process component. The ratio of these numbers provides information on the level of compliance achieved in each audited process component. This measure may indicate which specific process components need corrective action.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects.
- Useful for any project with a documented process.

Process Integration

- Requires a good process auditing procedure and a method for capturing findings of non-compliance.
- Insight is enhanced through the allocation of process findings to the associated development activities and system components.
- Actuals are relatively easy to collect when process audits are implemented. Most projects do not estimate non-compliance, but may set a threshold.
- Tracking the number of repeat findings can provide insight into the effectiveness of the corrective actions.
- Tracking can be performed at the process level, the process component level, or both.

Usually Applied During

- Project Planning (Actuals)
- Requirements Analysis (Actuals)
- Design (Actuals)
- Implementation (Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Number of process components reviewed
- Number of satisfactory process components

Typical Attributes

- Process identifier
- Finding category
- Initial audit/follow-up audit
- Organization

Typical Aggregation Structure

- Activity

Typically Collected for Each

- Process component

Count Actuals Based On

- Process audit results or findings

This measure answers questions such as:

How consistently is the documented process followed?

What are the opportunities to improve the process performance?

Is additional training of the documented process needed?

Are there any specific process components that are not performed as required by the documented process?

Process Efficiency

Common Issue Area: Process Performance

Process Efficiency measures monitor how well the project uses resources to perform its tasks. A goal of process improvement is to increase efficiency by enhancing process performance without compromising the quality of the product.

Project Application

- Applicable to all sizes and types of projects
- Applicable to all process models

Measures Included in this Category

- Productivity
- Cycle Time

Limitations

- The impact of dependencies among various process components makes it difficult to measure the efficiency of a single process component.

Related Measurement Categories

- Process Compliance
- Process Effectiveness

Example Indicator(s)

- Software Productivity - Historical versus Proposal (PSM Part 5, Section 2.25)
- Evaluating Options Using Software Productivity (PSM Part 5, Section 2.25)

Productivity

Category: Process Efficiency
Issue: Process Performance

The Productivity measure compares the amount of product completed to the amount of effort expended. This measure is a basic input to project planning and can evaluate whether performance levels are sufficient to meet cost and schedule estimates. Productivity is also useful early in the project for estimate and baseline comparisons before actual productivity data is available.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects.
- Applicable to all domains.

Process Integration

- To compare productivity from different projects, the same definitions of product size and effort must be used.
- The environment, language, tools, complexity, and experience of personnel will all affect achieved productivity.
- Definition of the effort measure should specify which labor components are included, such as project management and documentation.
- For software components, product size may be measured as lines of code, number of components, or the number of tables or records. Function points may also be substituted.
- Hardware product size may be measured as terminals, edges, or solder connections.

Usually Applied During

- Project Planning (Estimates)
- Requirements Analysis (Estimates and Actuals)
- Design (Estimates and Actuals)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Estimates and Actuals)

Specification Guidance

Typical Data Items

- Product size (e.g. lines of code)
- Number of labor hours

Typical Attributes

- Increment
- Language (for software)

Typical Aggregation Structure

- Activity

Typically Collected for Each

- Supplier

Count Actuals Based On

- Completion of increment
- Successful completion of testing

This measure answers questions such as:

Is the supplier producing at a sufficient rate to meet the completion date?

How efficient is the supplier's process?

Is the planned productivity rate realistic?

Cycle Time

Category: Process Efficiency
Issue: Process Performance

Cycle Time measures the length of time that it takes a process to complete all associated activities. The accumulation of all processes determines the total schedule to complete a project. Usually, a key objective in process improvement is to reduce overall cycle time.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects.
- May not be meaningful for projects that provide Level of Effort (LOE) systems engineering support.

Process Integration

- Must clearly define entry and exit criteria for each process.

Usually Applied During

- Project Planning (Estimates)
- Requirements Analysis (Estimates and Actuals)
- Design (Estimates and Actuals)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Estimates and Actuals)

Specification Guidance

Typical Data Items

- Date entered process
- Date exited process

Typical Attributes

- Process identifier
- Organization

Typical Aggregation Structure

- Activity

Typically Collected for Each

- Process

Count Actuals Based On

- Process entry and exit

This measure answers questions such as:

How long did it take to complete this process?

Has the cycle time been reduced?

Process Effectiveness

Common Issue Area: Process Performance

Process Effectiveness measures process performance and the consequences of poor performance. Every process has specific goals, and measures must relate to these goals. An ineffective process results in poor product quality or rework to fix the product.

Project Application

- Applicable to all sizes and types of projects
- Applicable to all processes

Measures Included in this Category

- Defect Containment
- Rework

Limitations

- It may be difficult to determine the specific process that caused a defect if it is detected later in the development.

Related Measurement Categories

- Process Efficiency
- Process Compliance

Example Indicator(s)

- Requirements Defects Discovered After Requirements Phase (PSM Part 5, Section 2.26)
- Development Effort by Activity - Compared to Total Rework Effort (PSM Part 5, Section 2.27)
- Rework Effort - by Activity (PSM Part 5, Section 2.27)

Defect Containment

Category: Process Effectiveness
Issue: Process Performance

The Defect Containment measure identifies defects that were inserted during a process and caught within the process, or its corresponding review activity. This measure indicates how well the review process is performing. The amount of defect containment is related to the amount of effort, resources and tools applied.

Selection Guidance

Project Application
- Applicable to all sizes and types of projects.

Process Integration
- Requires a clear understanding of the purpose and goals of each process.
- Entry and exit criteria must be defined for each process.
- Reviews provide the best source of defect data.

Usually Applied During
- Requirements Analysis (Actuals)
- Design (Actuals)
- Implementation (Actuals)
- Integration and Test (Actuals)
- Operations and maintenance (Actuals)

Specification Guidance

Typical Data Items
- Number of defects detected during a process
- Number of defects detected after completion of a process

Typical Attributes
- Process identifier
- Type of escape

Typical Aggregation Structure
- Activity

Typically Collected for Each
- Process

Count Actuals Based On
- Completion of activity review

This measure answers questions such as:

Is the process effective in identifying and resolving defects during the phase they were introduced?

How many defects are identified in later phases?

Rework

Category: Process Effectiveness
Issue: Process Performance

The Rework measure tracks the amount of work effort expended to fix defects. Rework may be expended to fix any product. This measure identifies the quality of the initial project effort, products that need the most rework, and processes that need improvement. Budgets should be estimated for rework in each phase.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects.
- Not generally used for non-developed items such as COTS.

Process Integration

- Rework data may be difficult to collect because some cost accounting systems do not itemize rework expenditures.
- For basic tracking, a single cost account can track all rework effort for the entire organization. For more advanced tracking, use multiple cost accounts to track rework by the component or activity level.
- Rework effort should only include effort associated with correcting defects. Effort expended to incorporate enhancements is not rework.
- Rework cost and schedule estimates should be included in the project plan and compared to actuals.
- For software components, focus on lines of code affected by rework (added, modified, deleted).
- For hardware components, focus on end items or Configuration items affected by rework.

Usually Applied During

- Planning (Estimates)
- Requirements Analysis (Estimates and Actuals)
- Design (Estimates and Actuals)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Estimates and Actuals)

Specification Guidance

Typical Data Items

- Labor hours
- Number of components affected by rework

Typical Attributes

- Organization
- Labor category
- Increment

Typical Aggregation Structure

- Activity
- Component

Typically Collected for Each

- Activity
- CI or equivalent

Count Actuals Based On

- Delivery of fixes to defects
- Completion of manufacture run

This measure answers questions such as:

How much effort was expended on fixing defects in the product?

What components required the most rework?

Technology Effectiveness Measurement Tables

- Technology Suitability
- Impact
- Technology Volatility

Technology Suitability

Common Issue Area: Technology Effectiveness

The Technology Suitability measures quantify the degree to which system requirements can be achieved by proposed technical solutions. These measures evaluate component characteristics that can be quantified during software/system selection and developmental testing phases. These measures assess the overall ability of a candidate technical solution or existing technology to meet the users' requirements. Technology Suitability measures also provide insight into performance and interoperability issues.

Cost, schedule, or resource constraints often drive changes that affect technology insertion. Changes to functional requirements may affect a technology's suitability for the solution. Likewise, changes in the technology (or product) may cause the candidate solution to be less suitable. Problems in system performance and interoperability may be caused by several factors, including requirements mismatch, unacceptable behavior, incompatibility among products, overlap or gaps in functionality, technology application shortfalls, incomplete products, or vendor inflexibility. Suitability measures may identify where redesign is needed for another technology to solve compatibility issues.

Project Application

- Applicable to all sizes and types of projects that are adopting new technology

Measures Included in this Category

- Requirements Coverage

Limitations

- Specifications for off-the-shelf components (COTS, GOTS, NDI, or reuse) may not provide the same information as new components in a design.
- Redesign may be required to utilize new technology.
- Custom software or hardware may be required to utilize new technology

Related Measurement Categories

- Functional Correctness
- Supportability - Maintainability
- Efficiency
- Portability
- Dependability - Reliability
- Impact
- Customer Support

Example Indicator(s)

- Critical Technology Requirements (PSM Part 5, Section 2.28)
- Technology Fit - Trends (PSM Part 5, Section 2.28)

Requirements Coverage

Category: Technology Suitability
Issue: Technology Effectiveness

The Requirements Coverage measure quantifies the amount of functionality that can be addressed by a specific technology or off-the-shelf component (COTS, GOTS, NDI, or reuse). This measure can also determine whether a candidate technology can provide the required functionality.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects considering new technologies.

Process Integration

- Requires a system-level functional decomposition.
- Needs well-defined requirements for system components and interfaces between system components.
- It is sometimes difficult to define a "function," but a consistently applied definition makes this measure more effective.
- Requirements Coverage is verified during Integration and Test. To reduce risk, prototypes may be used to measure the achievement of design requirements prior to implementation.
- Custom software may be needed to resolve compatibility problems.
- Redesign may be required to utilize new technology.
- New technology (e.g. automation of operations) is often inserted into existing systems during operations and maintenance.

Usually Applied During

- Project Planning (Estimates)
- Requirements Analysis (Estimates)
- Design (Estimates)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Number of requirements
- Number of requirements satisfied by the candidate technology

Typical Attributes

- Technology identifier
- Type of system component
- Type of requirement (user, system, software)
- Importance or priority of the requirement
- Technology source (COTS, GOTS, NDI, reuse)
- Vendor
- Increment
- Candidate technology

Typical Aggregation Structure

- Function

Typically Collected for Each

- Function

Count Actuals Based On

- Competion of selection study or testing

This measure answers questions such as:

How many functional requirements are provided by the proposed technology or technical solution?

How compatible is the technology with the requirements?

Impact

Common Issue Area: Technology Effectiveness

The Impact measures quantify the positive or negative effects of a new technology on the project cost, schedule, or technical performance. These measures track the effect of technologies that are new to the project or system. These measures help manage a technology's impact on products or processes, including: analysis selection, training, design, implementation, integration, test, installation, operation, and maintenance.

Project Application

- Applicable to projects that may adopt a new technology

Measures Included in this Category

- Technology Impact

Limitations

- It may be difficult to isolate the impact of a new technology on the performance of projects and products. Therefore, it is important to baseline the current software or system (cost, schedule, cycle time, technical performance, etc.) to assess the new technology's expected effects. Measures in this category - when selected and tailored appropriately - provide valuable insight into the impact of inserting new technology.

Related Measurement Categories

- Milestone Performance
- Financial Performance
- Functional Correctness
- Supportability - Maintainability
- Usability
- Dependability - Reliability
- Technology Suitability

Example Indicator(s)

- Mean Processing Time (PSM Part 5, Section 2.29)
- Average Cost Per Picture (PSM Part 5, Section 2.29)
- Estmated Yearly Maintenance Cost (PSM Part 5, Section 2.29)

Technology Impact

Category: Impact
Issue: Technology Effectiveness

The Technology Impact measure quantifies changes to the project or system that are attributed to a specific technology. These changes may be positive or negative. This measure can be used to support decisions for adopting a particular technology or to mitigate the negative effects of inserting a technology.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects.

Process Integration

- Plan to collect data in areas where impacts are expected.
- Technology impact data (cost, schedule, etc.) may be derived from other implemented measures.
- The measures must differentiate the impacts of inserting a technology and the impacts from other causes.
- Technology impact may extend beyond the scope of a single project. The introduction of a new technology into the customers' or users' environment may also impact training, operations, and maintenance of many other systems and projects. Organizational measures may be needed to assess these impacts.

Usually Applied During

- Requirements Analysis (Estimates and Actuals)
- Design (Estimates and Actuals)
- Implementation (Estimates and Actuals)
- Integration and Test (Estimates and Actuals)
- Operations and Maintenance (Estimates and Actuals)

Specification Guidance

Typical Data Items

- Number of requirements affected
- Number of components affected
- Cost (dollars) to implement new technology
- Effort (labor hours) to implement new technology
- Cost benefit of new technology

Typical Attributes

- Technology identifier
- Evaluation period
- Environment (development, operational)

Typical Aggregation Structure

- Function

Typically Collected for Each

- Function

Count Actuals Based On

- Integration and test of new technology

This measure answers questions such as:

How much time or cost will be saved by incorporating this technology into the project?

How much effort is needed to acquire, learn, and support the new technology?

What time and resources are needed to test and integrate the technology?

Technology Volatility

Common Issue Area: Technology Effectiveness

The Technology Volatility measures quantify a product's rate of change after the implementation of a technology. These measures provide insight into the relative maturity of a particular technology and the susceptibility of a technology to obsolescence. Other issues to consider that relate to technology volatility include product obsolescence, new version transition, interaction of products with different upgrade cycles, licensing and support costs, vendor viability, and product replacement. These measures in this category support decisions on *whether* to adopt the technology, *when* to adopt the technology, and when to *replace* the technology.

Project Application

- Applicable to projects adopting new technology

Measures Included in this Category

- Baseline Changes

Limitations

- Measures in this category can describe the historical stability of a technology, rather than future trends.
- Each technology must be measured at the level appropriate for its intended usage. Underlying technology may be mature, but the products implementing that technology may be immature, with high release or revision rates.

Related Measurement Categories

- Milestone Performance
- Financial Performance
- Supportability - Maintainability
- Usability
- Dependability - Reliability
- Impact

Example Indicator(s)

- Technical Volatility - Cumulative Releases (PSM Part 5, Section 2.30)
- Technical Volatility - Emerging Technology (PSM Part 5, Section 2.30)
- Technical Volatility - Established Technology (PSM Part 5, Section 2.30)

Baseline Changes

Category: Technology Volatility
Issue: Technology Effectiveness

The Baseline Changes measure monitors the number of times a product changes over time. The rate at which a product evolves can indicate the stability of the underlying technology or the stability of the product implementing that technology. This measure assesses the risk of incorporating unfamiliar technology into a project or system. In particular, it provides one view of the frequency at which the technology is likely to change. Information from this measure can help determine when to adopt a technology.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects.
- Applicable to all process models.

Process Integration

- Requires identification of candidate products or technologies to track.
- Requires a periodic survey of the status of identified products or technologies.
- Software patches that are not documented must be counted.

Usually Applied During

- Requirements analysis (Actuals)
- Design (Actuals)
- Implementation (Actuals)
- Integration and test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Number of times a product, or technology has been changed or released

Typical Attributes

- Product or technology identifier
- Increment
- Technology source (COTS, GOTS, NDI, reuse)

Typical Aggregation Structure

- Function

Typically Collected for Each

- Function

Count Actuals Based On

- Each new release or revision of a product or process that implements changes

This measure answers questions such as:

How long will the technology or product be viable within the system?

Can the technology or product be considered mature?

Should this technology or product be adopted now or when it has stabilized?

How often should the technology or product be upgraded?

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Customer Satisfaction Measurement Tables

- Customer Feedback
- Customer Support

Customer Feedback

Common Issue Area: Customer Satisfaction

Customer Feedback measures are used to determine customer satisfaction. These measures provide direct customer feedback rather than assuming the customer is satisfied if the product meets specified requirements. Generally, these measures are applied at a project level or aggregated with comparable measures from other projects having the same customer or concerns. Customer satisfaction is directly related to delivering products that consistently meet the specified requirements, that are built on time and within budget (contract-driven efforts), or that are reasonably priced (market-driven efforts).

Project Application

- Applicable to all sizes and types of projects
- Often used in marketing, particularly for follow-on work

Measures Included in this Category

- Survey Results
- Performance Rating

Limitations

- It may be difficult to get customer feedback in writing.
- Customer feedback can be difficult to address if various initiatives in the project and organization contribute to new business initiatives.
- Poor customer responses can bias future surveys and impact new business.

Related Measurement Categories

- Milestone Performance
- Financial Performance
- Functional Correctness
- Customer Support

Example Indicator(s)

- Customer Satisfaction Survey (PSM Part 5, Section 2.31)
- Composite Performance Award Scores (PSM Part 5, Section 2.32)
- Performance Award Category Scores (PSM Part 5, Section 2.32)

Survey Results

Category: Customer Feedback
Issue: Customer Satisfaction

Survey Results track customer satisfaction ratings, from both acquiring agencies and users. Survey Results also measures progress in providing products and services that meet the customer's needs and expectations.

Selection Guidance

Project Application

- Applicable to all domains.
- Generally applicable to all sizes and types of projects.

Process Integration

- For market-driven product development, identifying and surveying customers are integral to business development.
- For single-customer product development, requesting a satisfaction rating should be part of the customer interface.
- Survey design should minimize customer time and effort.
- Survey results are usually expressed as one or more ratings on a scale devised for each survey.
- Valid surveys require statistically significant samples.
- Use good survey practices, such as those recommended by the American Statistical Association.
- Keep surveys short, ideally 3-5 questions or five minutes.
- Provide survey results and subsequent actions to customers.

Usually Applied During

- Requirements Analysis (Actuals)
- Design (Actuals)
- Implementation (Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Timeliness rating
- Value rating
- Responsiveness rating
- Product quality rating
- Overall satisfaction rating

Typical Attributes

- Originator of survey (user, acquirer, supplier)
- Respondent (customer)
- Product or service rated

Typical Aggregation Structure

- Component

Typically Collected for Each

- Increment

Count Actuals Based On

- Major system reviews
- Increment delivery

This measure answers questions such as:

Are products meeting the customer's expectations?

Is the customer satisfaction trend holding steady or improving?

Are service processes producing good results?

Performance Rating

Category: Customer Feedback
Issue: Customer Satisfaction

Performance Rating measures the extent of customer satisfaction with a delivered product or with a project team's performance. The customer scores a product or the project team's performance with pre-defined evaluation criteria. The Performance Rating is usually expressed as a percentage of some monetary value, representing an incentive fee or profit. The purpose of the Performance Rating measure is to improve the products or the project team's performance.

Selection Guidance

Project Application

- Applicable to any project that has an established performance rating system between the acquirer and supplier.

Process Integration

- The acquirer and supplier must agree on a set of evaluation criteria and performance rating scores at the beginning of each evaluation period.
- Evaluation criteria can be weighted or prioritized.
- Performance Rating measures should be made available to all members of the project team to identify improvement areas.
- Performance Ratings are tracked for contract-driven efforts and typically occur only a few times a year. Therefore, performance ratings are not adequate for in-process feedback, except for long-term contracts.

Usually Applied During

- Requirements Analysis (Actuals)
- Design (Actuals)
- Implementation (Actuals)
- Integration and Test (Actuals)
- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Maximum score
- Rating

Typical Attributes

- Performance component identifier
- Evaluation criteria
- Evaluation criteria weight
- Evaluation period

Typical Aggregation Structure

- Activity
- Component

Typically Collected for Each

- Key activity
- Increment

Count Actuals Based On

- Completion of key activity
- Delivery of increment

This measure answers questions such as:

How is the system or supplier's performance perceived by the acquirer?

According to the customer, what areas need improvement?

Customer Support

Common Issue Area: Customer Satisfaction

Customer Support measures determine the utilization and responsiveness of the organization's customer support function. These measures assess customer satisfaction with products, and monitor the effectiveness of the organization's support interface. The Requests for Support measure may track the creation of problem reports on an existing product. Customer Support measures reveal the impact of a problem on users and provide feedback on overall product usability.

Project Application

- Useful when the organization provides ongoing support to the customer after delivery and installation
- Relevant to projects that perform ongoing evolution of a released product

Measures Included in this Category

- Requests for Support
- Support Time

Limitations

- The customer support function is normally separate from the development project, often resulting in communication problems.
- Requests for support may be received at different organizational levels, making consolidation of data difficult.

Related Measurement Categories

- Customer Feedback

Example Indicator(s)

- Total Calls Per Month by Priority (PSM Part 5, Section 2.33)
- Mean Response Time by Priority (PSM Part 5, Section 2.33)

Requests for Support

Category: Customer Support
Issue: Customer Satisfaction

The Requests for Support measure quantifies the number, type, status, and priority of product support calls from customers. This measure provides information on product defects or usability problems encountered in the field. The number of discovered defects indicates the quality of the delivered product. The number of reported usability problems reflects the usability of the product design. Support request status (number open and closed) measures the ability of the supplier to support the product after delivery. Tracking the length of time that requests remain unresolved can determine the level of customer satisfaction achieved by the product support activity. Each request's priority is proposed by the customer and assigned by the support activity, based on an assessment of the problem's impact on both the acquirer and supplier.

Selection Guidance

Project Application

- Applicable to all domains.
- Applicable to all sizes and types of projects.

Process Integration

- Requires a disciplined tracking process for customer requests.
- This measure is generally used only after a product has been delivered to a customer.
- The number of requests is relative to the number of customers or sites that use the product.

Usually Applied During

- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Number of requests received
- Number of reported defects

Typical Attributes

- Increment
- Priority (safety hazard, critical impact, minor)
- Type of support requested (documentation, training, technical assistance)
- Request mechanism (help desk call, e-mail, Internet)
- Non-support resolution (request is beyond support agreement, cause is customer error)
- Status code (open, closed)
- Customer or originator of the request
- Activity when problem was discovered

Typical Aggregation Structure

- Component
- Function

Typically Collected for Each

- CI or equivalent
- Function

Count Actuals Based On

- Requests received from a customer
- Underlying problem validated
- Resolution of request verified

This measure answers questions such as:

What types of support functions are requested most often?

Are customer requests answered and resolved in a timely manner?

Do components have to be recalled, redesigned, or provided with new operating procedures?

Which customers have a disproportionate amount of requests for support?

Support Time

Category: Customer Support
Issue: Customer Satisfaction

The Support Time measure addresses the time required to respond, resolve, or satisfy a customer's request for support. These measurements assess the responsiveness of the support activity and their ability to maintain the product.

Selection Guidance

Project Application

- Applicable to all sizes and types of projects that support products during operations and maintenance.
- Applicable to all domains.

Process Integration

- Requires collection and tracking of customer support requests.
- Requires formal planning and tracking of responses to all support requests.
- Response time is the length of time it takes to respond to customer requests for support. Average, minimum, or maximum time may be tracked.
- Resolution time is the length of time to adequately resolve customer support requests. Average, minimum, or maximum time may be tracked.

Usually Applied During

- Operations and Maintenance (Actuals)

Specification Guidance

Typical Data Items

- Number of requests received
- Average time to respond
- Maximum time to respond
- Average time to resolve
- Maximum time to resolve

Typical Attributes

- Type of maintenance required
- Increment
- Customer, or originator of the request
- Priority (safety hazard, critical impact, minor)
- Type of support requested (documentation, training, technical assistance)
- Request mechanism (help desk call, e-mail, Internet)
- Non-support resolution (request is beyond support agreement, cause is customer error)

Typical Aggregation Structure

- Component
- Function

Typically Collected for Each

- CI or equivalent
- Function

Count Actuals Based On

- Valid contract requests
- Customer acknowledged times

This measure answers questions such as:

How responsive is the support function to the customer?

Are customer needs and expectations being met?

On average, how long does it take to resolve a customer request?

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3

Adding Issue Areas, Categories, and Measures

Chapter 2 provides an extensive description of common issue areas, categories, and measures. However, the content of those tables only provides a starting point for measurement tailoring. It does not provide an exhaustive list of all possible measures. As explained in Part 2, new issue areas, categories, and measures may be defined during the tailoring activity. Moreover, the existing Issue - Category - Measure table (I-C-M table) may be modified to better support program and organizational needs.

As an organization gains experience in implementing measurement, it may choose to capture those new and changed definitions by updating the I-C-M tables provided in Chapter 2. The updated tables serve as an evolving repository of experience and lessons learned for the organization. This chapter outlines the steps required to enhance the I-C-M table.

3.1 Updating the Issue - Category - Measure Table

Maintaining a customized I-C-M table for an organization only makes sense when there is an organizational commitment to measurement. Each project's measurement plan identifies the tailoring of the I-C-M table to meet its specific information needs. Updating the project I-C-M table makes it possible to communicate the lessons learned in future or parallel projects. Much of the tailoring performed by one project within an organization may also be appropriate for other projects within the organization. Capturing the results of that tailoring in the organizational I-C-M table facilitates planning by future projects.

The I-C-M table may be tailored during the implementation of PSM within an organization, prior to any project tailoring. The need to tailor the organizational I-C-M table is likely to occur in situations where:

- The PSM approach is being applied outside of its pre-defined scope (software and systems engineering) or for purposes other than project management.
- The domain, technology, or specific project issues (e.g., safety) lead to the development of new measurement categories and measures.
- Recurring patterns of common issue areas, categories, and measures are recognized and the organization decides to formalize them.

Making and storing updates to the organizational I-C-M table is usually the responsibility of an organizational measurement steering committee (see Part 6) rather than the role of a project-level measurement analyst.

Before adding new elements to the existing I-C-M table, it is important to consider the following:

- **Is the candidate issue well defined?** For example, "lack of communication" often is cited as a problem or risk area. No single PSM issue can be mapped to this concern, because it is not described precisely. The obvious questions are, "What is not being communicated and to whom?" This kind of analysis usually leads to issues that can be mapped to one or more PSM issue areas.

- **Is the table deficiency actually a terminology problem?** Organizational terms may differ from those used in PSM. The issue descriptions, category tables, and measurement tables provided in Chapter 2 of the Guide should be thoroughly reviewed before concluding that the existing set does not apply. The glossary should also be consulted if terms used are not familiar to the reader. Rather than creating new elements, it may be more economical to modify an existing element to incorporate the local terminology.

- **Has the candidate measure been proven effective at providing insight into the issue?** The elements of the current I-C-M table are based on practical experience, not theoretical assumptions. Be cautious of adding unproven elements.

Updating the I-C-M table helps capture measurement experience for re-use. However, be careful that such changes reflect significant experience. Adding additional elements, especially ones that are not well-defined, adds complexity to the I-C-M table and inhibits its use.

3.2 Defining New Common Issue Areas, Categories, and Measures

The need for a new *common issue area* typically becomes apparent during the tailoring phase when a project-specific issue cannot be mapped to a PSM common issue area. The need for a new *measure*, or an entirely new *category of measures*, might arise when:

- None of the candidate measures are appropriate for target development environment

- Existing measures being collected prove invalid

- Existing measures do not provide the insight needed to address an issue.

New common issues areas, categories, or measures can be added to the existing set; elements of the current framework can be revised or adapted; and, completely new I-C-M tables can be created for non-project-oriented measurement applications. At the organization level, customizing the basic PSM I-C-M framework may be desirable to better reflect common project issues and to include those measures typically supported by the organization's process and tool set.

As new elements are proposed, it is recommended that complete issue descriptions, category questions, sample indicators, and full category and measurement tables be constructed. This level of definition clarifies why, what, and how data is being measured and provides the information needed to effectively implement measurement collection and reporting. Customization of the ICM framework should include all the above-mentioned components of PSM in addition to generation of a new I-C-M table (such as the one in Figure 3-1).

The definition of a new common issue area only requires naming it and describing the scope of objectives and obstacles it encompasses. Try to minimize the overlap with existing common issue areas. Defining new categories and measures can be accomplished by creating tables corresponding to the examples in Chapter 2. The elements of those tables have proven to be the most important characteristics of the categories and measures.

In selecting new common issue areas, categories, and measures to include in the tables, think about how these elements will be used. Their definitions must provide sufficient information for the user to decide whether or not they will provide the necessary insight. Providing sample indicators (see Part 5) helps to explain the potential usage of measures for decision-making.