Systems Engineering Measurement Primer

A Basic Introduction to Measurement Concepts and Use for Systems Engineering

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Preface

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1 INTRODUCTION

Welcome to the INCOSE Systems Engineering (SE) Measurement Primer. This Primer is an introduction to measurement for the beginning measurement practitioner in systems engineering. It is written from the perspective that the reader does not know the general philosophies shared by measurement practitioners, or has little experience selecting, specifying, and using measures. This Primer provides basic knowledge of measurement from which more specialized topics in measurement can be explored through references.

1.1 ORGANIZATION AND OBJECTIVES

The document is organized to address two main objectives. The first objective is to *define the basic concepts behind measurement and measurement programs* in such a way that they will be usable and readable, regardless of experience and background; these concepts are described in sections 2 and 3. The second objective is to *prepare and use a measurement program* by providing requisite background knowledge; sections 4 and 5 focus on this aim.

1.2 BACKGROUND

In the ten-plus years since the initial Systems Engineering (SE) Measurement Primer publication by the INCOSE Measurement Working Group (MWG), many significant and relevant activities and associated products have been developed by various industry groups.

For example:

- ISO/IEC 15939:2007, Systems and software engineering — Measurement process
- Software Engineering Institute (SEI) CMMI®-DEV and CMMI®-ACQ — Measurement and Analysis process area
- Practical Software and Systems Measurement (PSM)
- ISO/IEC 15288:2008, Systems and software engineering — System life cycle processes
- INCOSE-TP-2005-003-02, Systems Engineering Leading Indicators Guide, version 2.0, dated 29 January 2010
- INCOSE-TP-2003-020-01, Technical Measurement: A Collaborative Project of PSM, INCOSE, and Industry

The References in this document (Section 6) indicate where to go to get more detailed guidance for developing and implementing a SE Measurement program specific to the reader's project, program, organization or enterprise. A repository of measurement-related material is available to INCOSE members and persons who work for companies on INCOSE's Corporate Advisory Board (CAB) at: https://connect.incose.org/tb/SEsupport/mwg/default.aspx.

1.3 SCOPE

The measurement practices described here apply to all aspects of a systems engineering (SE) measurement process. The principle activities, tasks, and resources involved in an SE measurement process are, for simplicity, referred to as "measurement" or "measurement process" in this document.

The fundamental measurement concepts covered in this Primer include the language common to measurement practitioners (see Section 7 of this document for definitions of key terms), a description of the principles and lessons learned shared by most measurement programs and their users, and generic components of successful measurement programs. These principles are consistent with the *ISO/IEC 15939:2007 Systems and software engineering — Measurement process* and the *Practical Software and Systems Measurement (PSM)* guidebook which are among the leading sources for systems and software measurement. The contents of this Primer synthesize some guiding principles for those intending either to use measures or to set up a measurement program. Guidance is included on how to effectively use measurement, avoid its misuse, select good measures, obtain the benefits from correct use of measurement, and find references to other resources that discuss more detailed or specialized topics in measurement.

At the outset we recognize the strong interaction and overlap between Project/Program Management (PM) and Systems Engineering (SE) functions. The recommended SE measurement process described herein will help to define the types of information needed to support project/program management decisions and implement systems engineering best practices to improve performance.

Successful measurement programs are also dependent on the practitioners having a good understanding of statistical concepts before endeavoring to create a measurement program. Many of the terms and theories commonly used by measurement practitioners are derived from statistics. A few statistical concepts are mentioned or described briefly in this Primer for informational purposes only; however, this Primer will not provide the reader with any detailed explanations. It is possible to create a successful measurement program without having a solid statistical foundation, but it may make it more difficult and incurs the risk of misinterpretation of the significance of some measurement results.

2 BUSINESS VALUE OF MEASUREMENT

A measurement process efficiently delivers information to systems engineering managers who use it for decision-making. According to the *Practical Software and Systems Measurement* guide (PSM, section 1.1), measurement helps the project manager to:

- Monitor the progress and performance of activities
- Communicate effectively throughout the project organization
- Identify and correct problems early
- Make key tradeoffs
- Track specific project objectives
- Defend and justify decisions

For each of the above, measurement quantifies the relevant Systems Engineering processes or work products with respect to the needs and objectives of the project or enterprise. Common system engineering measures include timeliness, efficiency and effectiveness, performance requirements, quality attributes, conformance to standards, and parsimonious use of resources.

An important concept of successful measurement is the communication of meaningful information to the decision makers, for whom understanding what is being measured and how it is to be interpreted is essential.

Measurement also provides critical insight needed for continuous process improvement to achieve cost and cycle time reductions and/or quality or technical performance improvement.

2.1 WHY MEASURE SYSTEMS ENGINEERING?

Systems Engineering and other disciplines execute processes in order to produce their products (e.g., requirements, plans, specifications, designs, analyses, hardware, software, integration activities, and verification and validation procedures). As systems become more complex, management techniques such as measurement have evolved to allow managers to monitor and control these ever-increasingly complex development efforts.

Measurement information gathered from Systems Engineering is evaluated by managers who control the SE processes to improve the quality, timeliness, efficiency, and effectiveness of the products and supporting processes (analogous to the application of statistical process control on manufactured products). As indicated in Figure 2-1, measures focus on resources, process and work products. Measurement is a key element in the feedback control loop, indicated by green arrows in the figure, which allows monitoring of SE processes. In addition, "progress" measures take place at various points/events as the project activities are executed. Measurement data is collected and analyzed as the SE processes are performed to provide timely insight. The resulting analysis indicates the progress of various products (including interim) being generated. Measurement data for product measures, in turn, are aggregated into project measures which address overall project progress.

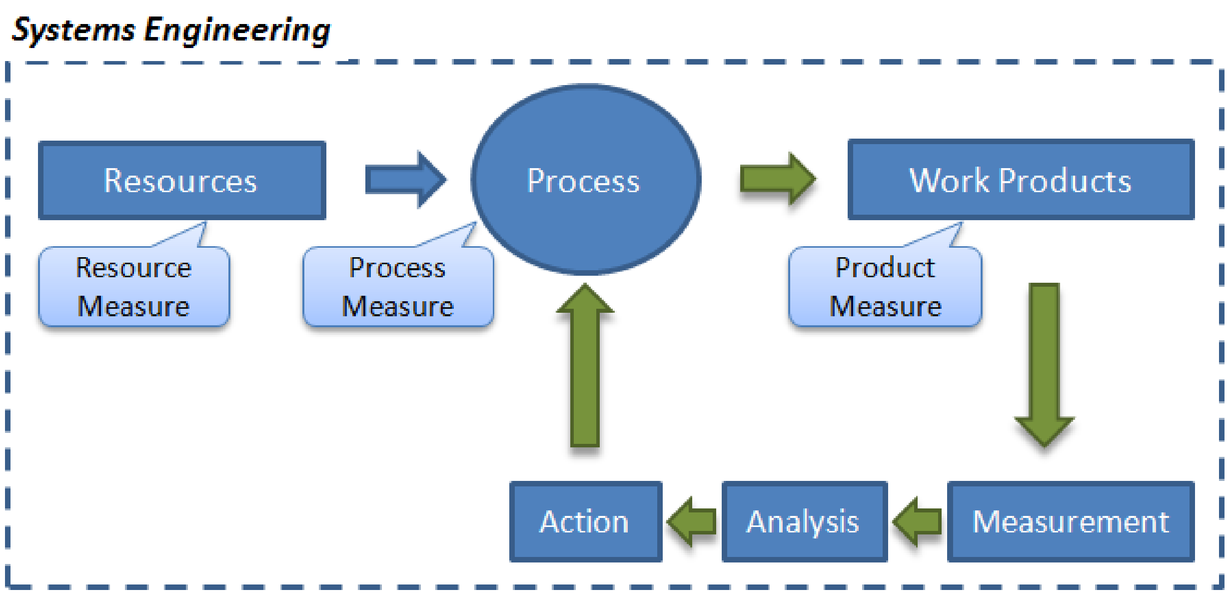

Figure 2-1: Measurement as a Feedback Control System

Process measures in this model can be used to diagnose deficient products and help understand why certain products are not satisfying requirements. For example, poor quality requirements (the product) may be due to failure to train requirements writers in how requirements should be written (the process). The latter provide direct measures of process outputs that are needed by downstream activities (e.g., requirements feed design activity, verification, etc.) Process measures also provide the information needed to produce estimates of the resources (e.g., time, effort) for an activity, as well as determine the efficiency of the process.

Measurement is also required for achieving the higher CMMI® maturity or capability levels. Starting at Level 2, the Measurement and Analysis process area outlines the processes necessary to adequately plan and define project measures. It includes processes for data collection, analysis, and reporting that are essential to establish a measurement capability. Additionally, it outlines more advanced process measurement. For example, CMMI® Maturity Level 4 (CMMI®-DEV, p. 34) requires the use of measurement in a manner that quantitatively contributes to managing the process implementation and control. An organizational capability to measure or assess conformance to process, quality of outputs or products, and effectiveness of process execution is necessary as a first step in making improvements. The products that are produced by these processes may be measured to determine quality and consistency.

Measuring the technical progress is necessary to gauge overall project progress. Generally, measures which focus on technical progress are called Technical Performance Measures, or TPMs. TPMs are used in conjunction to cost and schedule measures (e.g. earned-value management). Concepts, examples and guidance on TPMs can be found in INCOSE Technical Report, INCOSE-TP-2003-020-01, Technical Performance Measures for Systems Engineering.

Product measures that relate directly to requirements have been classified into several areas such as Measures of Effectiveness (MOEs), Measures of Performance (MOPs), Key Performance Parameters (KPPs), and Technical Performance Measures (TPMs).

2.2 PURPOSE OF MEASUREMENT

Each organization's processes and products are unique and are generally tailored for each project; therefore, any measurement program implemented for a particular process, product, or project must be tailored as well. However, some general purposes and guidelines for typical measurement performance and usage are shared by experienced measurement practitioners.

The primary purpose of a measure is to provide meaningful information regarding the quality, adequacy, and/or progress of process, project, and/or products. However, measures offer the insight needed for planning, controlling, managing, and improving:

- Product technical adequacy and performance
- Schedule and progress
- Resources and cost
- Growth and stability
- Product quality

- Life cycle process performance,
- Technology effectiveness
- Customer satisfaction

The objective of measurement is to obtain insight into issues that impact project cost, schedule, and technical (performance, functionality, and quality) objectives in order to enable the project decision makers to make informed decisions.

Applied systematically throughout the project, measurement helps to:

- Identify specific problems
- Assess the impacts of these problems with respect to all project control factors (cost, schedule, quality, functionality, and performance)
- Determine feasible alternative solutions
- Perform tradeoff analysis and select the optimal approach (for all tasks and corrective actions)
- Provide accountability of decisions
- Communicate progress, performance, and problems in a more precise, standard, objective manner throughout the organization

When the purpose of a measure is clearly defined, the chances of achieving that purpose are greatly improved. In selecting measures of interest, each measure should be considered from multiple perspectives including:

- Assessing progress in meeting performance objectives
- Identifying opportunities to improve process and product and evaluating improvement results
- Developing projections and plans with greater confidence
- Providing feedback on status and progress
- Enabling quantitative process management

Implementation and execution of the measurement program must be done in a manner that builds trust and support throughout the organization. Doubts can arise concerning the legitimacy of the measures or the value added to the process or product that is being measured and analyzed. There is often resistance to the “scrutiny” of measurement, even when the true intention is a beneficial one such as identifying ways to improve processes or products. Clearly defining the measures' purpose will help reduce the resistance and the potential for human bias (often unintentional) from creeping into the data, adding credibility to the "objective insight" purpose of measurement. Involving stakeholders in the process from the beginning will also improve trust and buy-in. Achieving acceptance for a measurement program in an organization requires that these plans and benefits be propagated to both those individuals who are involved in the measurement activity, as well as to those who are the recipients of measurement analysis results.

2.2.1 Communicate Effectively Throughout the Project Organization

Measurement is an effective status reporting tool, particularly when presented in graphical form. An example of such a measure might be on-time deliveries or requirements verification completeness. Measures provide the team with quantified information related to process, project, and or product, particularly in terms of status, progress, completion, and potential problems.

Measurement information is objectively documented and disseminated throughout an organization so that managers, executives, quality groups, suppliers and other stake holders can benefit from increased insight. Increased awareness of progress, through measurement, can reduce uncertainty and ambiguity, and improve organization focus with respect to risks and issues.

One notable improvement to communication of measurement is the introduction of a unique terminology for all concepts, activities, tasks, and entities pertaining to measurement. One part of this specific vocabulary includes a migration away from the term "metric." The word "metrics" is used in many organizations to refer to measurement concepts and practices discussed in this Primer. However, the term "metric" is not consistently defined or used within these organizations, nor is the term defined in measurement standards (e.g., ISO). In different organizations the term 'metric' is used to mean the data collected, the measure definition, the processed information presented and the process performed all at the same time, making it context dependent, ambiguous, and confusing. See Section 7 for definitions of key terms.

Additionally, ISO/IEC 15939 defines a measurement information model that includes a very specific vocabulary to remove ambiguity and aid communication between the measurement analysts and the decision makers.

2.2.2 Identify and Correct Problems Early

Measurement provides objective information to allow managers to identify problems and to take action to limit the impact of problems on the Systems Engineering effort. Measures help identify and manage risks before they become issues, and help identify root causes of problems to determine appropriate corrective and preventive actions.

The Systems Engineering Leading Indicators Guide version 2.0 (INCOSE-TP-2005-001-03) provides measures focused on early technical insight that can be used in conjunction with the risk management process. These early warning measures identify technical risks that warrant earlier "course corrections" to prevent risks from becoming problems. Using leading indicators for predictive correlations (i.e., current values that predict a future state) as well as establishing trends (i.e., how the measurement changes over time predicts a future state) are both valuable approaches to integrating SE measurement with risk and opportunity management and avoiding problem resolution and the need for corrective action.

2.2.3 MAKE KEY TRADEOFFS

In Systems Engineering projects, managers must often choose between two or more alternatives to make key tradeoffs. The measurement process provides managers with information that quantifies different aspects (e.g. maintainability, design cost, reuse) of each alternative. Measurement provides data that allows managers to make objective tradeoffs based on credible facts, rather than subjective ones.

2.2.4 TRACK SPECIFIC PROJECT OBJECTIVES

Progress with respect to achieving technical and management objectives can be measured so that decisions can be made to continue with current plans or to make revisions.

2.2.5 DEFEND AND JUSTIFY DECISIONS

Measurement provides the information for making decisions, and can be retained to defend and justify later questions about the decisions made.

2.3 USES OF MEASUREMENT

Measurement addresses the purposes identified in this section by helping the organization to do the following (see SEI/CMMI/MPM):

- *Characterize* or gain an understanding of their processes, project progress and/or products and establish baselines for future assessment of these
- *Evaluate* or determine project progress with respect to plans
- *Predict* resources, schedule and performance to support planning and trades
- *Identify* improvement opportunities for progress, processes and/or products, such as roadblocks to progress, root causes of problems in products, and inefficiencies in processes

2.3.1 Characterize: Gain Understanding of Products and Processes

2.3.1.1 Measuring Process Performance

With organizations trying to do more with fewer resources, process measurement is critical in understanding process efficiency and effectiveness. Additionally, most process improvement frameworks, such as capability models, require some level of process measurement at each level above the model's initial level.

Measuring process performance starts with identifying the measurable attributes of the process. These should then be assessed against organizational objectives to select the attributes that will be measured. Periodic measurement of these attributes is the basis of *characterizing* the organization's performance of that process. The data can be tracked against the business objectives to *evaluate* the performance and used to identify those attributes of the process that are the highest priority to *improve*. See the SEI MPM reference for more information.

2.3.1.2 Measuring Technical Performance

In the engineering of a system, Technical Performance Measures (TPMs) are a very common form of product measurement that also provides insight into project accomplishment towards the technical goals. An example of a TPM is the *weight* of the end-product, such as an aircraft, where the product must be delivered weighing less than a certain amount. Throughout the project, as components are designed, selected and integrated, the overall weight expressed as a TPM is calculated and monitored.

TPMs are critical technical parameters that a project monitors to ensure that the technical objectives of a product or project will be realized. Typically, TPMs have planned values at defined time increments, against which the estimated and actual values are plotted. Collection of TPMs allows trend detection and correction, and supports risk identification and assessment, thereby providing feedback information to identify potential performance problems prior to incurring significant cost or schedule impacts.

TPMs are selected by identifying the elements of the system for which performance is critical. Review of the systems engineering documentation and requirements specifications help identify these elements and the necessary planned values. However, the number of TPMs selected at the system level must be kept small to be cost-effective, since each system level TPM may be supported by several lower level, more detailed parameters. Thus, only the most critical parameters should be selected and the following criteria should be considered in the selection process:

- The parameter is one of the best indicators of the total system performance
- The parameter is directly measurable and easy to analyze and interpret

- The parameter can be defined with relatively meaningful tolerance bands

TPMs can be related to any functional aspect of the system; software, hardware, operations, or logistics. See the DSMC SEMG reference for more TPM information.

2.3.2 IMPROVE: IDENTIFYING AND EVALUATING IMPROVEMENT OPPORTUNITIES

Measures are analyzed and combined to form indicators that provide the insight needed to identify opportunities for improvement. Opportunities for improvement are identified by analyzing actual measured process, product, or project attributes against target values and business objectives. Where variances exist are potential areas for improvement opportunities. These are then evaluated and prioritized based on the severity of the variance and the importance of the objectives. When improvements are made, measures are essential to discerning if the improvement activity has a favorable outcome. Although anecdotal information can indicate that a process or product has improved, only measures can *quantify* the improvement. Of course, the measurement information must be recorded in the same manner for both the initial and end states. As an example, a measure such as specification defects can be monitored in an effort to improve the specification development process and provide evidence that the improvement action was successful.

2.3.2.1 ENABLING QUANTITATIVE PROCESS MANAGEMENT (QPM)

The purpose of QPM is to control the process performance of a project quantitatively. QPM, a key element of process maturity and assessment models such as the CMMI®, involves establishing goals for performance of processes, collecting and analyzing the measures of process performance, and making adjustments to maintain process performance within acceptable limits. This goal is more extensive than simple process improvement; it requires every player in an organization to be involved in not only the collection and analysis of measures, but also in the use of measures to aid identification and monitoring improvement opportunities in every element of the performance of business processes.

2.3.3 PREDICT: FACILITATING PROJECTIONS AND PLANNING

Projections and planning are improved by the availability of historical data. The data is used to formulate statistical and causal models for predictions. New projects can be budgeted, scheduled, and planned much more effectively if measures which provide historical data on previous similar projects or products are used. Organizations begin by compiling a database of information. As more data is collected, better baselines and control limits are established. Periodically, estimation models should be calibrated against this historical data.

2.3.4 EVALUATE: PROVIDING FEEDBACK AND STATUS

Measures can provide valuable feedback to the team or customer. A measure such as *customer satisfaction*, typically measured using a survey, provides feedback on the overall satisfaction with a product or service. A *product penetration* measure provides feedback on how well the organization has done in penetrating a given market. *Team effectiveness* measures based on surveys provide feedback to the team on how effective the individual members perceive the team to be.

2.4 SUMMARY

As part of an SE Management closed-loop feedback control system, a measurement-based feedback process improves the effectiveness and efficiency of the project team by:

- Analyzing trends that help focus on problem areas at the earliest point in time
- Providing early insight into error-prone products that can then be corrected earlier and thereby at lower cost
- Avoiding or minimizing cost overruns and schedule slips by detecting them early enough in the project to implement corrective actions
- Identifying complexities in the requirements development, design, technical performance progress, etc., to enable a focus on risk areas
- Performing better technical planning, and making adjustments to resources based on discrepancies between planned and actual progress

3 MEASUREMENT PROCESS

A measurement program is a systematic and repeatable process and infrastructure that delivers objective information to managers and other stakeholders. The measurement process, like other systems engineering processes, should follow a documented plan which describes the goals and business value of the process, and should be evaluated periodically.

A measurement process is much more than the data collected and the calculation of an indicator. Effective measurement requires planning of what will be measured, how the measurement will be performed, how frequently the measure will be taken, how the data will be analyzed, what reporting is needed, what actions will be taken from the results, and who is responsible for each of these activities.

3.1 MEASUREMENT PROCESS OVERVIEW

Measurement needs to be viewed as a process for obtaining vital insight into the progress, products, and/or processes of the project/program/enterprise or system(s) being developed. Measurement should not be viewed as a set of predefined measures that never change throughout the project. Instead, the measurement process needs to address the current issues/concerns/objectives at hand and should change to address evolving engineering and business needs.

The measurement process provides the mechanisms for identifying and addressing information needs of all types and levels. This process consists of a set of activities that are generally applicable, regardless of the specific information needs of any situation. It addresses both the selection of appropriate measures to satisfy the information needs and the collection and analysis of the data. Figure 3-1 provides a synthesized representation of the measurement processes described in ISO/IEC 15939, Practical Software and Systems Measurement (PSM), and the Capability Maturity Model Integration Measurement and Analysis Process Area. Each of these authoritative measurement references portrays the process activities of a measurement process in very similar ways. (Note: one reason for this is that some of the same people (including INCOSE members) were involved in the development of each standard or model.) This section provides an overview of these common measurement process activities, or sub-processes. Subsequent sections go into more detail.

Figure 3-1 identifies four iterative activities: establish, plan, perform, and evaluate. Together, plan and perform are referred to as the “core measurement process” because these are the activities that interact most intensely with measurement users. The Technical and Management Processes represent the project’s decision-making activities. The project's information needs are derived based on the project's goals, objectives, risks, and known issues.

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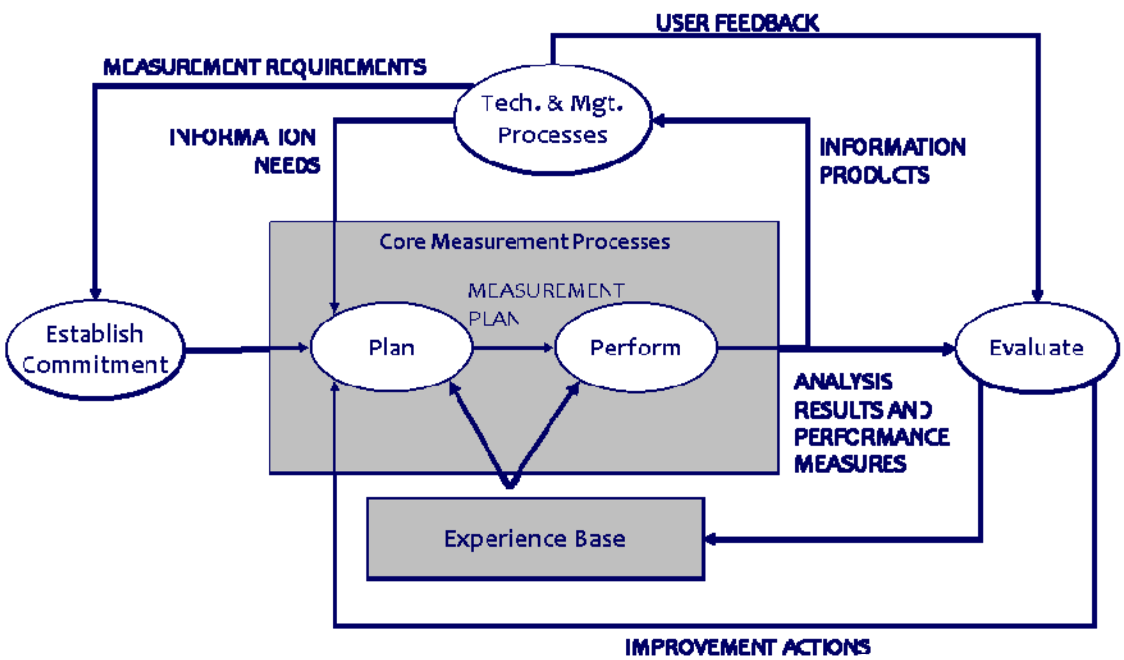

Figure 3-1: Measurement Process

3.1.1 Establish Commitment

The recognition of specific information needs provides a motivation for implementing a measurement program. However, the deployment of an effective measurement program usually requires a change in organizational culture and infrastructure. This change cannot occur without obtaining the management commitment to create an environment in which measurement can be successful. Commitment involves (1) defining the focus and scope of the measurement program, (2) providing funding, resources, and training, and (3) participating in the process as a measurement user.

3.1.2 Plan

This activity focuses on developing a plan (i.e., the what, why, who, when, and how) to implement a successful measurement program. Sufficient planning avoids some of the common problems encountered in measurement implementations, including the following:

- Having a lot of data but no actionable information
- Lack of data integrity
- Misuse of data

The planning activity helps to overcome these problems by first identifying key decisions that come from the intended measurement user population. (e.g., what does management need to know – why and when?) These decisions are used to derive information needs which are used to select a specific set of measures and subsequent calculations and analyses. The plan does not need to be a formal document. It can be incorporated into other planning documents as long as the measurement activities are defined and communicated to all involved. See §3.2 for more elaboration.

3.1.3 Perform

The execution of the developed measurement plan should yield the intended information products. An 'information product' is the resultant report, analyses, etc. of a measurement program which is the mechanism for communicating measurement results with decision makers. Data collection, analysis and reporting activities that follow defined procedures increase the likelihood of success. Additionally, the measurement process must be responsive to changes in project information needs and be responsive to decision maker inquiries. While a standard set of analyses and reports usually are defined for routine reporting, a successful measurement program has the ability to generate follow-up questions and insights into performance. It is during the 'perform' activity that a measurement database is created and populated. See §3.3 for more elaboration.

3.1.4 Evaluate

This activity involves both measuring the performance of the measurement process itself and evaluating feedback from measurement users. Essentially this is a quality assurance and process improvement activity. See CMMI® for more details. An experience created during the 'perform' activity identifies needs to be captured, usually in an experience database, so measurement assets and lessons learned can be leveraged to improve the measurement capability over time. This experience base can range from a simple collection of testimonials about specific measures and the measurement process to a comprehensive database of lessons learned. Note that this database is used not only to improve current measurement processes, but is also used in future projects for planning and estimation.

3.2 PLAN MEASUREMENT

The act of planning is considered one of the most important measurement best practices, whether the focus is for an enterprise, project, process, or product development. As a saying goes (source unknown)...

> *'If you don't know where you're going – how do you know you made it, or are heading in the right direction?*'

Much evidence supports that good up-front planning saves more effort and resources in the long run. *Pay now or pay more later!* This applies to planning your measurement program also.

More specifically, the planning activity, and its resultant Plan, will help project and technical (e.g., Systems Engineers) management and their staff meet cost, schedule and technical performance objectives. The resulting measurement plan provides a basis for informed decision-making and establishes a foundation for project, organization, and enterprise performance.

Measurement must be viewed as a process: collected measure data and the associated analysis must meet specific project information needs. Measures selected during the planning stage should be based on data available from technical and management processes and products. The specified level of detail (of each measure) should relate to the identification of specific problems, issues, and risks – what has gone, or may go, wrong in the project. Measurement provides a basis for *objective* communication among the staff, management, users and other stakeholders. An example measurement plan template can be found at PSM or SEI sources noted in the Introduction and References sections of this Primer.

The basic steps in planning measurement are described in the following sections.

3.2.1 ALIGN MEASUREMENT WITH ORGANIZATIONAL NEEDS

Higher levels in the organization may require standards (e.g., best practices for measuring reliability performance) and specific information needs (e.g., resources, productivity) for continuous process improvement and aggregate measures of the health of the organization/enterprise. This Primer, however, will focus on the lower levels of application (i.e. product, process, or project).

3.2.2 IDENTIFY AND PRIORITIZE INFORMATION NEEDS

Information needs, which vary from project to project, drive the measurement process. Thus, there is no "one size fits all" set of measures. Instead, technical and (other) management processes provide a set of information needs which act as the requirements of measurement.

As a starting point, the project management team (which should include lead/chief system engineer) and stakeholders identify the information needs specific to their project and prioritize them. Per PSM, there are several typical information needs categories that apply to many projects. The following categories help identify project-specific information needs:

- Schedule and Progress
- Resources and Cost
- System Performance
- Growth and Stability
- Product Quality
- Life Cycle Process
- Technology Effectiveness
- Customer/User Satisfaction

Inputs to this step are the objectives, issues, environment, risks and other information needs. The following are some typical sources for these inputs:

- Project risk analysis
- Project constraints and assumptions
- Product acceptance criteria
- Known project problems
- Project goals and objectives
- External requirements or dependencies

Criteria for prioritization rely on constructing a set of criteria and associated weights which represent the importance of each criterion to the decision makers. This ranking will be tempered by the effectiveness and efficiency of gaining such information (i.e., is the effort to gain the needed information worth the cost?)

3.2.3 Specify Measures that Satisfy Information Needs.

Top-level information needs are usually defined as ‘Indicators’ that are derived from base measures related to some attributes (i.e., the ‘raw’ data) which is converted/ translated into useful information for decision makers. There are several templates that one can use to define and describe the measurement approach (see PSM, CMMI®-

DEV: Measurement & Analysis process area). Furthermore, both PSM and SE leading Indicators references provide good examples.

The following describes characteristics of good measures:

- **Relevance -** "Why do I want to collect this measure? Is there ambiguity in what it is trying to accomplish?" Only select measures that do not have numerous interpretations and that are pertinent to an end result you are trying to obtain.
- **Completeness -** "Have I covered all the bases? Have I left out a key parameter that is needed to analyze my results? Is there a need to weight one parameter more than another?" Be sure you identify a balanced set of measures and that your emphasis does not become skewed.
- **Timeliness -** "Did I find out what I needed to know in time to make a difference?" Be sure collection and analysis will provide the needed information in time to allow corrective action to be initiated.
- **Simplicity -** "Can I collect and analyze the data easily and cost effectively? Can the users/managers understand what it means?" Keep it as simple and logical as possible. The measures should be easy to collect, analyze, and understand.
- **Cost Effectiveness -** "Can I afford it? Can I *not* afford it? Does it provide more value than it costs?" Use data that is economical to collect. Use organizational or customer required data to address other project issues, where applicable. Leverage data collected for current management practices.
- **Repeatability -** "Will the same conditions provide the same answer twice? Is the accuracy and precision adequate?" This is important for comparing measures across projects.
- **Accuracy -** "Is my data really relevant to my purpose? Are my measures reliable? Am I measuring at the appropriate time?" Accuracy of a measure is the extent to which the numeric value of a measure truly represents the entity being measured.

It is important to specify measures in an unambiguous manner. A measurement specification serves as the common set of instructions for obtaining, evaluating, and correctly interpreting the measurement data. Each measure needs to mean the same thing to each practitioner. The measure specification should include:

- A clear definition of the measure
- Data types
- Data collection frequency (on a periodic basis, not event driven basis; usually monthly/weekly)

- Data preparation required
- Level and scope of measurement (At what level is data collected? What activities is it collected from?)
- Applicable phases for the measure and data collection
- Interpretation notes

3.2.4 Define Data Collection, Analysis, Storage, and Reporting

The measurement process and procedures should be integrated into the project's technical and management processes to the extent possible. This minimizes resources used and possible sources of errors and miscommunication. In other words, to the extent feasible, use data obtained or readily available from current or planned project activities rather than introduce a new measurement activity.

A clearly defined and repeatable procedure should describe the method of data collection. This procedure must identify the point(s) in time when the data will be collected, what (if any) tools will be used to accomplish collection, the people responsible for collecting the data, how the data will be validated, and what is done with the data once it is collected (storage and preparation). A simple example of a data collection method could be that on the first day of every month, a project member will be responsible for manually totaling the number of defects found in a particular product by any customer since the beginning of the previous month.

The measurement analysis that will be performed following the data collection can only be as good as the data that goes into the analysis. Therefore, it is important to validate and verify the data that is collected. To help ensure that data collected is valid, the following should be attributes of the data collection activities, with someone given responsibility to ensure the action:

- All contractors and subcontractors should participate in the data collection
- Delivered data is periodically audited for quality, regardless of whether the data is delivered from an internal or external source
- Determination of data/measure combinations, comparisons, and other analysis needed is communicated to all responsible parties (including developers or maintainers)
- Data collected is demonstrated to be valid by the collecting party and is verified for adequacy

3.2.5 Define Criteria for Evaluating the Measurement Process

It is important to not only evaluate the validity and effectiveness of the measures themselves, but also to seek improvements to the measurement process for efficiency gains at the project level or higher levels of the organization. Usually a failure in a product requirement can be attributed to some aspect of the process that produced it – including the planning itself, lack of effective training, lack of good tools, etc.

3.2.6 Allocate Resources to Measurement – Consider Human Factors

In this step, the organization determines the level of commitment that it will provide to the measurement process. Commitment is essential throughout the measurement process. An organization's commitment is the number of staff, budget, facilities and other resources that will be allocated to measurement. The extent of commitment drives the scope of measurement. The organization should finalize its commitment before measurement planning is initiated, and also before approving the Measurement Plan.

Cultural and organizational changes and implications must be anticipated. If they are not, they often become the major obstacle in establishing a successful measurement program. For example, performance measures of a process will often provide information and insight that ultimately leads to a more effective and efficient process. This enhanced process may require less effort and reduced staff to perform the same function.

Management should allay employees' anxiety of job loss, while still promoting the trustful environment of process introspection that is required for maintaining a viable measurement program. Without proper planning and communication regarding these factors, data will be biased, or perceived to be so, and the measurement program may be rendered ineffective.

3.2.7 Acquire and deploy supporting technologies.

Acquiring tools, appropriate staff skills, and training are critical to the efficiency and effectiveness of the measurement program. All stakeholders must have a common understanding of the what, why, who, when and how. Tools are important to minimize effort, to reduce sources of human error, and to provide timely, accurate, and useful information.

The Measurement Plan embodies the results of this Plan Measurement activity for baselining, training, monitoring, and communicating.

3.3 PERFORM MEASUREMENT

The purpose of the "Perform Measurement" activity is to implement the measurement plan within the project to provide the decision makers with the right information at the right time. The data collection and processing, data analysis, communication of measurement results, acquisition of staff and tools, and training all take place in this measurement activity.

Some key principles for performing measurement are as follows:

- This activity provides a systematic method for obtaining and converting data into usable information for decision makers.
- Like Planning, Performing should be flexible and robust to adapt to changing information needs, constraints, etc.
- Collection, analyses, and recommendations are the primary tasks of this activity.

The basic steps in performing measurement are described in the following sections.

3.3.1 INTEGRATE MEASUREMENT INTO RELEVANT PROJECT PROCESSES

Each information need in the measurement plan requires data to be collected from engineering and management processes, in order to construct measures. To gather required data, the measurement process must be integrated into other processes.

To the extent feasible, use current project processes, procedures, tools, and staff to collect and process appropriate data; be sure to communicate the purpose of the measurement data to all participants. Staff may require training in methodologies and tools.

3.3.2 COLLECT, PROCESS, STORE AND VERIFY MEASUREMENT DATA

Automate, as feasible, data collection and processing functions to be more cost effective and efficient. Additionally, collected measurement data must be verified by, for example, ensuring that values are in the correct range, scale or set of allowable states/values. The measurement templates developed during the planning process should be used for collecting, processing, storing, and verifying the acquired data.

3.3.3 ANALYZE DATA AND DEVELOP INFORMATION PRODUCTS

Appropriate trained and skilled quantitative analysts oversee the analysis procedures. Again, to the extent feasible, this is automated (e.g., statistical regression or trend analyses). The raw data are transformed into indicators that are useful to the decision makers and that relate to measurement objectives, issues, risks and constraints.

Interpretations and conclusions are drawn by the analysts and stakeholders. It is important to periodically assess the current results against the assumptions that made up the original plan to determine if they remain valid or if adjustments are needed.

In more detail, the key analysis activity includes estimating, assessing feasibility of measurement and related plans, tracking performance against plans, identifying issues, problems and risks:

- *Estimating* is based on a database from previous projects or other methods to assess effort for the project/activity envisioned; data collected and validated with lessons learned are then included in the database from this project for future estimation efforts.
- Assessing *feasibility* relates to placing all estimation in context and then determining whether it still makes sense and that the resources estimates, schedule, and performance appear realistic – it's a sanity check usually performed by an integrated product team (IPT) lead.
- Tracking *plan vs. actual* is basic project management; if the differences are significant, or portends by trend analyses that it may fall outside expected limits – then action is necessary to quickly 'fix' the problem or place in a risk database for mitigation activities to monitor.

  Additional analyses, including modeling and simulation, may be necessary to determine root cause, and/or assess alternative solutions.

3.3.4 DOCUMENT, MAKE RECOMMENDATIONS AND COMMUNICATE RESULTS TO MEASUREMENT USERS.

Prepare results with interpretation and recommendations to be provided to decision makers. Decisions can lead to the following types of actions:

- Choosing an alternative based on analyses
- Changes/modifications to project plans or processes
- Actions to fix problems
- Developing risk mitigation plans
- Obtaining additional data/information to better understand issues/risks
- Reallocating resources

Information should be clear, concise, timely, accurate, and relevant.

The failure of a measurement program can usually be attributed to either poor Planning and/or poor execution of this Performing activity.

4 APPLICATION GUIDANCE AND LESSONS LEARNED

For those embarking for the first time into the world of measurement, and perhaps beginning to plan a measurement program, there are some factors about measurement and lessons learned that are helpful to know. A description of the right and wrong ways to use measurement, some helpful hints about creating or maintaining a good measurement program, and some considerations of the influence that human factors can have on measurement programs are provided here for your assistance.

4.1 CONTRASTING CORRECT AND INCORRECT USES OF MEASUREMENT

Measures that are used correctly will promote understanding and motivate proper action. But what happens if a measure is used incorrectly? What is the right or wrong way to use measures? This section answers those questions by listing the effects of using measures both in a constructive way and in a destructive way.

A measure used correctly:

- Has value to the user/customer, or as an attribute essential to user/customer satisfaction. The users of measurement can be people internal or external to the organization – they can all be stakeholders of the measurement program.
- Tells how well organizational goals and objectives are being met through processes and tasks.
- Stands the test of time. A measure that is used continually and is an accepted part of an organization's processes is most likely one that is being beneficial to that organization.
- Is the basis of indicators that provide insight that drives appropriate action.
- Is understood by all using it.
- Is accurate.
- Minimizes biases by being independently audited/assessed to ensure correctness.

Measures are not always used appropriately. How do you know if a measure is being abused? You can recognize an *incorrectly* used measure if it:

- Is interpreted as team or personnel control tool? When the measure is purposefully used in this way, a natural result will be people feeling distrustful, and "gaming" of the system will occur.

- Lasts forever. Not all measures are appropriate to all phases of the lifecycle. There is no "perfect" measure; measures need to adapt to products and processes as they evolve within a changing environment, conditions, objectives, etc.
- Is used as an absolute. A single measure by itself is rarely an absolute indicator of anything.
- Only collecting/using data that are available to make a point (possible bias!)

4.2 TIPS AND RULES OF THUMB

Although measurement cannot guarantee program success, it will provide insight to make better decisions. The objective is to obtain the best insight possible. To facilitate this, a set of lessons learned from successful measurement practitioners has been pulled together. This set of tips and rules of thumb for making measurement a more effective project management tool and increasing the measurement program's probability of success are as follows:

- While it is possible to measure just about anything, the limitation of resources demand that we limit measurement to those items that can lead to better decisions and help us improve SE and project performance. Projects should resist performing measurement to simply "check the box" without clearly understanding how the information will be used to make decisions, as this leads to greater cost without realizable benefits or linkage to decision-making.
- Project issues (risks, concerns, constraints, and objectives) should drive the measures and indicators selected. Constrain the measures to those measuring process, product, or project attributes that require additional insight.
- Make sure that any standard (core) set of measures is kept small (try not to exceed 6). This will allow for comparison across the organization and across projects without significantly impacting the use of measures for project specific insight. Additional measures should be based on project/product specific goals, objectives, issues, and risks.
- Assign a measurement process "owner."
- Measures and their analysis should be traceable to issues, decisions and corrective actions. This allows better evaluation of the usefulness of the measures and provides better project accountability.
- Re-evaluate your measurement program at regular intervals. Is it working? Is adjustment needed to the process or measures used?
- You cannot measure what is not defined. For process measures, ensure you have a process defined first.
- Historically, people resist the idea of being measured. Find a way to use measurement in a positive, team unifying role.

- Measurement should be an integral part of the program management process throughout the entire life cycle and used as part of the basis of decisions.
- The measurement process should be a planned and natural part of the technical processes. This will minimize the amount of effort needed to collect data. Where possible select measures that require data that is naturally available in the development process. A data collection method that can be tailored to become part of the routine work that must occur anyway has the best chance of not being labeled as an additional burden.
- Try to automate data collection and reporting as much as possible. This removes potential bias in the data and provides data in a regular, timely manner.
- Measurement results should be interpreted in the context of other sources of information. When measurement results are combined with other program data, better insight can be gained of actual problem existence and the root cause of the problems. This insight is needed to make effective decisions. The types of data that are combined are dependent on the purpose of the measurement.
- Estimation models should be calibrated with actual historic data.

When analyzing measurement data, keep these tips in mind:

- A tool introduced to observe processes and/or products will, by its very nature, influence the output. Be aware of the influence that introducing a measurement program is having to avoid misdiagnosing an improvement as being the result of process or product changes.
- There may be multiple factors affecting the results, confounding the analysis and the decision maker.
- Correlation between two variables does not necessarily imply that changing one causes a change in the other!
- Projecting a trend based on history is likely to provide incorrect interpretations if you do not understand all of the underlying factors. For example, say you identify a trend of having a low number of defects found per widget. You might be tempted to expect to continue to measure low numbers of defects. But if you are not in a test mode, then it would be expected that low numbers of defects would be found until a test mode is entered. A sudden jump in the number of defects found per widget would be unexpected unless the underlying factor of current mode of operation is taken into account when analyzing historical data.
- Scaling factors and weights can distort or hide information.

As with any good organizational initiative, a successful measurement program requires preplanning. This planning will improve management's ability to obtain and comprehend the information yielded by the measurement results and assists making appropriate improvement changes. Encouraging management to define their goals and expectations for achievement will also increase their participation in the preplanning phases. As a minimum, the planning effort should include consideration and definition of the following:

- Project/process/product issues. The issues identified drive the aspects of the project, process, or product which are targeted to be measured and improved. Some examples include any organizational goals and objectives, process improvement objectives and evaluation criteria/guidelines, risks, concerns, and programmatic or technical constraints.
- Measures and their specifications. As a minimum, specification of the measures includes its definition, data collection required, and interpretation notes.
- Specification of data flow. This could include data sources, frequency of data collection, the method for collection, and, if required, the delivery method of the measurement results.
- Measurement aggregation structures (i.e., what level of summarization is needed to provide the appropriate insight for each level of decision).
- Frequency and type of analysis and reporting.
- Lines of communication and interfaces (defining discrete channels for open and honest two-way communication).
- The roles and responsibilities of all involved parties. Some typical roles that are defined for measurement programs are the measurement analyst, the collector of the measures, and the customer of the measurement results, which can be the program management team, the end-product customer, and other decision makers.
- The awareness and cooperation of the organizational cultural changes that will be made. Possible ways to help people become aware of the changes that will occur are to support training, mentoring, open discussions, policies that minimize misuse of measurement, and the communication of the expected reactions to the changes.

5 EXAMPLE MEASURES

In Section 2, three different types of measures were discussed: Process, Product, and Progress. This section will illustrate a measure from each area and how each one is used in the SE process. The measures chosen for this section were selected as being representative of each of the types of measure. They are not necessarily advocated as the measure one should use for all organizations. As emphasized earlier, the measures selected should be based upon specified goals and objectives. Remember that in an actual application of these or any other measures, all applicable measures and project information that is available should be used to support making decisions. Use extreme caution if you decide on a course of action based upon a single measure in isolation!

5.1 EXAMPLE PROCESS MEASURE: REVIEW RATE

This measure is obtained from the Development Team and can be used by the management, the development team, and any individuals concerned with the quality of the review process. The number is usually calculated on a project basis but compared against the results from similar projects. This comparison might involve using statistical control charts to insure that adequate time is being spent in the review process.

This measure is obtained by dividing some measure of size for the project by the cumulative amount of time spent in preparing for the review. Size can be determined by such factors as: number of requirements, number of documentation pages, number of test items covered, or number of lines-of-code covered at the review. The important issue is to agree on one measure of size and then use it for all the projects so that valid comparisons can be drawn. This rate can be calculated for designated reviews during the development process and then compared against other projects' review rates from their equivalent stages in development. If a given project violates the statistical control limits, the development team needs to ask why. This rate can also be correlated with number of errors found.

Figure 5-1 is an example of a plot of this measure along with the corresponding statistical control limits that are derived from other projects' review rates at those same points in the development schedule. The X-axis represents the time at which the designated reviews occur, while the Y-axis is the review rate. The calculated review rate for the project of interest and the associated quality control limits are plotted on this graph. As can be seen from the graph, at the third major review, the review rate is higher than the control limits. This may indicate that not enough time was spent in reviewing the material. Inadequate time spent in the review process could result in system errors going undetected until later development phases. Defects found later in development are more costly to fix than are defects found earlier in development, and this measure may be one indicator of either an increase in cost to fix problems found late in development or a decrease in quality of the end product (for those defects that go completely undetected).

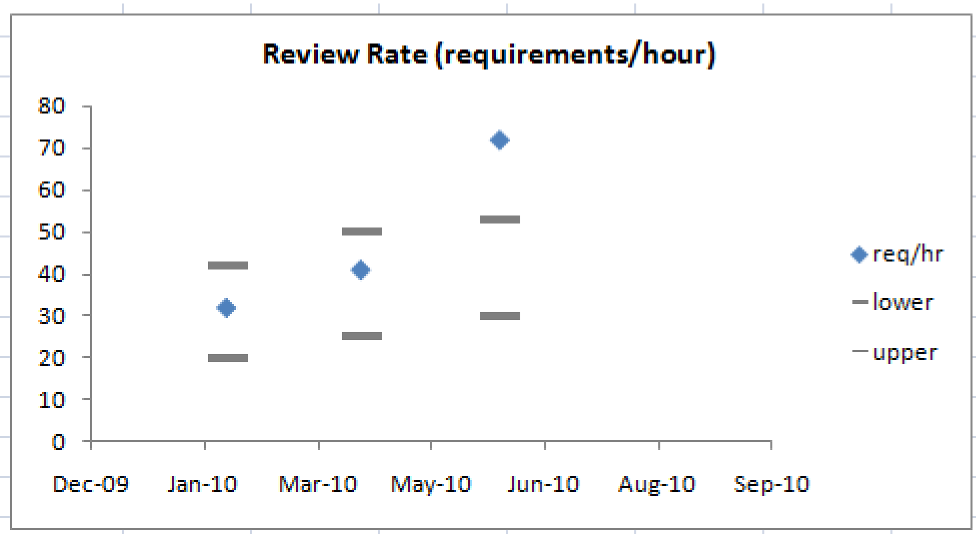

Figure 5-1: Plot of Review Rate

5.2 EXAMPLE PRODUCT MEASURE: DEFECT DENSITY

This measure reflects the weighted average number of major defects per standardized system engineering "size" of a given project within an organization. A "defect" might be defined as any deviation or omission from the system's requirements; namely an error. By major defect we might mean one that would result in the system not being able to perform its mission. Each organization would need to define its own "severity" classification and then decide upon which levels of that scheme constitute major errors. Standardize "size" can be measured as: number of requirements, number of Function Points, number of documentation pages, number of lines of computer code, etc., standardized by an appropriate factor. The important factor is to determine a common measure of "size" within the organization for every product. The information needed to calculate Defect Density can be found in an organization's problem reporting database and measurement database (or equivalent database that keeps the "size" of the project). The user of this measure would be the organization's management, the various project team leaders and developers, and anyone else concerned with tracking the quality of the organization as it pertains to product quality. This measure would be reported on at least an annual basis to provide the overall organization's quality trend. This measure could also be tracked per project and reported at each major milestone review.

For our example, suppose we consider “size” using the number of system requirements with a resizing factor of 100. Suppose we have three projects with respective weightings assigned as .50, .25, and .25. Leadership feels that Project 1 (.5) is twice as important as the other two. (Determining weights is a highly subjective judgment. If leadership does not specify the weights to employ, equal weighting can be used.) Suppose for the last four years that the value of this measure has been reported as 3.7, 3.4, 3.2, and 3.1. For this year, the cumulative total number of requirements for each project was respectively 800, 700, and 300 respectively. Resizing these values by 100 yields 8, 7, and 3. Suppose from the problem report database we find the cumulative number of major defects for each of these projects were: 16, 4, and 20, respectively. Then the value of this measure for this reporting period is the weighted sum of the resized defects rate per 100 requirements:

$$\text{Defect Density} = .50*(16/8) + .25*(4/7) + .25*(20/3) = 2.8$$

The organization is therefore "averaging" across the three projects about 2–3 major defects in every 100 system requirements. If we plot this measure over time, we can see how well the organization is doing in improving quality. This is illustrated in Figure 5-2.

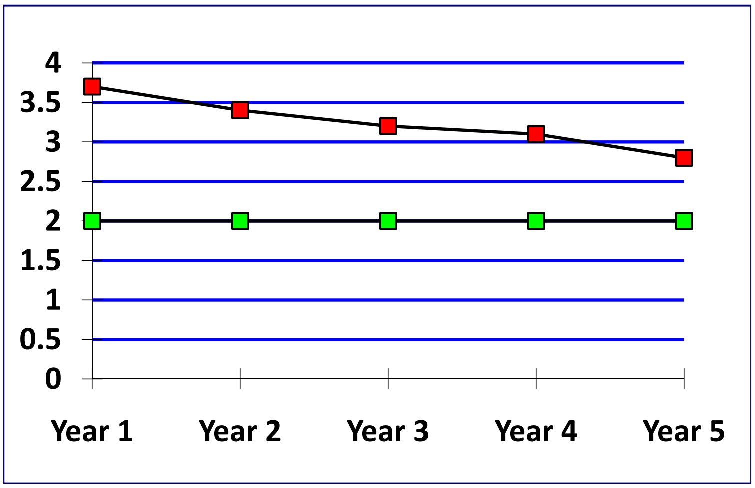

Figure 5-2: Defect Density Plotted Against Year

In the plot we see the organization's goal is two major defects for every 100 system requirements. The organization has shown steady progress to achieve that.

5.3 EXAMPLE PROGRESS MEASURE: REQUIREMENTS STABILITY

This is a measure that reflects the number of requirements that have changed (e.g. added, modified, or deleted from the last baselining) divided by the current number of baselined requirements. The higher this number is the more unstable the requirements appear. Low values indicate stability. If the requirements are changing too fast, this introduces problems in all areas of the system development, especially in meeting schedule and keeping within budget. The data for this measure is obtained for a given baseline from a requirements baseline management database or equivalent. This measure can be reported weekly or monthly depending upon the needs of the organization and the nature of the project. This measure is of interest to project management and the system developers.

For an example of this measure suppose from the last baseline: 5 new requirements were added, 6 deleted, and 10 have been modified for a total of 21 changes. Suppose that there are 100 requirements at the current baseline. Thus, the requirements stability measure is:

Requirements Stability (present) = 21/100 = .21.

Suppose for the past 6 baselines of the system, the values were 1, .6, .5, .3, .27, and .18 respectively. (Notice if we have a new system development the value of this measure is initially 1 since we have all new requirements.) Figure 5-3 shows a plot of this measure against the baseline version number with baseline 0 being the start of this new system. As we can see from this plot the requirement changes are slowing down indicating the number of changes is getting smaller. We see that we have achieved our goal of no more than 25 requirement changes per 100 requirements by baseline 5. Also we can get an idea of how fast we are achieving this stability by looking at the slope of this curve.

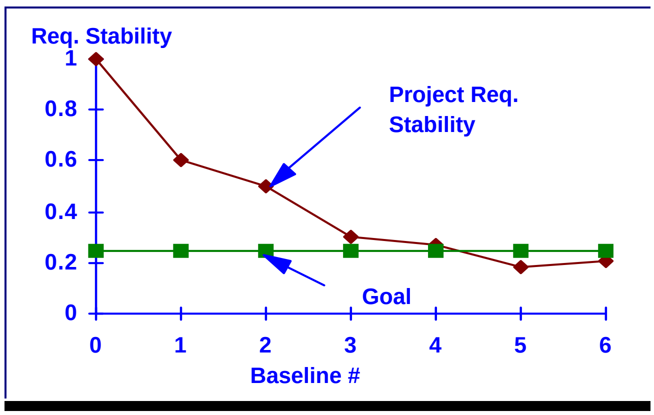

Figure 5-3: Plot of Requirements Stability vs. Baseline Number

The user of this measure would need to establish the acceptable ranges and rates of change. In addition the user needs to be aware of a possible ripple effect in that a few modifications to major requirements could affect many others, thereby inflating this measure.

6 SUMMARY

The importance of any measure is that it serves as an indicator or flag. Something has changed in the process. That change may be good, detrimental, or neutral to our system development. The key is to determine why the value of the measure has changed, make a determination of the impact, and then determine whether any action is required!

The reader is again reminded to use caution in drawing inferences in any of the above examples. One must look at a number of measures to get a total perspective of the system development before taking any action. Consider all available data relating to the problem, both qualitative and quantitative.

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8 KEY MEASUREMENT TERMS

attribute

property or characteristic of an entity that can be distinguished quantitatively or qualitatively by human or automated means

(source: ISO/IEC 15939)

base measure

measure defined in terms of an attribute and the method for quantifying it

Note 1: A base measure is functionally independent of other measures.

Note 2: Based on the definition in [International Vocabulary of Basic and General Terms in Metrology, 1993].

(source: ISO/IEC 15939)

data

collection of values assigned to base measures, derived measures, and/or indicators

(source: ISO/IEC 15939)

derived measure

measure that is defined as a function of two or more values of base measures

(source: ISO/IEC 15939)

entity

object that is to be characterized by measuring its attributes

Note: An entity can be a process, product, project, or resource.

(source: ISO/IEC 15939)

indicator

measure that provides an estimate or evaluation of specified attributes derived from a model with respect to defined information needs

(source: ISO/IEC 15939)

information need

insight necessary to manage objectives, goals, risks, and problems

(source: ISO/IEC 15939)

information product

one or more indicators and their associated interpretations that address an information need

Example: A comparison of a measured defect rate to planned defect rate along with an assessment of whether or not the difference indicates a problem.

(source: ISO/IEC 15939)

issue

a risk, constraint, objective, or concern, often associated with resources, progress, quality, or performance. Issues represent current or potential problem areas that should be monitored.

(source: Practical Software and Systems Measurement)

measure (noun)

variable to which a value is assigned as the result of measurement

Note: The term “measures” is used to refer collectively to base measures, derived measures, and indicators.

(source: ISO/IEC 15939)

measure (verb)

to make a measurement

(source: ISO/IEC 14598-1:1996)

measurement

set of operations having the object of determining a value of a measure

(Adapted from the International Vocabulary of Basic and General Terms in Metrology, 1993)

measurement analyst

individual or organization that is responsible for the planning, performance, evaluation, and improvement of measurement

(source: ISO/IEC 15939)

measurement experience base

data store that contains the evaluation of the information products and the measurement process as well as any lessons learned during the measurement process

(source: ISO/IEC 15939)

measurement procedure

set of operations, described specifically, used in the performance of a particular measurement according to a given method

(source: International Vocabulary of Basic and General Terms in Metrology, 1993)

measurement process

the process for establishing, planning, performing and evaluating measurement within an overall project, enterprise, or organizational measurement structure

(source: ISO/IEC 15939)

measurement process owner

individual or organization responsible for the measurement process

(source: ISO/IEC 15939)

measurement program

an organizational initiative responsible for the planning, educating, and facilitation/execution of measurement for the purpose of process, product, and/or project control and improvement.

measurement user

individual or organization that uses the information products

(source: ISO/IEC 15939)

model

algorithm or calculation combining one or more base and/or derived measures with associated decision criteria

(source: ISO/IEC 15939)

process

set of interrelated or interacting activities which transforms inputs into outputs

(source: ISO 9000:2005)

process measure

a measure of how well a given process or activity is working, which can provide insight into process stability and process improvement opportunities. Historical data from process measures also provides a basis for estimation of processes applied on similar projects. An example of this type of measure might be activity cycle time or rework factors.

product

the result of a process

NOTE There are four agreed generic product categories: hardware (e.g. engine mechanical part); software (e.g. computer program); services (e.g. transport); and processed materials (e.g. lubricant). Hardware and processed materials are generally tangible products, while software or services are generally intangible. Most products comprise elements belonging to different generic product categories. Whether the product is then called hardware, processed material, software or service depends on the dominant element.

(source: ISO 9000:2005)

product measure

a measure of the characteristics or quality of an end item. This end item could be anything from the shipped product to the system design specification document to a quantifiable measure of service performed or level-of-effort provided.

progress measure

this measure provides project or program status in terms of schedule and cost. It measures values or changes over time, generally against planned values. Most budget/cost and schedule measures are progress measures.

project

an endeavor with defined start and finish dates undertaken to create a product or service in accordance with specified resources and requirements

Note: A project may be viewed as a unique process comprising coordinated and controlled activities and may be composed of activities from the Project Processes and Technical Processes defined in this International Standard.

(Adapted from ISO 9000: 2005)

service

performance of activities, work, or duties associated with a product

(source: ISO/IEC 12207:2008)

stakeholder

an individual or organization having a right, share, claim, or interest in a system or in its possession of characteristics that meet their needs and expectations

Note: Within this international standard, an individual or organization that sponsors measurement, provides data, is a user of the measurement results or otherwise participates in the measurement process.

(source: ISO/IEC 15288:2008)

system

a combination of interacting elements organized to achieve one or more stated purposes. A system may be considered as a product or as the services it provides.

(source: ISO/IEC 15288:2008)

8. FEEDBACK FORM

Name: ____

Company: ____

Address: ____

____

____

Would you like responses to your comments (Y/N)? __

Location of Comment (Section, Page #)	**Description of Comment**

Send to:

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7670 Opportunity Rd., Suite 220
San Diego, CA 92111-2222