# *Acquisition Measurement*

## *A Collaborative Project of PSM*

TECHNICAL REPORT PREPARED BY

## RITA CREEL, SOFTWARE ENGINEERING INSTITUTE

## JOE DEAN, US AIR FORCE

## CHERYL JONES, US ARMY

### *Prepared on behalf of the PSM Acquisition Measurement TWG*

*21 July 2008*

*Version 1.1*



*Practical Software and Systems Measurement*

# Acknowledgements

# Contents

## List of Figures

## List of Tables

# Acquisition Measurement

Version 1.1

July 21, 2008

## 1  Introduction

What is Acquisition Measurement?  Is it something I should be doing?  How does it differ from my supplier's measurement activities?

*Acquisition measurement* is the process an acquirer uses to obtain, analyze, and apply data to make informed decisions on the activities, processes, products, and resources needed to conduct acquisition. Having the right data at the right time is essential for effective acquisition management, so measurement is something every acquirer should care about doing well.  While supplier measurement focuses on the supplier, acquisition measurement turns the lens on the acquirer.

This paper provides a foundation for the discussion and advancement of acquisition measurement.  Its primary focus is on improving the way in which acquisition projects and organizations manage and conduct their own activities.  A secondary focus is management and oversight of the supplier.  As such, the intended audience includes those charged with managing acquisition projects or organizations, performing the day-to-day work of these projects or organizations, and improving acquisition process performance.

The material in this paper is based on existing guidance developed by the Practical Software and Systems Measurement (PSM) Project for supplier measurement.  Readers unfamiliar with PSM are strongly encouraged to download and read Chapter 1 of the PSM book, available at www.psmsc.com, which provides a brief introduction to PSM.

**Why Focus on Acquisition Measurement?**

If an acquirer is already using supplier measures to evaluate project progress, quality and performance, are measures of the acquirer's work still needed?  After all, isn't it the delivered capability – produced by the supplier – that matters most?

While delivered capabilities and products are the end goal, acquisition success is highly dependent on the foundation laid by the acquirer's activities and products.  For DoD acquirers, shortcomings in acquisition products and processes have been repeatedly cited in Government studies as fundamental causes of project failure [DSB 2000, GAO 2003, GAO 2004, and GAO 2008].  In many cases, the project office seems to have been caught off guard with these failures, and indeed, a key recommendation emerging from these studies is use of measures, by both the acquirer and supplier. In fact, one study described leading (successful) developers as "relentless in their efforts to collect metrics to improve project outcomes and processes" [GAO 2004].

As an acquisition project manager or member of an acquisition project team, how can measurement help you?  Let's look at some scenarios to illustrate.

Scenario 1

Imagine a new assignment as an acquisition project manager. You begin just as the project office is beginning to prepare a request for proposal (RFP). You ask for status on the project requirements that will form the foundation for the RFP and will be given to suppliers who intend to bid.

Your deputy tells you the requirements are "almost" done. He explains there are a few stakeholder meetings he's been trying to set up for several months. He adds that there are about 30 to-be-determined (TBD) requirements in the document, out of about 200 requirements total, but tells you not to worry because they aren't really essential to the proposals. Finally, he informs you that the staff member leading requirements development left last month and work on requirements has slowed down since then.

You meet with your new boss that afternoon. She asks you how close you are to completing the requirements. How will you answer? Perhaps you'll repeat your deputy's assessment; perhaps you'll ask for more time. But as of this moment, you really don't know how much work remains or how much risk you would incur by guessing when the requirements will be ready to proceed.

Scenario 2

Now imagine a different scenario. You are, again, in a new assignment as an acquisition project manager, engaging just before RFP preparation begins. You ask your deputy for status on project requirements. He invites you to his office, where he clicks on a project dashboard icon, and selects "requirements progress indicators" from a list of indicator categories. The first indicator illustrates, with weekly data, the total number of requirements, the number reviewed, and the number of TBD requirements. He clicks on one of the TBDs and a window pops up explaining the status of that requirement, its impacts, and the plan for resolving the uncertainty. Other requirements progress indicators show requirements by source, capability, quality characteristics, and priority. He explains that the requirements development lead has left, but that work on requirements continues, as evidenced by daily changes in data.

You spend a few hours with the project dashboard. That afternoon, you meet with your boss and explain that based on progress trend lines and outstanding meetings with a few stakeholders, you project that requirements will be sufficiently complete and stable in about six more weeks. You show her the evidence for your assessment and explain that since you're new, you'll want to validate the numbers but you believe they are sound. She responds that she's familiar with the indicators, is confident they're sound, and will assist you in engaging the remaining stakeholders.

Which project manager would you rather be? While real life situations may be more complex than the above scenarios, it is nonetheless true that measurement provides information that enables us to make defensible decisions in a timely fashion. And effective decision making – based on objective characterizations of activities, resources, schedules, product and process characteristics, and project dynamics – is a key to acquisition project success.

### Relating Acquisition Activities and Products to Successful Outcomes

If we consider some basic elements that enable a supplier to deliver the right capability within cost and schedule constraints and at the right levels of performance, dependability, and supportability, we might come up with the following list:

- Sound understanding of what the acquirer is asking for, and what the user needs

- Sufficient schedule and funding for the effort, including engineering and quality activities

- Enough stability to develop and deliver defined increments of capability

- An understanding of current performance with respect to technical progress, cost, and schedule, and ability to predict future performance

- Ability to identify issues and risks as early as possible, and to track and manage them to closure

- Ability to credibly defend estimates, technical and management decisions, and requests for additional resources, schedule, or requirements relief

Note that many of these elements depend on the acquirer's ability to do the following:

- Understand user and other stakeholder requirements and the steps necessary to acquire a system to meet them

- Clearly identify project objectives and express them to the supplier in the form of technical and contractual requirements

- Develop products such as product and system requirements, requests for proposal, statements of work, descriptions of expected deliverables, requirements for technical and management meetings, and milestone and award fee criteria

- Evaluate proposals

- Prepare for and execute effective contract kick-off meetings

- Plan for and conduct evaluations of engineering activities and products, managing change, tracking performance, and countless other activities

- Communicate effectively with the supplier

Acquirers are accountable for their own activities and products which influence the outcome of the supplier's efforts. We identify a basic set of acquirer activities in Appendix B, *Summary Acquisition Project Work Breakdown Structure*. It is important to identify the information needs for managing and making decisions regarding the activities that apply to your project. An *information need* is defined as insight needed to manage objectives, goals, risks, and problems [ISO/IEC 2007]. Once identified, information needs can be translated into basic requirements for measures, some dealing with the acquirer's internal activities and products and others with the supplier's.

### How Can This Paper Help?

As acquirers, much of what we know about measurement is focused on supplier products and processes. While many resources are available on measurement in general and in assisting acquirers

in applying measurement to supplier activities and products,[1] little information is available to support acquisition measurement. To begin to address the gap, the Practical Software and Systems (PSM) Measurement Project developed this introductory paper on acquisition measurement.

The paper describes fundamental concepts for acquisition measurement with a special focus on acquisition products, processes, and resources. It shows how acquisition measures, in conjunction with supplier measures, provide essential information for decision making throughout the life cycle of an acquisition project. Finally, it relates acquisition project measures to acquisition enterprise measures and decisions, i.e., those at higher levels of authority and responsibility with respect to the acquisition project.

## Key Terms

This section defines four key terms used in this paper, Acquisition, Acquisition Measurement, Acquisition Enterprise, and Acquisition Project. While other definitions may exist for these terms, we have chosen the definitions in Table 1 for our discussion. Appendix A contains definitions of additional terms used.

**Table 1. Key Terms and Definitions**

| Term | Definition |
|---|---|
| Acquisition | The process of obtaining a system product or service. (ISO/IEC 15288:2008) [ISO/IEC 2008b] |
| Acquisition Measurement | The process an acquirer uses to obtain, analyze, and apply quantitative data for effective management and control over the activities, processes, products, resources, and environmental factors needed to conduct acquisition.<br><br>Acquisition measurement encompasses all factors affecting the acquirer's ability to meet objectives, both internal factors the acquirer has control over and external factors it may be unable to influence. Measuring and analyzing the latter enables the acquirer to identify and respond to related risks and problems. |
| Acquisition Enterprise | A person or a group of people and facilities with an arrangement of responsibilities, authorities, and relationships focused on Acquisition. (Adapted from ISO/IEC 15288:2008 definition of Organization) [ISO/IEC 2008b]<br><br>An acquisition enterprise may be comprised of one or more lower level acquisition enterprises (also referred to as sub-enterprises) and acquisition projects. Acquisition sub-enterprises may in turn be comprised of acquisition sub-enterprises and acquisition projects. This hierarchy is illustrated in<br><br>Figure 1. |
| Acquisition Project | An endeavor with defined start and finish dates undertaken to acquire a product or service in accordance with specified resources and requirements and focused on Acquisition. (Adapted from ISO/IEC 15288:2008 definition of Project) [ISO/IEC 2008b]<br><br>An *Acquisition Project* may "belong" to or be governed by an *Acquisition Enterprise* as shown in Figure1. |

[1] Examples include McGarry et al. 2002, DoD 2003, INCOSE 2007, Park et al. 1996, and Rozum and Florac 1994.

**Figure 1. Acquisition Enterprise and Acquisition Project Hierarchy**



Acquisition Enterprise Measurement

Acquisition Project Measurement
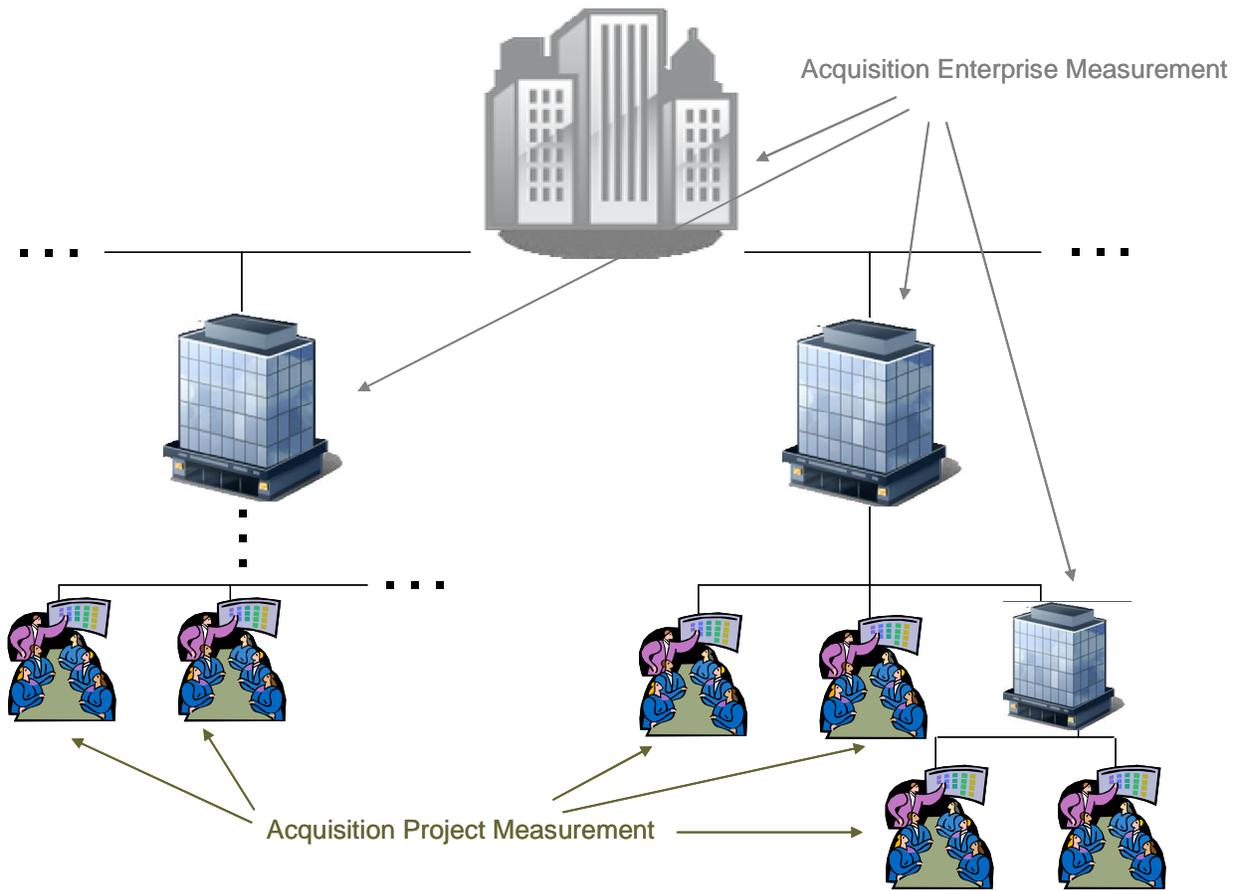
# 2  Acquisition Measurement Building Blocks

To be truly effective, an acquisition measurement capability depends on four essential building blocks:  the measurement process, measurement infrastructure, clearly defined roles and responsibilities, and relationships.  We will discuss each of these in turn.

## Measurement Process

The first essential building block for acquisition measurement is a sound, well-executed measurement process.  The PSM Process is an information-driven measurement process that addresses the unique technical and business goals of an organization [McGarry et al. 2002].  PSM represents best practices used by measurement professionals within the software and system acquisition and engineering communities.

The PSM process, depicted in Figure 2, consists of four major activities:  Plan Measurement, Perform Measurement, Establish and Sustain Commitment, and Evaluate Measurement.  The Core Measurement Process box includes the "up and running" measurement activities, *Plan* and *Perform* measurement*.  Establish and Sustain Commitment* provides resources and motivation for measurement.  *Evaluate* Measurement is a periodic, systematic assessment of whether the measures and measurement process are meeting needs.

Project and enterprise decision makers operate within the white box, *Technical and Management Processes*. They define measurement information needs and use measures to make decisions.

**Figure 2. The PSM Process**
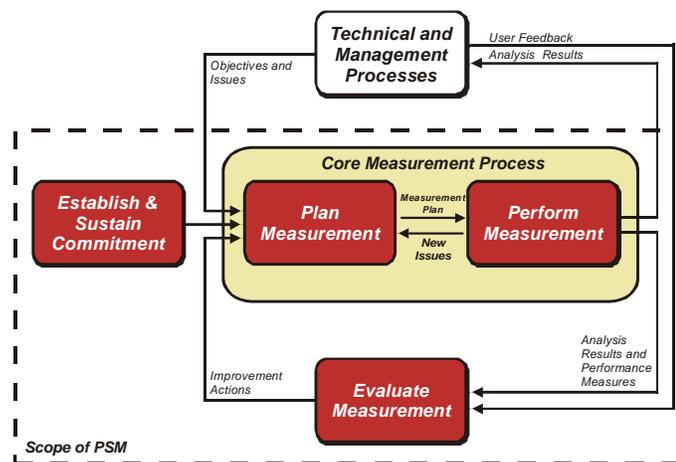
A summary of the tasks involved in each PSM activity is provided in Table 2.  Detailed information may be found in the book **Practical Software Measurement: Objective Information for Decision Makers** [McGarry et al. 2002] and at www.psmsc.com.


**Table 2. PSM Activities**

| PSM Activity | Key Activity Steps |
|---|---|
| Plan Measurement | Identify information needs.  Select, prioritize, and specify corresponding measures.  Prepare a measurement plan. |
| Perform Measurement | Collect and validate data.  Process and analyze data.  Generate reports.  Make recommendations that lead to decisions and actions. |
| Establish and Sustain Commitment | Obtain organizational commitment.  Define roles and responsibilities.  Provide resources.  Review implementation progress. |
| Evaluate Measurement | Conduct pre-planned, periodic evaluations of the measures and the measurement process against pre-defined criteria. |


## Measurement Infrastructure

The second essential building block for acquisition measurement is the measurement infrastructure. The measurement infrastructure embodies resources and artifacts necessary for effective implementation of the measurement process.  As such, it includes the measurement plan and procedures; resources associated with implementing and sustaining them (e.g., tools, facilities, personnel, and the measurement repository); and training.

Use of a consistent measurement process and infrastructure is encouraged, especially within and across projects and governing enterprises that frequently exchange measurement information. Training in the process and use of common or interoperable tools will facilitate data sharing, analysis, and understanding.  A well-structured measurement repository enables data providers and users to obtain and use consistent views of the data, and to create an archive for historical analysis purposes.

## Clearly Defined Roles and Responsibilities

The third essential building block for acquisition measurement is a set of clearly defined roles and responsibilities for measurement. A commitment to five roles and the responsibilities they engender is critical to success.  These five roles include Champion, Executive Manger, Project Manager, Measurement Analyst, and Team Member.  Table 3 describes general responsibilities for each role. Sections 3 and 4 identify specific responsibilities for each role in executing a PSM-based measurement process for acquisition project measurement and acquisition enterprise measurement.

**Table 3. Acquisition Measurement Roles and Responsibilities**

| Role Name | Description of General Responsibilities |
|---|---|
| Champion | Responsible for promoting the use of measurement, obtaining and allocating necessary funding and resources, and verifying implementation.  Also responsible for ensuring the measurement user's information needs are met.  Champions may exist at the project or enterprise level, or both. |
| Executive Manager | Responsible for identifying enterprise-level information needs, supplying resources for enterprise-level measurement activities, and using measures to make decisions impacting the enterprise. |
| Project Manager | Responsible for managing project cost, schedule, quality, performance, and risk.  Involved in developing measurement information needs, reviewing measurement plans, and ensuring implementation.  Uses measures to make decisions; evaluates measures and the measurement process.  Supplies data to the enterprise level. |
| Measurement Analyst | Responsible for developing the measurement plan, collecting and analyzing data, and reporting results and recommendations.  Also involved in evaluating the measures and measurement process. |
| Team Member | Responsible for assisting the measurement analyst in identifying and defining measures, reviewing and supplying data, and evaluating the measures and measurement process. |

## Relationships

The fourth essential building block for acquisition measurement is the ability to build and sustain relationships.  Measurement, in essence, provides a vehicle for communication that is based on objective data.  High-functioning relationships between providers and recipients of data are essential.  Concerns over potential negative consequences often result in repression of the data needed to identify and solve problems.

# 3  Measurement at the Acquisition Project Level

The work of an acquisition project is defined, structured, executed, evaluated, and adjusted at the acquisition project level.  Success is highly dependent on the ability to obtain, analyze and use emerging information about current status and evolving needs. Measures at the acquisition project level come from – and are used by – acquisition program personnel who are performing, leading, and managing the work.  In addition, much of the measurement data used at the acquisition enterprise level originates at the acquisition project level.

## Getting started

### What Information Do You Need?

To get started with measurement at the acquisition project level, ask

> *What information do I need to manage my project successfully?*

In other words,

> *What do I need to know or understand about my acquisition project activities and products as they relate to project goals, objectives, risks, issues and requests for information received from the enterprise level or other external sources?*

These questions will help you identify your measurement *information needs.* This is the first step in identifying the right measures for your project, measures that will be truly informative and useful. The questions, explored in an iterative process that starts at a high level and drills down into more detail, focus directly on your purposes for measurement, the specific questions you need answered by quantitative data.  Note that information needs will evolve over the life of your project as circumstances change and internal and external events impact your project.

### What Data Do You Need?

Once you have an initial set of information needs, you can begin to visualize the kinds of measurement reports that will help you make objective decisions and manage your project with confidence.  We call these reports *indicators.* An *indicator* depicts data that is analyzed using a specified process to provide an estimate or evaluation of selected, measurable attributes.  For each information need, you can sketch out a candidate indicator (e.g., a table or graph) or set of indicators. Once you have done so, you can identify the data elements (or *base measures*) needed to produce the indicator.  We will present examples of getting from information needs to indicators to base measures later in this section.

After you've identified candidate indicators based on information needs, it's important to consider the availability of the base measures needed to construct the indicator.  Are the measures already collected? If not, are they readily available?  And if they are not readily available, could other base measures be used to produce the indicator?  If you determine that producing a candidate indicator will be too resource intensive, you may need to choose an alternative indicator.

### How Do You Document Your Project Measures?

Once you have selected indicators to meet your information needs, you'll need to create a *measurement specification* for each indicator [McGarry et al. 2002]. A measurement specification provides a complete definition of an indicator, from the information needs it is to satisfy, to a depiction of the indicator, data collected to produce it, and the process for analyzing the data and creating and interpreting the indicator. A blank measurement specification template and completed examples are available from the PSM website at http://www.psmsc.com/SampleMeasures.asp.

### Who Will Perform Data Collection, Analysis, and Archival?

It's critical to assign responsibility for data collection, analysis, and archival as well as for the use of data in decision making. An Acquisition Project Measurement Plan should be prepared documenting these responsibilities and the processes for carrying them out. A sample Measurement Plan outline is provided in Appendix D.

## Identifying Project-Level Measures – An Example

In the previous section, we explained how measures should flow from information needs regarding project activities and products. Appendix B provides a generic Acquisition Work Breakdown Structure that you can use as an aid to help identify candidate activities and products for measurement. Here are some examples of typical activities conducted by acquisition projects:

- Conducting architecture trade studies

- Documenting capabilities, stakeholder requirements, and system concepts

- Preparing for and conducting source selection activities

- Reviewing and monitoring supplier activities and products and coordinating acquirer participation in reviews and technical exchange meetings (this will include analysis of supplier measures)

- Conducting acquisition activities and developing acquisition office products.

- Monitoring acquisition project progress toward interim goals and objectives as well as major milestones (this will include analysis of supplier measures)

- Managing and tracking progress and resources expended on project activities as well as on activities and tasks directed from the enterprise level

Once you know your project objectives, activities, and products, you can identify measurement information needs. Table 4 provides an example, listing project objectives, a few of the activities involved in meeting them, and the associated information needs. These are examples only – many others could be identified.

**Table 4. Example – Project Objectives, Activities, and Information Needs**

| Project Objectives | Activities and Products | Example Information Needs<br>*\* indicates information need common to most activities and products* |
|---|---|---|
| Delivered capability meets user needs at desired performance and quality and within budget and schedule | Define and Document Stakeholder Requirements | Do I have the right personnel (quantity, skill, availability)?*<br><br>Are the schedule and budget reasonable and are we on track?*<br><br>Is the product of adequate quality?*<br><br>What are the risks to conducting and completing this activity? What are the risks to other activities or products influenced by this one?*<br><br>Are requirements suitable for use in subsequent activities (e.g., design, development, test)? |
| | Prepare the Request for Proposal | Are the statement of work, instructions to offerors, evaluation criteria, and CDRL of sufficient quality prior to releasing the RFP? |
| | Review supplier products | Are my supplier review activities identifying defects and risks that could have a significant negative impact on cost, schedule, or performance? |
| Communicate effectively with enterprise-level executive management | Respond to enterprise-level requests for project information<br><br>Provide regular reports on project accomplishments and concerns | How much effort is expended on external requests and reports?<br><br>Am I responding and reporting in a timely manner? |

Note that some information needs are common to many, if not most, activities and products. In Table 4, column 3, these were indicated with an asterisk (*). Table 5 maps the common information needs to the seven common PSM *information categories*. *Information categories* represent broad areas of concern that must be managed in most projects. The seven PSM information categories are Schedule and Progress, Resources and Cost, Product Size and Stability, Product Quality, Process Performance, Technology Effectiveness, and Customer Satisfaction [McGarry et al. 2002]. You can use these categories to help you brainstorm information needs for your project.

**Table 5. Project Information Needs and PSM Common Information Categories**

| PSM Common Information Category | Project Information Need |
|---|---|
| Schedule and Progress | Are the **schedule** and budget reasonable and are we on track? |
| Resources and Cost | Do I have the right **personnel** (quantity, skill, availability)? |
| | How do the size and complexity of this activity and product **influence the effort** required? |
| | Are the schedule and **budget** reasonable and are we are on track? |
| Product Size and Stability | How do the **size and complexity** of this activity and product influence the effort required? |
| | How many **changes** to the product are there and what is their impact? |
| Product Quality | Is product of adequate **quality**? |
| Process Performance | Are we conducting the activity **efficiently and effectively**? |
| Technology Effectiveness | Are the **candidate technologies suitable** to meet identified needs within cost and schedule, and if not, what alternatives are available? |
| Customer Satisfaction | Are **users and other key stakeholders** adequately engaged and are the users satisfied? |

Note: In considering measurement information needs, also consider risks to completing activities and products, as you may need quantitative data to manage these risks.

The next step is to review information needs and the PSM information categories and visualize candidate indicators that could be used to manage the project and support decision making. You may need more than one indicator to meet an information need. Similarly, a single indicator, properly constructed, may be relevant to more than one information need.

Once you've identified one or more candidate indicators, you can define the data, or *base measures*, needed to construct the indicator. A *base measure* is a number that quantifies a single, independent attribute of an activity, process, or resource along with the method for quantifying it [adapted from ISO/IEC 2007 definition of Base Measure]. Table 6 provides an example of the process of moving from information needs to measures.

**Table 6. Example – From Project Information Needs to Potential Measures**

| Information Need, Information Category, and Analysis Questions | Potential Measures |
|---|---|
| **Information Need**<br><br>What skills do I need?  Will they be available when needed?  What is my associated risk mitigation strategy?<br><br>**Information Category**<br><br>Resources and Cost (needed, projected, actual)<br><br>**Analysis Questions**<br><br>What are my projected staffing needs, based on past similar projects?  How many qualified people do I think I can get?  How am I doing in obtaining qualified personnel? Do I need to make a case for increased staffing? Are my products and activities suffering from staffing shortfalls? (Product Quality indicators would be useful in answering this last question.) | **Candidate Indicator**<br><br><br>Project Skills Needs - As of 1 Mar 2008<br><br>**Base Measures to Generate Indicator**<br><br>Needed # of personnel needed by skill and month (use past data, if available)<br><br>Projected # in planned time frame (use projected staffing allocation)<br><br>Actual # assigned |
| **Information Need**<br><br>Are the test procedures adequate to verify that functional, performance, and quality requirements have been met?  Are we making adequate progress at completing test procedures?<br><br>**Information Categories**<br><br>Schedule and Progress<br>Product Quality<br>Process Effectiveness<br><br>**Analysis Questions**<br><br>For each test procedure, how many of the allocated requirements have adequate verification steps?  Are we missing verification issues that we should be catching? (Process Effectiveness indicators, e.g., defect escapes, could be used to answer this question; the indicator shown does not.) | **Candidate Indicator** (relates to Schedule and Progress & Product Quality)<br><br><br>Test Procedure Readiness -- Summary View as of 1 Mar 2009<br><br>**Base Measures to Generate Indicator**<br><br>For each test procedure:<br><br>    # of requirements allocated<br><br>    planned # of requirements with completed verification steps (per plan for completion)<br><br>    actual # of requirements with completed verification steps (per acquisition project office review) |
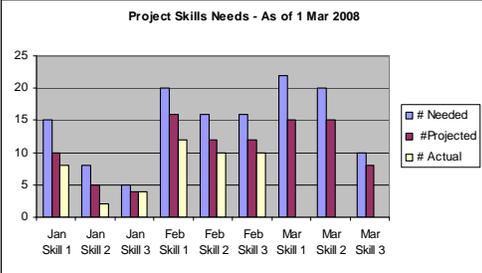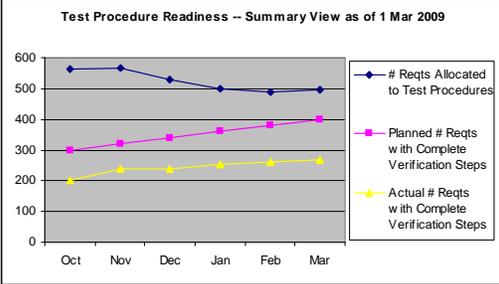
Additional examples of information needs and potential measures are provided in Appendix C, *Summary Acquisition ICM Table*. Again, the examples above and in the appendix are for illustration only.  You should select measures based on your own information needs and the needs of the enterprise to which your project reports.  Most of your measures will be based on activities you perform along with products produced and resources consumed by these activities.

## Roles and Responsibilities

Roles and responsibilities in executing a PSM-based acquisition project measurement process are identified in Table 7.

**Table 7. Acquisition Project Measurement Roles and Responsibilities**

| If your Acquisition Project Role is … | Then your Acquisition Project Measurement Responsibilities are … |
|---|---|
| Project Manager | **For Plan Measurement**<br><br>Identify acquisition project goals, objectives, issues and risks<br><br>With team, identify acquisition project activities, artifacts, and resources related to requirements development, architecture and concept studies, request for proposal preparation, project monitoring, and systems engineering and quality activities (The Summary Acquisition Work Breakdown Structure in Appendix B may be useful for this exercise)<br><br>Given the above information, identify project information needs<br><br>Determine how measurement will fit into the day-to-day operation of the acquisition project – know how you will use measures to make decisions<br><br>Assist in designing indicators, graphical or tabular depictions of measurement data intended to meet your information needs<br><br>Define roles and responsibilities and identify resources for measurement planning, infrastructure development and support, training, data collection and processing, and analysis and decision making at various levels of the acquisition project<br><br>**For Perform Measurement**<br><br>Use measures to make decisions<br><br>Be aware of use of measures throughout project<br><br>Request adjustments to measures as needs dictate<br><br>**For Evaluate Measurement**<br><br>Serve as a "Champion" for measurement on your project (see Table 2) – in evaluating measurement, ensure measurement users' needs are met, that measurement adds value<br><br>Sponsor and participate in periodic evaluations of efficiency and effectiveness of the measures and measurement process. Providing feedback on quality and usefulness<br><br>Support necessary adjustments to the measures and measurement process<br><br>**For Establish and Sustain Measurement Commitment**<br><br>Serve as a "Champion" for measurement on your project (see Table 2) – shepherd the implementation and be involved in its enhancement, in growing its value<br><br>Provide resources and monitor progress toward measurement process stand-up<br><br>Participate in implementation and training activities |

| If your Acquisition Project Role is … | Then your Acquisition Project Measurement Responsibilities are … |
|---|---|
| Team Member | **For Plan Measurement**<br><br>Assist project manager in identifying information needs<br><br>Assist measurement analyst in identifying data to be collected to construct indicators, frequency of collection and reporting, and associated responsibilities<br><br>**For Perform Measurement**<br><br>Assist measurement collection, per measurement plan<br><br>Use measures<br><br>Respond to questions regarding measurement data<br><br>**For Evaluate Measurement**<br><br>Provide feedback and participate in evaluation activities<br><br>**For Establish and Sustain Measurement Commitment**<br><br>Participate in implementation and training activities |
| Measurement Analyst | **For Plan Measurement**<br><br>Define and specify measures based on information needs<br><br>Prepare measurement plan, working with project manager and team members<br><br>Work with information technology personnel to identify and implement infrastructure needs<br><br>**For Perform Measurement**<br><br>Obtain, validate and analyze measures and prepare measurement reports<br><br>Respond to questions regarding analysis<br><br>**For Evaluate Measurement**<br><br>Provide feedback and facilitate evaluation activities<br><br>Adjust measures and measurement process, as needed, obtaining help from information technology for infrastructure issues<br><br>**For Establish and Sustain Measurement Commitment**<br><br>Participate in implementation and training activities |

# 4 Measurement at the Acquisition Enterprise Level

Managing an acquisition enterprise – an organization responsible for one or more acquisition projects – is increasingly challenging. Resource shortfalls, funding instability, schedule constraints, external mandates, technology advances, and reporting requirements strain the enterprise and demand considerable agility and an ability to balance competing concerns. But without accurate, timely data, achieving balance and agility is a game of chance rather than skill. Acquisition enterprise measurement is intended to support the efforts of the enterprise at overseeing its projects and initiatives and adapting to changing conditions.

You will note many parallels between acquisition enterprise measurement and acquisition project measurement. The same process applies to identifying information needs, indicators, and measures – the main distinction is that the focus is on the overarching enterprise rather than the project.

## Getting started

### What Information Do You Need?

To get started with measurement at the acquisition enterprise level, ask

*What information do I need to manage my enterprise successfully?*

In other words,

*What do I need to know or understand about the organizations and projects reporting to me, and about my enterprise-level activities and products as they relate to enterprise-level goals, objectives, risks, issues and requests for information received from the outside the enterprise?*

The form of these questions is similar to the form of project-level questions but the specific questions differ because enterprise-level responsibilities and concerns differ from those at the project level. For example, at the project level, the focus is on activities and products related to a single project whereas at the enterprise level, the focus is on governance of multiple projects; enterprise-wide practices for acquisition project management, systems engineering, configuration management, training, staffing, and other activities; and representation of the enterprise and its projects to outside parties.

The result of analyzing these questions is a set of documented information needs. Refer to "Getting Started" in Section 3, Measurement at the Acquisition Project Level, for brief summaries on using information needs to identify indicators and data, documenting project measures, and assigning responsibility for data collection, analysis, and archival. This information applies to the enterprise level as well and is not repeated here.

## Identifying Enterprise-Level Measures – An Example

As described in Section 3, measures should flow from information needs regarding activities, products, objectives, and risks. Section 3 provided project-level examples.

Here are some examples of acquisition enterprise responsibilities for supporting and governing acquisition projects:

- Project portfolio management and strategic planning for acquisition projects

- Securing and justifying funding for acquisition projects; presenting status to external organizations

- Making project go/no-go decisions (e.g., at milestones or key decision points)

- Developing and enforcing enterprise-level policies, instructions, and practices for acquisition management, systems engineering, life cycle model application, quality management, configuration management, teaming, and other activities

- Overseeing studies and analysis, research, and technology insertion

- Providing organizational training policies and resources

- Managing human resources

- Developing and enforcing financial management practices

- Providing the information technology infrastructure

- Managing facilities

The generic Acquisition Work Breakdown Structure in Appendix B illustrates some of these responsibilities under the "Organizational Project-Enabling Processes" category.

Once you have identified your enterprise objectives, activities, and products, you can identify measurement information needs. Table 8 provides an example, listing some enterprise objectives, a few of the activities involved in meeting them, and the associated information needs. These are examples only – many others could be identified.

**Table 8. Example – Enterprise Objectives, Activities, and Information Needs**

| Enterprise Objectives | Activities and Products | Example Information Needs |
|---|---|---|
| Ensure enterprise-wide acquisition management practices are efficient and effective across the project portfolio | Develop practices | Are the right personnel engaged (quantity, skill, availability)?<br>Are the schedule and budget reasonable and are we on track?<br>Is the practice documentation of adequate quality? |
| | Provide training | Are the training materials completed as planned?<br>How many of the "target" trainees are completing training on time? |
| | Evaluate practice effectiveness | Are new practices resulting in performance improvements? |
| Ensure projects in the portfolio meet performance and quality objectives and are delivered within cost and schedule constraints | Define performance and quality measurement guidelines | How many projects use the guidelines?<br>Do the guidelines provide advance warning of issues and risks? |
| | Conduct independent cost and schedule analyses | Do analysis methods provide estimates that match project estimates? Actual costs? |
| | Use performance, quality, cost, and schedule data to identify needed course corrections | Do the data indicate that course corrections are having the intended impact? |
| Make defensible go/no-go decisions | Analyze data and information from projects | Is the project technically feasible within cost and schedule constraints?<br>Is the project performing well technically and programmatically?<br>What are the risks of continuing? Of stopping work? |
| | Prepare decision justification | What are the impacts and risks of this decision?<br>Are negative impacts and risks mitigated to an acceptable level? |
| Facilitate rapid deployment of promising new technologies (special instance of go/no-go decision) | Evaluate project proposals for technology insertion (technical, cost, schedule) | What is the likelihood and benefit of success?<br>What are the impacts of failure and can they be mitigated?<br>Are proposals sound and is the risk tolerable?<br>Are "off-ramps" built into the proposal, if needed? |
| | Prepare decision justification | (Same as for "Make defensible go/no-go decisions") |

In Table 5, Project Information Needs were mapped to PSM Common Information Categories. A similar table may be constructed for Enterprise Information Needs.

The next step is to review the enterprise information needs you've identified and visualize candidate indicators that could be used to manage enterprise activities and support decision making. Again, it's important to consider the effort to produce an indicator. If it's too costly or effort-intensive, it may be better to consider using a different indicator that would give you similar information. Table 9 provides an example of the process of moving from enterprise-level information needs to measures.

**Table 9. Example – From Enterprise Information Needs to Potential Measures**

| Information Need, Information Category, and Analysis Questions | Potential Measures |
|---|---|
| **Information Need**<br><br>Are personnel being trained on the new practice in a timely fashion?<br><br>**Information Category**<br><br>Schedule and Progress<br><br>**Analysis Questions**<br><br>Are personnel being trained?<br><br>Is the training effective, i.e., is the material presented in a way such that students can relate to it? (Use a Customer Satisfaction indicator, where the student is the customer, to answer.)<br><br>Is the new practice effective, i.e., is performance improving? (Use Product Performance indicators to answer.) | **Candidate Indicator**<br><br><br><br>**Base Measures to Generate Indicator**<br><br># of personnel trained each month (planned)<br><br># of personnel trained each month (actual) |
| **Information Need**<br><br>How many external actions are open at each level of criticality? Are there actions that require additional effort?<br><br>**Information Categories**<br><br>Schedule and Progress<br><br>**Analysis Questions**<br><br>How many critical actions have been open more than 30 days?<br><br>Are delays in closing actions impacting customer satisfaction?<br><br>What efforts (cost, personnel, time) are being applied to critical actions that have been open > 90 days? Can we change our resolution approach for these? | **Candidate Indicator** (relates to Schedule and Progress & Product Quality)<br><br><br><br>**Base Measures to Generate Indicator**<br><br># of open external actions, with # days since opened |
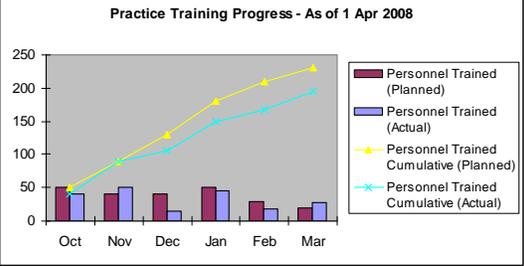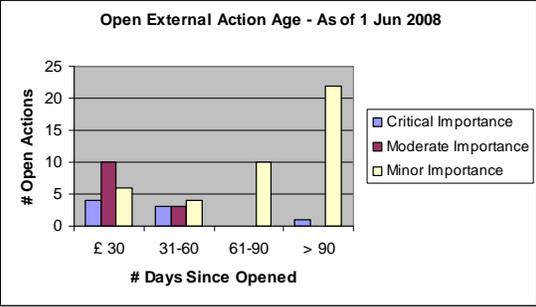
## Roles and Responsibilities

Roles and responsibilities in executing a PSM-based acquisition enterprise measurement process are similar to those for acquisition project measurement. The main differences are at the management level. Table 10 describes Executive Manager responsibilities for enterprise-level measurement. These correspond to Project Manager responsibilities for project-level measurement, but they are not identical. For descriptions of Team Member and Measurement Analyst responsibilities, refer to Table 7.

**Table 10. Acquisition Enterprise Measurement Roles and Responsibilities**

| If your Acquisition Enterprise Role is … | Then your Acquisition Enterprise Measurement Responsibilities are … |
|---|---|
| Executive Manager | **For Plan Measurement**<br><br>Identify acquisition enterprise goals and objectives, issues and risks<br><br>With team, identify acquisition enterprise activities, artifacts, and resources<br><br>Given the above information, identify enterprise information needs<br><br>Determine how measurement will fit into the day-to-day operation of the acquisition enterprise – know how you will use measures to make decisions<br><br>Determine which information needs require enterprise-level data, project-level data, or both<br><br>Assign responsibility for designing indicators based on reported enterprise- or project-level data; participate in indicator design or review to ensure information needs are met<br><br>Define roles and responsibilities and identify resources for measurement planning, infrastructure development and support, training, data collection and processing, and analysis and decision making at various levels of the acquisition enterprise<br><br>**For Perform Measurement**<br><br>Use measures to make decisions<br><br>Be aware of use of measures across enterprise-level tasks and by projects reporting to the enterprise<br><br>Request adjustments to measures as needs dictate<br><br>**For Evaluate Measurement**<br><br>Serve as a "Champion" for measurement within the enterprise (see Table 3) – in evaluating measurement, ensure measurement users' needs are met, that measurement adds value<br><br>Sponsor and participate in periodic evaluations of efficiency and effectiveness of the measures and measurement process, providing feedback on quality and usefulness<br><br>Support necessary adjustments to the measures and measurement process<br><br>**For Establish and Sustain Measurement Commitment**<br><br>Serve as a "Champion" for measurement within the enterprise (see Table 3) – shepherd the implementation and be involved in its enhancement, in growing its value<br><br>Provide resources and monitor progress toward measurement process stand-up<br><br>Participate in implementation and training activities |

# 5 The Big Picture

We close this paper by exploring two big-picture questions for acquisition measurement:

- How does acquisition measurement fit into the overall acquirer-supplier context?
- What are the key enablers of acquisition measurement success?

## Acquisition Measurement in the Acquirer-Supplier Context

Acquisition measurement is only effective in the context of acquisition technical and management processes and acquirer-supplier relationships. Figure 3 illustrates this context. The left portion of the figure depicts acquisition measurement and the right supplier measurement. Enterprise-level measurement is shown at the top of the figure and project-level measurement at the bottom.

**Figure 3. Acquisition Measurement in Context**
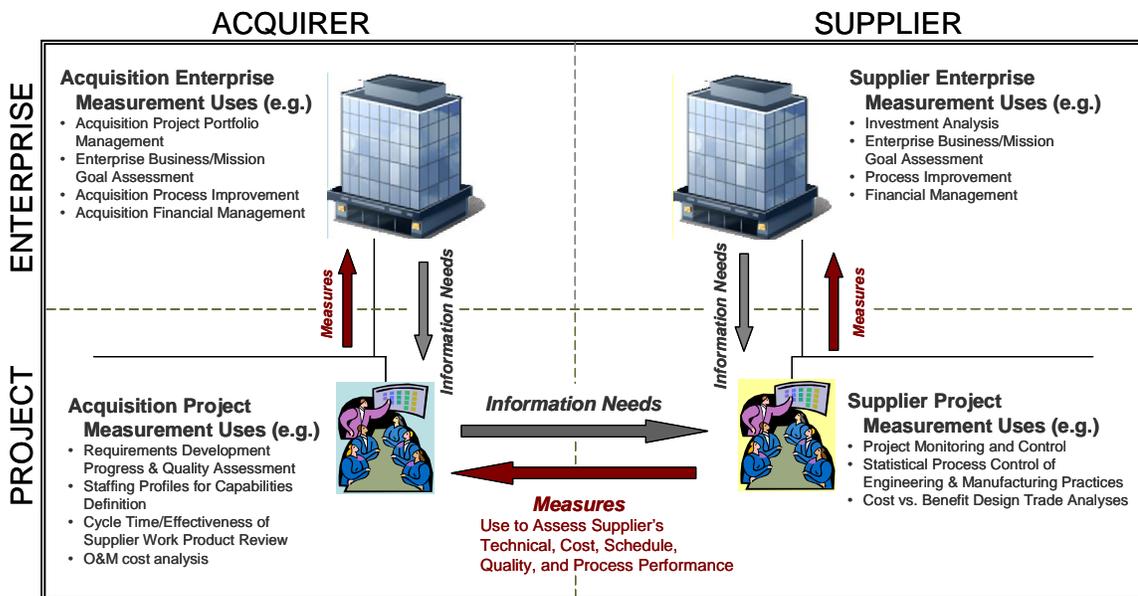


Acquisition project measurement (bottom left) focuses on acquirer objectives, activities, and products. A complementary relationship exists between supplier and acquirer project measurement: the acquirer provides *Information Needs* (arrow pointing right) and the supplier responds with *Measures* (arrow pointing left). Supplier project measurement (bottom right) focuses on supplier objectives, activities, and products.

While the supplier may have different goals, objectives, and measures, the supplier's enterprise-to-project relationships are analogous to acquirer enterprise-to-project relationships. In each case, project-level *Measures* (arrows pointing upward) are supplied in response to enterprise-level *Information Needs* (arrows pointing downward).

## Keys to Success

While no simple formula exists for ensuring measurement is successful, we can share with you some keys to success.  These keys, lessons learned from numerous efforts to apply measurement, are described in more detail in the book **Practical Software Measurement: Objective Information for Decision Makers** [McGarry et al. 2002].

- **Start small**
  Begin with a few measures that address key information needs, continually adapt them to evolving needs, and build a comprehensive measurement program over time.

- **Provide adequate training**
  Provide general training throughout the organization on the capabilities, intended uses, and limitations of the measurement process. Specific training for each role – champion, executive manager, project manager, measurement analyst, and team member – should target that role's needs.

- **Rigorously define measures**
  Thoroughly define measures and ensure the definitions are reviewed and agreed to by key stakeholders.  This increases understanding and the ability to use measures, and reduces the likelihood that measures will be misinterpreted. To help ensure measures are completely defined use a template, such as the PSM Measurement Specification Template [McGarry et al. 2002] available at http://www.psmsc.com/SampleMeasures.asp.

- **Assign roles and responsibilities**
  Accurate data collection and recording are key to producing trustworthy measures. Assigning accountability for timely, accurate, and complete data collection, analysis, and reporting is essential.

- **Demonstrate commitment**
  Demonstrate sustained commitment by using measurement in decision making. Make results visible and illustrate how they support project and enterprise objectives.

- **Minimize costs**
  Ensure that measures selected for collection and analysis are needed.  Don't buy tools without determining their applicability to your situation and evaluating the costs versus benefits of adoption and maintenance.  Existing tools may serve the purpose, especially when starting out in measurement.

- **Adopt an "Action Orientation"**
  Use measurement data proactively to identify risks and problems, evaluate candidate management actions, and report project status.  Make these uses visible throughout the project or enterprise.

- **Communicate**
  Establish effective interfaces among the projects, work groups, and individuals affected by the measurement process.  Communicate trends – both positive and negative – in a timely fashion**.**

☞ **Don't use measures (data) to determine rewards and punishments**
Make it clear that measurement will be used to manage and control the project – not to evaluate personnel – and that there will be no repercussions for reporting honest data. Use of data to reward and punish often results in manipulation of data to obtain an acceptable (but meaningless) answer.

To help you gauge your progress, the following indicators of a successful measurement activity are identified in the book **Practical Software Measurement: Objective Information for Decision Makers** [McGarry et al. 2002]:

☑ Data collection is automatic and natural

☑ Data is widely available

☑ People seek data as a basis for decision making

☑ Failure leads to understanding rather than blame

☑ Numeric objectives are accompanied by rational plans

☑ Improvements are made regularly to the measurement process

## Conclusion

Acquisition success is heavily influenced by the quality and timeliness of acquisition activities and work products. Acquisition measurement can help us understand and improve these activities and products, which lay the foundation for supplier efforts. As we've shown, measurement is an essential tool for objective management of an acquisition project or an enterprise responsible for multiple acquisition projects. The measurement process itself has value – the act of identifying measures can lead to clear statements of objectives, questions, and information needs. And the measurement data provided by the process enables timely, objective analysis and decision making.

In this paper, we've shown how the PSM process can be applied to identify, define, and use acquisition measures at both the project and enterprise levels. We've also provided examples of candidate indicators and appendices with supplementary information, including definitions, a PSM process summary, references, and samples of an acquisition work breakdown structure, an acquisition measure table, and a measurement plan outline. Sample measurement specifications are available at http://www.psmsc.com/SampleMeasures.asp.

We hope you will use the information in this paper to begin establishing measurement for your own acquisition project or enterprise. We welcome feedback on the content as well as suggestions for further publications at psm@psmsc.com. Finally, we wish you success as you embark on your efforts to establish a successful acquisition measurement practice for your own project or enterprise.

# Appendix A:  Definitions

This appendix includes definitions of selected system, software, and measurement terms. Standard definitions are used, where they exist.

| Term | Definition |
|---|---|
| Acquirer | Stakeholder that acquires or produces a product or service from a supplier. (ISO/IEC 15288:2008) [ISO/IEC 2008b] |
| Acquisition | The process of obtaining a system product or service. (ISO/IEC 15288:2008) [ISO/IEC 2008b] |
| Acquisition Enterprise | A person or a group of people and facilities with an arrangement of responsibilities, authorities, and relationships focused on Acquisition. (Adapted from ISO/IEC 15288:2008 definition of Organization) [ISO/IEC 2008b]<br><br>An acquisition enterprise may be comprised of one or more lower level acquisition enterprises (also referred to as sub-enterprises) and acquisition projects.  Acquisition sub-enterprises may in turn be comprised of acquisition sub-enterprises and acquisition projects. |
| Acquisition Measurement | The process an acquirer uses to obtain, analyze, and apply quantitative data for effective management and control over the activities, processes, products, resources, and environmental factors needed to conduct acquisition.<br><br>Acquisition measurement encompasses all factors affecting the acquirer's ability to meet objectives, both internal factors the acquirer has control over and external factors it may be unable to influence.  Measuring and analyzing the latter enables the acquirer to identify and respond to related risks and problems. |
| Acquisition Project | An endeavor with defined start and finish dates undertaken to acquire a product or service in accordance with specified resources and requirements and focused on Acquisition. (Adapted from ISO/IEC 15288:2008 definition of Project) [ISO/IEC 2008b]<br><br>An *Acquisition Project* may "belong" to or be governed by an *Acquisition Enterprise*. |
| Attribute | Property or characteristics of an *entity* that can be distinguished quantitatively or qualitatively by human or automated means. (ISO/IEC 15939:2007) [ISO/IEC 2007] |
| Base Measure | *Measure* defined in terms of an *attribute* and the method for quantifying it. (ISO/IEC 15939:2007) [ISO/IEC 2007] |
| Decision Criteria | Thresholds, targets, or patterns used to determine the need for action or further investigation, or to describe the level of confidence in a given result. (ISO/IEC 15939:2007) [ISO/IEC 2007] |
| Derived Measure | *Measure* that is defined as a function of two or more *values* of *base measures*. (ISO/IEC 15939:2007) [ISO/IEC 2007] |
| Entity | Object that is to be characterized by measuring its *attributes*.  Note: An entity can be a process, product, project, or resource. (ISO/IEC 15939:2007) [ISO/IEC 2007] |

| Term | Definition |
|---|---|
| Indicator | *Measure* that provides an estimate or evaluation of specified *attributes* derived from a model with respect to defined *information needs*. (ISO/IEC 15939:2007) [ISO/IEC 2007] |
| Information Need | Insight necessary to manage objectives, goals, risks, and problems.(ISO/IEC 15939:2007) [ISO/IEC 2007] |
| Information Product | One or more *indicators* and their associated *interpretations* that address an *information need*. (ISO/IEC 15939:2007) [ISO/IEC 2007] |
| Measurable Concept | Abstract relationship between attributes of entities and information needs. (ISO/IEC 15939:2007) [ISO/IEC 2007] |
| Measure | Noun: Variable to which a *value* is assigned as the result of *measurement*. The plural form "measures" is used to refer collectively to *base measures*, *derived measures*, and *indicators*. (ISO/IEC 15939:2007) [ISO/IEC 2007]<br><br>Verb: To make a *measurement*. (ISO/IEC 15939:2007) [ISO/IEC 2007] |
| Model | Algorithm or calculation combining one or more *base* and/or *derived measures* with associated *decision criteria*. (ISO/IEC 15939:2007) [ISO/IEC 2007] |
| Stakeholder | 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. (ISO/IEC 15288:2008) [ISO/IEC 2008b] |
| Supplier | Organization or individual that enters into an agreement with the acquirer for the supply of a product or service.  The "supplier" could be a contractor, producer, seller, or vendor. Sometimes, the acquirer and supplier are part of the same organization. (ISO/IEC 15288:2008) [ISO/IEC 2008b] |
| Value | Numerical or categorical result assigned to a *base measure*. (ISO/IEC 15288:2008) [ISO/IEC 2008b] |

# Appendix B:  Acquisition Work Breakdown Structure

This appendix contains the Acquisition Work Breakdown Structure (WBS) created by the PSM Acquisition Measurement Working Group.  Primary sources for developing the WBS include ISO/IEC 15288:2008, System Life Cycle Processes [ISO/IEC 2008b] and ISO/IEC 12207:2008, Software Life Cycle Processes [ISO/IEC 2008a], and Capability Maturity Model Integration for Acquisition (CMMI-ACQ), Version 1.2 (CMMI-ACQ) [SEI 2007 and Richter 2008].

The appendix contains the following:

- Figure 4, PSM Acquisition WBS – Levels 1-3.

- Table 11, PSM Acquisition WBS – Levels 1-5

- Table 12**,** PSM Acquisition WBS with Notes – Levels 1-5

**Figure 4. PSM Acquisition WBS – Levels 1 - 3**
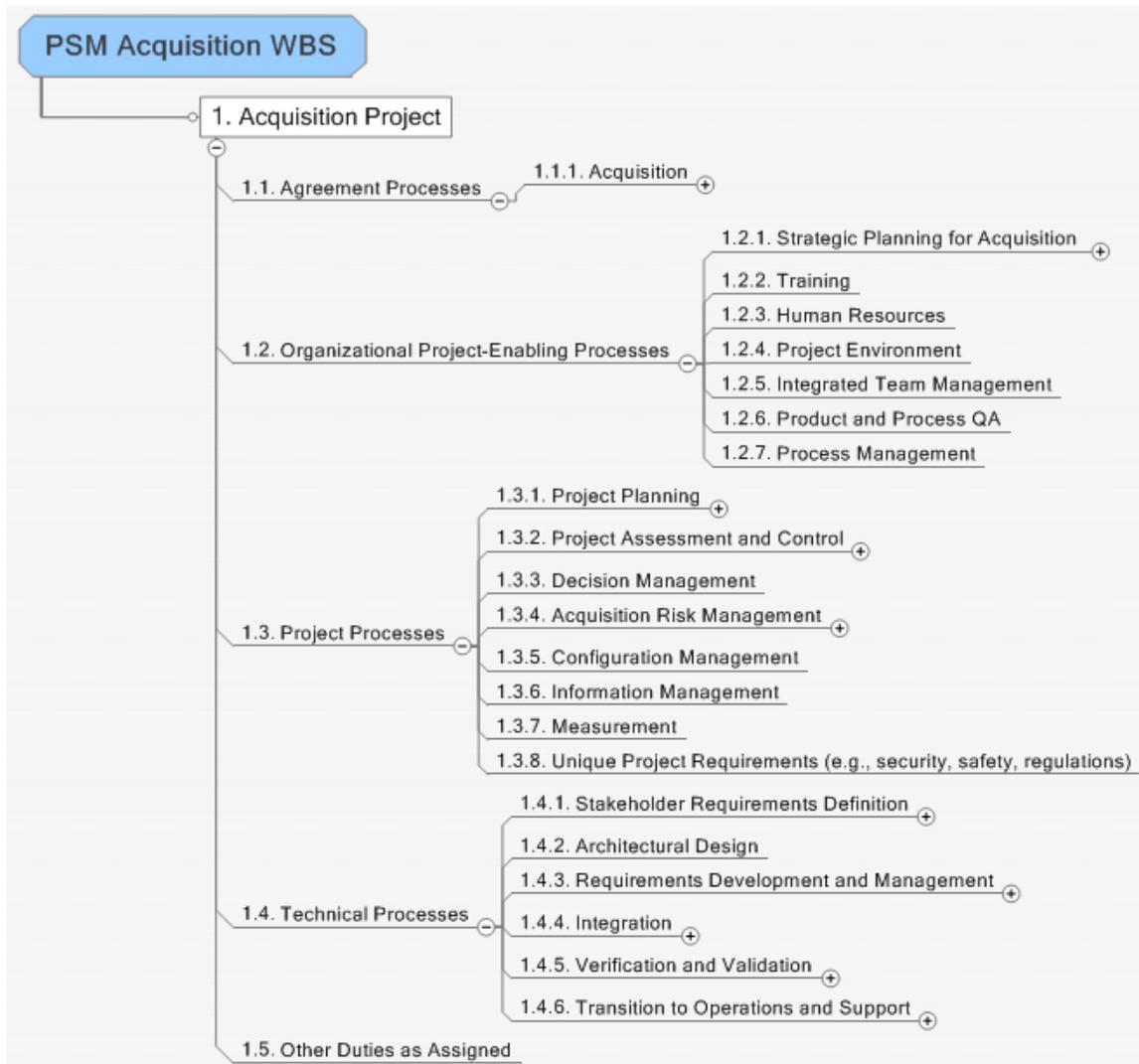
**Table 11. PSM Acquisition WBS, Levels 1 - 5**

| WBS | Title |
|---|---|
| 1 . 0 | Acquisition Project |
| 1 . 1 | Agreement Processes |
| 1 . 1 . 1 | Acquisition |
| 1 . 1 . 1 . 1 | Solicitation and Source Selection |
| 1 . 1 . 1 . 2 | Contract Management |
| 1 . 2 | Organizational Project-Enabling Processes |
| 1 . 2 . 1 | Strategic Planning for Acquisition |
| 1 . 2 . 1 . 1 | Studies and Analyses |
| 1 . 2 . 2 | Training |
| 1 . 2 . 3 | Human Resource Management |
| 1 . 2 . 4 | Project Environment |
| 1 . 2 . 5 | Integrated Team Management |
| 1 . 2 . 6 | Product and Process QA |
| 1 . 2 . 7 | Process Management |
| 1 . 3 | Project Processes |
| 1 . 3 . 1 | Project Planning |
| 1 . 3 . 1 . 1 | Acquisition Strategy Development |
| 1 . 3 . 1 . 2 | Detailed Acquisition Planning |
| 1 . 3 . 2 | Project Assessment and Control |
| 1 . 3 . 2 . 1 | Acquisition Execution and Control |
| 1 . 3 . 2 . 1 . 1 | Supplier Performance Management |
| 1 . 3 . 2 . 1 . 2 | Supplier Product Evaluation/Review |
| 1 . 3 . 2 . 1 . 3 | Supplier Process Evaluation/Review |
| 1 . 3 . 2 . 2 | Acquisition Product Review |
| 1 . 3 . 2 . 3 | Financial Management |
| 1 . 3 . 3 | Decision Management |
| 1 . 3 . 4 | Acquisition Risk Management |
| 1 . 3 . 4 . 1 | Risk Management Planning |
| 1 . 3 . 4 . 2 | Risk Management |
| 1 . 3 . 4 . 2 . 1 | Proactive Risk Identification |
| 1 . 3 . 4 . 2 . 2 | Monitoring |

| WBS | Title |
|---|---|
| 1 . 3 . 4 . 2 . 3 | Mitigation |
| 1 . 3 . 4 . 2 . 4 | Retirement |
| 1 . 3 . 5 | Configuration Management |
| 1 . 3 . 6 | Information Management |
| 1 . 3 . 7 | Measurement |
| 1 . 3 . 8 | Unique Project Requirements (e.g., security, safety, regulations) |
| 1 . 4 | Technical Processes |
| 1 . 4 . 1 | Stakeholder Requirements Definition |
| 1 . 4 . 1 . 1 | Stakeholder Requirements Definition Planning |
| 1 . 4 . 1 . 2 | Stakeholder Requirements Elicitation and Documentation |
| 1 . 4 . 1 . 3 | Studies and Analyses |
| 1 . 4 . 2 | Architectural Design |
| 1 . 4 . 3 | Requirements Development and Management |
| 1 . 4 . 3 . 1 | Requirements Development and Management Planning |
| 1 . 4 . 3 . 2 | Requirements Elicitation and Documentation |
| 1 . 4 . 3 . 3 | Supplier Requirements Traceability Monitoring |
| 1 . 4 . 3 . 4 | Requirements Management |
| 1 . 4 . 4 | Integration |
| 1 . 4 . 4 . 1 | Integration Planning |
| 1 . 4 . 4 . 2 | Integration Execution |
| 1 . 4 . 5 | Verification and Validation |
| 1 . 4 . 5 . 1 | Verification and Validation Planning |
| 1 . 4 . 5 . 2 | Verification |
| 1 . 4 . 5 . 3 | Validation |
| 1 . 4 . 6 | Transition to Operations and Support |
| 1 . 4 . 6 . 1 | Planning for Transition |
| 1 . 4 . 6 . 2 | Distribution Management |
| 1 . 4 . 6 . 3 | Delivery |
| 1 . 4 . 6 . 4 | Project Closeout or Iteration Assessment |
| 1 . 5 | Other Duties as Assigned |

**Table 12. PSM Acquisition WBS with Notes,  Levels 1 – 5**

| WBS | Title | NOTES |
|---|---|---|
| 1 . 0 | **Acquisition Project** | The Acquisition Project or Program of interest is at the top level of the WBS. Note: Some organizations use the word "project" and some the word "program" to apply to an acquisition effort.  Some organizations use "program" to refer to an acquisition effort that may consist of several acquisition projects, where each project involves the acquisition of one or more end items or services. |
| 1 . 1 | **Agreement Processes** | |
| 1 . 1 . 1 | **Acquisition** | Identifies the process the organization has to do to implement a formal agreement with a supplier. |
| 1 . 1 . 2 | **Solicitation and Source Selection** | Development of a Due Diligence Questionnaire (for preparing RFP/RFI), applying FAR regulations, ensuring compliance with the law (e.g., FISMA provisions, 30 Sep 2005); through the supply chain. |
| 1 . 1 . 3 | **Contract Management** | Initiation, implementation and maintenance of a contract, including billings, payments and award fees. |
| 1 . 2 | **Organizational Project-Enabling Processes** | |
| 1 . 2 . 1 | **Strategic Planning for Acquisition** | Development of Enterprise Goals and high (above project) level strategic plans for enterprise. |
| 1 . 2 . 1 . 1 | **Studies and Analyses** | Studies and Analysis related to enterprise level mission needs, capabilities (existing and gaps) and concept of operations and sustainment.  Other enterprise level studies, e.g., strategic technology identification and evaluation, S&T analysis, market analysis, industrial based capacity analysis. |

| WBS | Title | NOTES |
|---|---|---|
| 1 . 2 . 2 | **Training** | For EVERYTHING!  Use process asset library (PAL), if have one.  For some (Risk & Measurement), could encompass acquirer- supplier team training. |
| 1 . 2 . 3 | **Human Resource Management** | Insuring proper talent and number of individuals required are available |
| 1 . 2 . 4 | **Project Environment** | Facilities, infrastructure and IT Support. |
| 1 . 2 . 5 | **Integrated Team Management** | Team / Team Member Identification.  Team Structure and Decision-Making Authority Definition.  Team charter (roles, responsibilities, and authority for making and implementing decisions).  Identifies boundaries for authority with respect to cost  and schedule changes, and technical redirection.  How does integrated team protect information/work products? What can be shared and what cannot?  Post-Contract Award Workshops: How do the acquirer-supplier-user function as a team, what are the processes for meetings, Action Item tracking and resolution, ...? How do they jointly manage risks? What are the joint measurement activities?  What are the common tools and libraries the team will used? Where are the team's processes documented?  Check IPPD in the CMMI for measurable capabilities. |
| 1 . 2 . 6 | **Product and Process QA** | This supports the delivery of high-quality products and services by providing the project staff and managers the appropriate visibility into, and feedback on, processes and associated work products throughout the life of the project. |

| WBS | Title | NOTES |
|---|---|---|
| 1 . 2 . 7 | **Process Management** | Identification of needed processes for the acquisition project. Development of project acquisition processes, or tailoring from org processes. Assessment of project acquisition processes to ensure effectiveness (not just compliance). Managing changes/updates to project acquisition processes. |
| 1 . 3 | **Project Processes** | |
| 1 . 3 . 1 | **Project Planning** | What needs to get done to plan overall acquisition, select supplier(s), execute and control acquisition program, and transition it to operations and support (and other technical and project processes). |
| 1 . 3 . 1 . 1 | **Acquisition Strategy Development** | Development of project acquisition strategy, based on reducing key risks. Includes things like program structure, acquisition approach, life cycle model, solicitation type, contract approach, risk management, test and evaluation, and product support. |
| 1 . 3 . 1 . 2 | **Detailed Acquisition Planning** | Compliance w/ FAR & agency elaborations. Planning for all the activities in this WBS (requirements, v&v, process management). Development of an acquisition plan that implements the acquisition strategy. |
| 1 . 3 . 2 | **Project Assessment and Control** | Assessment includes the identification, analysis and prioritization of identified project risks. Control includes the management planning, resolution and monitoring of those risks. |
| 1 . 3 . 2 . 1 | **Acquisition Execution and Control** | Controlling the acquisition processes through performance and product reviews. |

| WBS | Title | NOTES |
|---|---|---|
| 1 . 3 . 2 . 1 . 1 | **Supplier Performance Management** | Includes things like cost-schedule- performance evaluation (e.g., earned value, TPMs, etc.) |
| 1 . 3 . 2 . 1 . 2 | **Supplier Product Evaluation/Review** | Includes detailed review or evaluation of supplier products (architecture, requirements, designs, planning documents, test information, etc.).  Might include alpha/beta testing. |
| 1 . 3 . 2 . 1 . 3 | **Supplier Process Evaluation/Review** | This would include review of supplier processes, e.g., requirements management, project planning, etc.; option to do this should be identified in RFP or during contract negotiation, based on process risks. This might include Internal Baseline Reviews (IBR). |
| 1 . 3 . 2 . 2 | **Acquisition Product Review** | Review of acquirer products (plans such as SEMP and TEMP, CONOPs, RFP, requirements/capabilities documents, etc.) |
| 1 . 3 . 2 . 3 | **Financial Management** | Insuring all of the funds are acquired and obligated as needed and the documentation is maintained as required. |
| 1 . 3 . 3 | **Decision Management** | Insuring processes are in place to insure adequate decision making and follow through. |
| 1 . 3 . 4 | **Acquisition Risk Management** | This includes the entire spectrum of risks to an acquisition and the operational community, not just traditional cost, schedule, and performance risks.  This is MORE than just the supplier's set of risks (the acquirer needs to identify risks on its own and not just rely on the supplier).  It includes Risks relative to all the other top-level WBS elements (acquisition mgmt, funds availability, acquisition support, requirements, verification and validation, into team mgmt, process mgmt, and other duties). |

| WBS | Title | NOTES |
|---|---|---|
| 1 . 3 . 4 . 1 | **Risk Management Planning** | Identify reliance on other programs (e.g., acquisition programs) or immature technologies. |
| 1 . 3 . 4 . 2 | **Risk Management** | Identify processes to report, manage and track risk. |
| 1 . 3 . 4 . 2 . 1 | **Proactive Risk Identification** | Develop the criteria to  identify what is a risk element and how to report it. |
| 1 . 3 . 4 . 2 . 2 | **Monitoring** | Have risk review boards and or reports to identify the risk status on a regular basis. |
| 1 . 3 . 4 . 2 . 3 | **Mitigation** | Identify the actions needed to reduce and/or eliminate the risk element. |
| 1 . 3 . 4 . 2 . 4 | **Retirement** | When the risk is no longer a threat have the information about it archived and available on future activities that may encounter the same risk scenario. |
| 1 . 3 . 5 | **Configuration Management** | Tracking the development and changes to specific products. |
| 1 . 3 . 6 | **Information Management** | Having the processes in place to allow the needed information to flow to the proper areas within an organization to insure efficient development. |
| 1 . 3 . 7 | **Measurement** | Development of the measurement process and identification of needed measures for the Acquisition Process. |
| 1 . 3 . 8 | **Unique Project Requirements (e.g., security, safety, regulations)** | Security (clearances, secure facilities, program-specific protection initiatives, secure communications).  Safety (nuclear, assembly and test facility safety, etc.). Regulations and legislation (e.g., import/export, ITAR). |
| 1 . 4 | **Technical Processes** | |

| WBS | Title | NOTES |
|---|---|---|
| 1 . 4 . 1 | **Stakeholder Requirements Definition** | Elicitation and definition of user needs/mission capabilities. |
| 1 . 4 . 1 . 1 | **Stakeholder Requirements Definition Planning** | Planning--essential to give this activity the best chance at success. Often done haphazardly (series of poorly planned meetings with no purpose/outcome/products defined) |
| 1 . 4 . 1 . 2 | **Stakeholder Requirements Elicitation and Documentation** | Insuring the Basic Requirements of the stakeholders are socialized to all and documented at least to what their priorities are. |
| 1 . 4 . 1 . 3 | **Studies and Analyses** | Studies and analyses specifically directed toward project stakeholder requirements, questions, issues, and concerns. |
| 1 . 4 . 2 | **Architectural Design** | Development of an architectural design / operational architecture to guide operational requirements analysis and specification. Definition of architectural quality attributes (e.g., reliability, security, safety, maintainability, performance, availability, modifiability). |
| 1 . 4 . 3 | **Requirements Development and Management** | These activities permeate the life cycle and either affect or are affected by all other top-level WBS elements. Successful Requirement Dev and Mgmt is essential to successful acquisition. |
| 1 . 4 . 3 . 1 | **Requirements Development and Management Planning** | E.g., later acquisition. lifecycle planning for requirements activities; planning when and how going to elicit new requirements from user community |

| WBS | Title | NOTES |
|---|---|---|
| 1 . 4 . 3 . 2 | **Requirements Elicitation and Documentation** | Identifying the details of the stakeholder needs and constraints (expectations management). Prioritize and identify all interfaces.  Identify requirements derived from laws, regulations, and standards. |
| 1 . 4 . 3 . 3 | **Supplier Requirements Traceability Monitoring** | As the requirements are identified, prioritized etc, the supplier develops a process to monitor the status of the requirements and report to the acquirer on a regular basis. |
| 1 . 4 . 3 . 4 | **Requirements Management** | Managing through measurement the quality, cost and schedule of the requirements and the development of the product. |
| 1 . 4 . 4 | **Integration** | Insuring the process are in place to insure the product is adequately integrated into its proposed environment. |
| 1 . 4 . 4 . 1 | **Integration Planning** | Putting together the processes that are expected to be used to implement proper integration of the product including measurement of appropriate activities. |
| 1 . 4 . 4 . 2 | **Integration Execution** | During Integration, monitoring/measuring the activities and quality of the product. |
| 1 . 4 . 5 | **Verification and Validation** | These activities are closely tied to Requirement Dev and Mgmt, and like Requirement Dev and Mgmt, they permeate the lifecycle and affect or are affected by all other top-level WBS elements. |
| 1 . 4 . 5 . 1 | **Verification and Validation Planning** | Verification: am I building the system right?  Validation: am I building the right system? |
| 1 . 4 . 5 . 2 | **Verification** | e.g., peer reviews, technical reviews, ITAs, walkthroughs, T&E against specifications |

| WBS | Title | NOTES |
|---|---|---|
| 1 . 4 . 5 . 3 | **Validation** | e.g., operational acceptance test/review, user/operator review of documentation (e.g., planning documents, data collecting docs), user/operator review of prototypes |
| 1 . 4 . 6 | **Transition to Operations and Support** | Acquirer to stakeholder (user, operations, support organization, distribution network, etc.) |
| 1 . 4 . 6 . 1 | **Planning for Transition** | The processes to take the project from development into the hands of the acquirer. |
| 1 . 4 . 6 . 2 | **Distribution Management** | Managing the initial distribution and subsequent releases to the acquirer |
| 1 . 4 . 6 . 3 | **Delivery** | The process to insure the acquirer has received the products in good condition. |
| 1 . 4 . 6 . 4 | **Project Closeout or Iteration Assessment** | The processes involved with shutting down the project including disposal if needed. |
| 1 . 5 | **Other Duties as Assigned** | Special studies and analyses, not planned initially (need arises during the acquisition life cycle). Unplanned tasking. Unplanned reporting. Unplanned audits. Taskers from GAO, OSD oversight, etc. Continuous justification of funding requirements. Program adjustment and change management. Calls to the Hill or OSD. Status reports. External audits and reviews. Policy reviews. Reorganizations. Gathering lessons learned. |

# Appendix C:  Summary Acquisition ICM$^2$ Tables

This section contains two tables, the first for enterprise-level measures and the second for project-level measures.

**Table 13.  Acquisition Enterprise-Level ICM Table**

| Acquisition Enterprise-Level ICM Table | | | | |
|---|---|---|---|---|
| **Information Categories** | **Questions Addressed** | **Measurable Concepts** | **Measures** | **Notes** |
| Schedule & Progress | Are the projects within this enterprise on track? | Milestone Completion | Milestone Progress Interim Progress Trend | Milestones mean major milestones such as major reviews and delivery dates. For the enterprise, want some early indication of whether major milestones will be met. |
| | What is the degree of risk associated with each project? Which projects are most at risk? | Risk Status | Risk Likelihood and Impact | At the highest level. Likelihood and Consequence for the top 10 risks on each project. |
| | What is the enterprise work backlog?  What should be scheduled next? | Work Backlog | Open Defects Enhancements Needs | Measure/categorize open defects, enhancements, and needs by priority level |

---

$^2$ *ICM* stands for **I**nformation Category-Measurable **C**oncept-**M**easure.  The ICM table provides sample Information Needs and associated candidate measurable concepts and measures for each.

| Acquisition Enterprise-Level ICM Table | | | | |
|---|---|---|---|---|
| **Information Categories** | **Questions Addressed** | **Measurable Concepts** | **Measures** | **Notes** |
| Resources & Cost | Does the enterprise budget and funding process support the financial needs of the projects? | Financial Adequacy | Obligation Rates Disbursement Rates Funding Availability | Is funding available for each project as needed?  Consider:<br>- spread of money across the year for multiple projects<br>- color of money and plus-ups for government projects<br>- funding blocks, pull-backs<br>- studies, management reserve, as well as development and maintenance projects |
| Resources & Cost, Cont'd | Within the enterprise, are there sufficient qualified resources (people)? | Personnel Effort | Effort Experience Level Staff Turnover Workforce Age Profiles Education/Training Profiles | Consider:<br>- turnover rate<br>- military rotations<br>- training, education<br>- motivation<br>- etc. |
| Product Size & Stability | How many systems are in development?  How big are they?  How many systems are being maintained?  How big are they?  What are the trends over time? | Physical Size and Stability Functional Size and Stability | Interfaces Interface Complexity Lines of Code Requirements | |
| | Are requirements (needs) and architecture elements stable? | Functional Size and Stability | Requirements Volatility Architecture Elements Volatility | |

| Acquisition Enterprise-Level ICM Table | | | | |
|---|---|---|---|---|
| **Information Categories** | **Questions Addressed** | **Measurable Concepts** | **Measures** | **Notes** |
| Product Quality | Are the projects delivering quality products that meet performance requirements? | Functional Correctness Dependability-Reliability | Needs Tested Successfully Defect Density Defect Escapes Components Accepted | At the aggregate level. Does the project meet: - user expectations (needs, not specifications) - TPMs - delivery criteria - permissible levels of delivered defects? |
| | Are known problems being resolved? | Functional Correctness | Defects Resolved | During warranty or against backlog of issues |
| Process Performance | Are the processes sufficient to operate efficiently in support of the acquisition activities | Process Effectiveness | Process Capability Process Adherence | E.g. Capability (and not level) with respect to CMMI-ACQ process areas. Getting projects on contract in a timely manner with a sufficient level of quality |
| | What are enterprise norms for completing acquisition activities (schedule, cost, productivity)? | Process Efficiency | Cycle Time Effort Productivity | E.g. get a RFP package out, review proposals, review CDRLs, etc. (assuming sufficient level of quality) |
| | What are enterprise norms for completing development activities (schedule, cost, productivity)? | Process Efficiency | Cycle Time Effort Productivity | |
| Technology Effectiveness | Does the enterprise have sufficient technology insertion plans and implementations? | Technology Adoption | Needs Met by Technology Insertion Technology Refresh Rate | |
| Customer Satisfaction | Are user needs / concerns being met?  Is the enterprise delivering the products that are needed with sufficient functionality and performance for the mission? | Customer Feedback Customer Support | Satisfaction Ratings Requests for Support | |

**Table 14.  Acquisition Project Level ICM Table**

| Acquisition Project Level ICM Table | | | | |
|---|---|---|---|---|
| **Information Categories** | **Questions Addressed** | **Measurable Concepts** | **Measures** | **Notes** |
| Schedule & Progress | Are acquisition activities and commitments completed as scheduled? | Milestone Completion Work Unit Progress | Milestone Dates Test Cases Attempted and Passed Requirements Documented and Reviewed Requirements Traced and Tested Reviews Completed Action Items Closed | Milestones mean acquisition milestones Work Unit Progress - measure slippage Milestones could include developing the RFP, bidding and source selection, awards, contract modifications, reviewing CDRLs, test progress, developing SAMP, SEMP, TEMP, contract monitoring and review, funding milestones |
| | What is the degree of risk associated the project?  What are the highest risks? | Risk Status | Risk Status | Detailed risks |
| Schedule & Progress Resources & Cost | Has the acquisition office established realistic cost and schedule parameters for the system and for acquisition activities?  Have the system proposals been evaluated for realistic cost and schedule projections? | Schedule Feasibility Cost Feasibility | Schedule Probability Cost Probability | Evaluate for both acquisiton activities and for development activities. Include updates as schedules and funding changes. Note:  need to make sure that there is a separate, realistic  schedule acquisition office activities, including realistic review and approval times.  Is the RFP development schedule realistic? Is the transition to support schedule realistic? Have critical paths been identified? Have we identified and planned for budgetary milestones? |
| | Are the development schedule and cost realistic? | Schedule Feasibility Cost Feasibility | Schedule Probability Cost Probability | Consider any changes made prior to award/initiation. |

| Acquisition Project Level ICM Table | | | | |
|---|---|---|---|---|
| **Information Categories** | **Questions Addressed** | **Measurable Concepts** | **Measures** | **Notes** |
| Resources & Cost | Does the project have sufficient money to conduct acquisition activities on this project? | Financial Performance | Cost BCWS, BCWP, ACWP | Requires good EV on acquisition activities. |
| | Does the project have sufficient qualified resources to conduct acquisition activities on this project? | Personnel Effort | Effort Experience Level Staff Turnover | |
| | Does the project have sufficient resources / infrastructure to conduct acquisition activities on this project? | Environmental and Support Resources | Quantity Needed and Available Time Available and Used | Facilities, material, test labs and equipment, SCIFs, software tools, simulation tools, etc. |
| Product Size & Stability | Are the user needs / top-level requirements and architectures stable?  What is the impact of changes? | Functional Size and Stability | Needs Volatility Architecture Volatility | Addressing those user needs / top-level requirements managed by the acquirer. Might be documented in operational capability documents, operational scenarios, top-level performance specifications. Want to measure # of architecture-level changes over time, driven by changes in user needs and/or requirements, which can tell us if we have a robust, flexible architecture. |
| | How many external interfaces exist in a program?   Are all external interfaces clearly identified?  Are the interfaces stable? Are external interfaces developed and tested as planned? | Functional Size and Stability | External Interface Volatility | External interfaces to other systems or program offices. |

| Acquisition Project Level ICM Table | | | | |
|---|---|---|---|---|
| **Information Categories** | **Questions Addressed** | **Measurable Concepts** | **Measures** | **Notes** |
| Product Quality | Is the project delivering quality products that meet performance requirements? | Functional Correctness Dependability- Reliability | Needs Tested Successfully Defect Density Defect Escapes TPMs Components Accepted Mean Time to Failure | Does the project meet: - user expectations (needs, not specifications) - TPMs - specifications (i.e. specified requirements that are traced to needs) - delivery criteria - permissible levels of delivered defects? |
| | How many defects are found in the acquisition work products? How much rework is required? | Functional Correctness Process Effectiveness | Defects Rework Effort Rework Components | Components are acquisition work products. |
| | How difficult is the product to maintain?  How much will it cost? How many people are required for a certain level of support? | Maintainability Financial Performance Personnel Effort | Cost Staff Level | |
| | Have you adequately budgeted, planned, and executed requirements for safety?  What is the residual safety risk of the system? | Safety | Safety Risk Incidents Incurred Cost per Incident | |
| | Have you adequately budgeted, planned, and executed requirements for security? | Security | IT Security Cost Physical Security Cost | |
| Process Performance | How effective & efficient is the acquisition office in identifying defects in system products? | Process Effectiveness | Defect Escapes | Evaluate defects identified by the acquisition organization against those identified by the supplier against those identified in the delivered product. |

| Acquisition Project Level ICM Table | | | | |
|---|---|---|---|---|
| **Information Categories** | **Questions Addressed** | **Measurable Concepts** | **Measures** | **Notes** |
| | How much time & effort is spent on various acquisition office activities? | Process Efficiency | Productivity | |
| Technology Effectiveness | Does the project have sufficient technology insertion plans and implementations? | Technology Adoption | Needs Met by Technology Insertion Technology Refresh Rate | |
| Customer Satisfaction | Is the end user satisfied with the acquisition office activities and interactions? Is there sufficient user involvement? Are user action items recorded and completed? | Customer Feedback Customer Support | Satisfaction Ratings Action Items Opened and Completed | |

# Appendix D:  Sample Measurement Plan Outline

## *Measurement Plan Outline*
### *Adapted from [McGarry et al. 2002]*

*Part 1 – Introduction*
- Purpose and Scope

*Part 2 – Project Description*
- Technical and Management Characteristics

*Part 3 – Measurement Approach*
- How Measurement is Integrated into the Project or Enterprise Processes
- Measurement Points of Contact (acquirer, supplier, subcontractors)
- Measurement Roles, Responsibilities, and Resources
- Organizational Communications and Interfaces
- Tools and Databases
- Phased Implementation (if applicable)
- Evaluation Criteria

*Part 4 – Description of Project Issues and Objectives*
- Organizational Goals and Issues
- Prioritized list of Information Needs

*Part 5 – System and Software Measures and Specifications*
- Include for Each Identified Information Need (these items comprise the measurement *construct*, which is defined in [McGarry et al. 2002] and [ISO/IEC 2007]
    - Measurable Concept
    - Relevant Entities
    - Attributes
    - Base Measures
    - Measurement Method
    - Scale
    - Type of Scale
    - Unit of Measurement
    - Derived Measure
    - Measurement Function
    - Indicator
    - Analysis Model
    - Decision Criteria

*Part 6 – Project Aggregation Structures*
- Component Aggregation Structure, such as configuration items or units
- Activity Aggregation Structure, such as Requirements Analysis, Design, Implementation, and Integration and Test
- Functional Aggregation Structure

*Part 7 – Reporting*
- Reporting Mechanisms and Periodicity
- Content of Reports

# Appendix E:  References

[DoD 2003]  *Practical Software and Systems Measurement: A Foundation for Objective Project Management*, version 4.0c. March 2003. www.psmsc.com

[DSB 2000]  Defense Science Board.  *Report of the Defense Science Board Task force on Defense Software.*  November 2000.

[GAO 2003]  Government Accountability Office (GAO). *DEFENSE ACQUISITIONS: Improvements Needed in Space Systems Acquisition Management Policy* (GAO Report GAO-03-1073).  September 2003.

[GAO 2004]  Government Accountability Office (GAO). *DEFENSE ACQUISITIONS: Stronger Management Practices Are Needed to Improve DoD's Software-Intensive Weapon Acquisitions* (GAO Report GAO-04-393).  March 2004.

[GAO 2008]  Government Accountability Office (GAO). *DEFENSE ACQUISITIONS: Assessments of Selected Weapons Programs* (GAO Report GAO-08-467SP).  March 2008.

[INCOSE 2007] International Council on Systems Engineering. *Systems Engineering Leading Indicators Guide*, version 1.0. INCOSE-TP-2005-001-02. June 2007.

[ISO/IEC 2007]  ISO/IEC. Systems and software engineering – Measurement process. ISO/IEC 15939:2007(E). ISO/IEC. 2007.

[ISO/IEC 2008a]  ISO/IEC. Systems and software engineering – Software life cycle processes. ISO/IEC 12207:2008(E). ISO/IEC. 2008.

[ISO/IEC 2008b]  ISO/IEC. Systems and software engineering – System life cycle processes. ISO/IEC 15288:2008(E). ISO/IEC. 2008.

[McGarry et al. 2002]  McGarry, John, David Card, Cheryl Jones, Beth Layman, Elizabeth Clark, Joseph Dean, and Fred Hall. **Practical Software Measurement: Objective Information for Decision Makers**. Addison-Wesley. 2002

[Richter 2008]  Richter, Karen.  *CMMI for Acquisition (CMMI-ACQ) Primer, Version 1.2* (CMU/SEI-2008-TR-010).  Pittsburgh, PA: Software Engineering Institute, Carnegie Mellon University. May 2008.

[SEI 2007] CMMI-ACQ Product Team.  *Capability Maturity Model Integration for Acquisition, Version 1.2* (CMU/SEI-2007-TR-017). Pittsburgh, PA: Software Engineering Institute, Carnegie Mellon University. November 2007.