

Applying PSM to Enterprise Measurement

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Abstract

This report describes the application of the concepts of Practical Software Measurement (PSM) to satisfy the information needs of enterprise management. In particular, it focuses on the relationship between PSM, an established approach for project measurement, and the Balanced Scorecard, an established approach for enterprise measurement. The key to integrating the two approaches lies in reconciling the two views of information needs.

1. Introduction

Many approaches to performance measurement recommend an initial focus on measurement at the project level. This is partly a matter of convenience (by definition a project has a defined starting point and ending point) and priority (estimating and accounting for the cost of products is a basic business problem). Nevertheless, the success of an organization eventually must be assessed as an enterprise, which includes factors other than the success of individual project success.

An enterprise is a self-contained business entity with profit and loss responsibility. An enterprise is intended to persist over time in one or more marketplaces. Enterprises may be comprised of other enterprises. Some large long-lived projects may be organized and behave like enterprises.

Practical Software and Systems Measurement [1, 2], hereafter referred to as PSM, has become widely accepted in industry as the measurement approach for the management of software-intensive system development projects. PSM derives from a measurement framework that consists of four elements [3]:

- Information (measurement) needs
- Information (measurement) user
- Measurement process model
- Measurement information model

The PSM process and information models have been codified as an international standard [4].

PSM focuses on the information needs of the project manager as the measurement user. The information needs of the enterprise manager are different in some important ways. The Balanced Scorecard (BSC) [5] provides a widely accepted definition of the common

information needs of enterprise managers. However, the BSC approach does not provide elements corresponding to the PSM measurement process and information models. This report describes how the PSM approach can be adapted to satisfy the information needs of the enterprise manager within the context of the BSC.

The BSC evolved from experience with enterprises engaged in “continuous” production and sales. Their processes operate continually, delivering products and generating revenue. However, the business of many enterprises depends on successful completion of “projects”. That is, they periodically undertake a major effort that may result in delivery of the full operational capability only after several years. These project-based enterprises often have difficulty implementing satisfactory BSC systems. This report integrates BSC and PSM concepts to provide a comprehensive solution for enterprise measurement that addresses those difficulties.

2. Comparison of PSM and Balanced Scorecard

The four elements of the framework introduced in Section 1 establish a basis for comparing the PSM and BSC approaches to measurement. The following paragraphs discuss each element of the framework in turn.

2.1 DECISION-MAKERS

The essential purpose of a measurement program is to provide information that assists decision makers in selecting successful courses of action. The decisions that are made can be organized into four types or classes: enterprise, process, project, and product. These classes are not meant to imply levels in any specific organizational structure. The classes are areas of responsibility that may be mapped to many different organizational structures in different ways. However, any healthy, self-sufficient organization must address all of them in some form. The real discriminator between the classes of decision-making processes is the focus of concern and responsibility of the decision maker rather than its specific hierarchical position.

Enterprise decisions involve investing in products and services to offer in a market or investing in improvements that enhance organizational performance. The allocation of investments seeks to maximize customer satisfaction, market share, and profitability simultaneously, although tradeoffs often are necessary.

Process decisions focus on the efficiency and effectiveness of the organization's means of accomplishing work. Thus, decisions refer to people, methods, and technology (e.g., tools and infrastructure that support those processes). The processes of typical organizations may include software and systems engineering, manufacturing, marketing, finance, product support, and human resources.

Since PSM has traditionally addressed support for project and product decision-making, they are not a focus of this report. However, measurement and analysis of all types often depends on many of the same sources of data, so project and product data are often

summarized as the basis for enterprise and process decisions. The BSC, on the other hand, focuses on the enterprise decision-making, which incorporates information outside the scope of projects. In this respect the two approaches are quite different.

2.2 INFORMATION NEEDS

Information needs may be defined in terms of objectives and obstacles to achieving those objectives. Defining an objective creates the need to establish measures to track progress. An objective may be a goal or a constraint. Goals may be strategic improvement or tactical performance targets. Constraints may be non-negotiable budgets, schedules or technical performance requirements.

Measuring performance relative to an objective usually is not enough to achieve it. Action must be taken to change performance and overcome the associated obstacles. Taking action usually requires investment. Different action strategies usually encounter different obstacles. Obstacles include risks, problems, and lack of information. The obstacles themselves must be measured and managed to maximize the chances of achieving the objective. Thus, the obstacles also become the basis for information needs.

Because each class of decision-making addresses different responsibilities, the objectives at each level may be somewhat different. Moreover, different obstacles are encountered at each level. Differing objectives and obstacles lead to different information needs and measurements. Nevertheless, the information needs of the various classes of decision-making processes are not independent. Moreover, information needs may be deployed throughout the organization. Goals at one level of decision-making may become constraints (and consequently information needs) at another level. Several organizational levels may need to act in coordination to achieve a common objective.

The enterprise decision maker assumes responsibility for the long-term health of the organization and its ability to successfully compete in its selected marketplace(s). Typically, this means increasing revenues and profitability. The enterprise decision maker attempts to maximize market share by satisfying customers while at the same time preserving or increasing profitability. This is accomplished by appropriately allocating investments (time and money) between projects that deliver products and services that customers want, and the processes (methods, tools, infrastructure) and people that help projects perform better. The enterprise manager usually does not direct these initiatives personally but must monitor the outcome. Similarly, the enterprise manager must track the overall status of projects producing products and services for customers. Tracking the status of those investments requires only summary information about performance. However, process- and project-level decision makers require more detailed information about the activities for which they are responsible.

The BSC organizes the information needs of the enterprise manager into four perspectives: financial, customer, internal processes, and learning and growth. These are discussed in more detail in Section 3. PSM, on the other hand, organizes the information needs of the project manager into seven categories of information needs:

- Schedule and progress
- Resources and cost
- Product size and stability
- Product quality
- Process performance
- Technology effectiveness
- Customer satisfaction

While some of these categories don't obviously relate to the BSC approach, others seem to parallel the BSC perspectives:

- Resources and cost – financial
- Process performance – internal process
- Customer satisfaction – customer

The key to integrating the PSM and BSC approaches lies in reconciling the two views of information needs as discussed in Section 4.

2.3 MEASUREMENT PROCESS MODEL

The PSM [2] measurement process model (illustrated in Figure 1) consists of four basic activities:

- Establish commitment – obtain the necessary sponsorship and support to sustain a measurement program
- Plan measurement – understand the information needs and define appropriate measurement constructs to address them
- Perform measurement – collect and analyze data as defined by the measurement constructs
- Evaluate measurement – assess and improve the measurement program

These high-level activities apply equally well at the enterprise level as at the project-level. However, some differences occur in the details. For example, due to the broader nature of enterprise measurement, a broader commitment to measurement is required at this level than for project-level measurement.

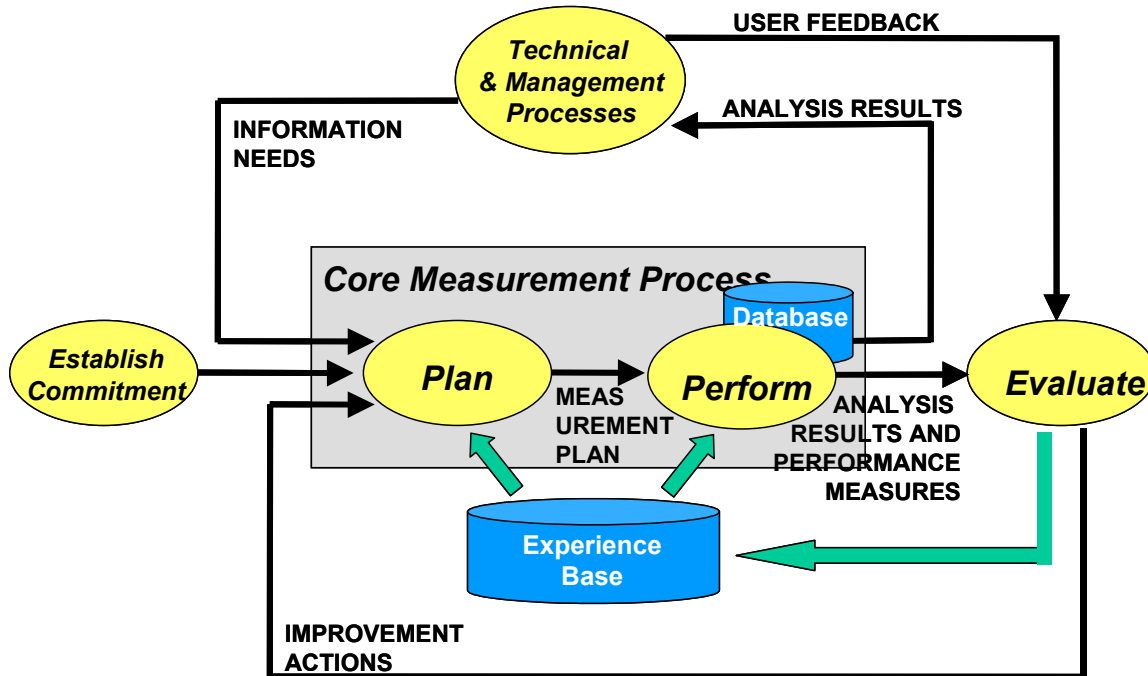


Figure 1. Measurement Process Model [2]

Planning and Performing are the “core measurement activities” at both the enterprise and project management levels. Planning focuses on identifying information needs and defining appropriate measurement constructs to address them. The BSC approach was designed to complement strategic planning. Thus, the BSC perspectives define the dimensions of an enterprise that might be altered via strategic initiatives. Selection of measures for the BSC is driven by the identification of the critical success factors for the intended strategy rather than the identification of risks to project objectives, as in PSM.

Performing consists largely of executing the measurement plan, with excursions from the plan as necessary to respond to the questions of the enterprise manager. The same PSM concerns for the validity of the data and the reproducibility of the analyses apply to the execution of enterprise measurement.

The PSM approach to measurement evaluation is tied to the measurement information model. As discussed in the next section, the information model applies broadly. Consequently, the primary differences in this activity involve assessing the “fitness for use” of the measures relative to the enterprise manager, rather than the project manager.

2.4 MEASUREMENT INFORMATION MODEL

The PSM [2] measurement information model (adapted from [4]) defines a consistent set of terms and concepts for describing measurement constructs and activities. The model defines three levels of measures (as illustrated in Figure 2):

- Base Measures – quantifications of a single attribute
- Derived Measures – combinations of values of base measures
- Indicators – base and/or derived measures with associated analysis models and decision criteria

This information model may be assumed to apply equally well to enterprise-level measurement because it was, itself, adapted from a widely accepted international vocabulary defined for measurement in general [6]. The modifications made in [2] and [4] simply adjust the terminology to better suit software engineering and information technology enterprises.

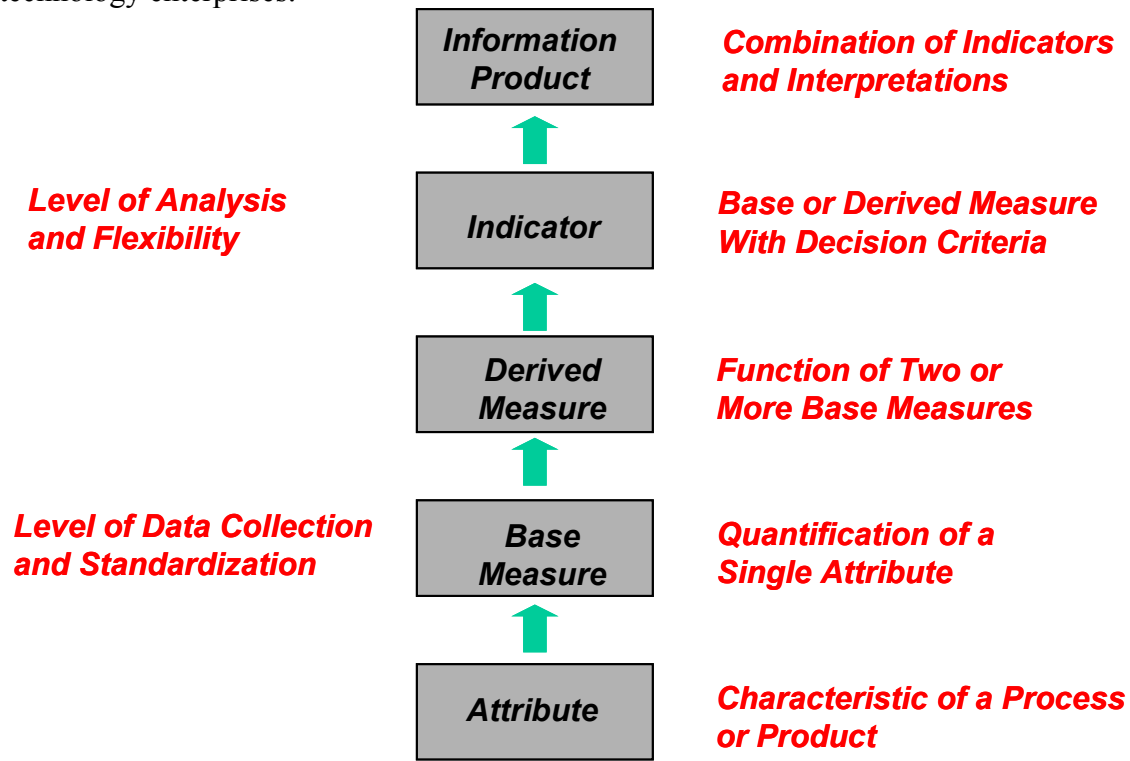


Figure 2. Measurement Information Model [2]

The information model helps to integrate measurement at different levels without limiting analysis flexibility. Base measures should be defined and used consistently throughout the organization. For example, effort should be counted in the same way regardless of whether it is being used in computing project productivity or analyzing enterprise-wide cost of quality. However, the indicators used by individual decision-makers should be adapted to the specific purpose for which they are intended.

The indicators used for enterprise-level decision making differ substantially from those used in project management. However, a detailed explanation of return on investment, cost of quality analysis, and other techniques used in enterprise-level decision-making falls beyond the scope of this report.

3. Perspectives of the Balanced Scorecard

The preceding section demonstrated that project-level and enterprise-level measurement differ most substantially with respect to the nature of the decision-maker and information needs supported. Consequently, this section elaborates on those elements of the measurement framework, as viewed through the Balanced Scorecard.

Traditionally, enterprise management has focused on measuring the “profit and loss” dimension of enterprises, while minimizing attention to the “persistence over time in one more marketplaces” dimension. The BSC was developed to provide management with a more “balanced” view of enterprise performance, one that would help to maintain a healthy and growing enterprise. The BSC accomplishes this by defining four perspectives to guide the selection of appropriate measures:

- Financial Performance
- Customer Satisfaction
- Internal Process (or Operational) Performance
- Learning and Growth (Innovation and Competence)

In addition to these four standard perspectives, a fifth may be added [7], Project Oversight. The BSC evolved from experience with enterprises engaged in “continuous” production and sales. Their processes operate continually delivering products and generating revenue. However, many enterprises depend on the successful completion of periodic “projects”. While it can be argued that Project Oversight can be covered under Internal Process Performance, the significance of project performance to the health of these enterprises demands additional emphasis within the BSC framework to achieve proper “balance”.

Each of these perspectives defines a common area of information needs. That is, the enterprise manager needs some visibility in each area. Exactly what needs to be measured with an area depends on the nature of the business and management’s strategy. As discussed later, PSM defines an effective approach for selecting and specifying appropriate measures within these perspectives. Table 1 lists some of the measurable concepts and prospective measures associated with these perspectives.

Table 1. Refinement of BSC Perspectives

| Balanced Scorecard Perspective | Measurable Concepts | Prospective Measures |
|---------------------------------------|----------------------------|-----------------------------|
| Financial | Market Growth | Revenue |

| | | |
|---------------------|----------------|--|
| | | Market Share |
| | Profit Growth | Earnings per Share before Interest and Taxes |
| | Price | Unit Price |
| Customer | Satisfaction | Survey Results |
| | Expectation | Marketing Claims |
| Internal Processes | Time to Market | Engineering Cycle Time |
| | Cost | Unit Cost Productivity Cost of Quality |
| | Quality | Delivered Defect Rate |
| Learning and Growth | Innovation | Publications Patents |
| | Competence | Years of Education |
| Project Oversight | Risk | Risk Exposure |
| | Progress | Cost Performance Index Schedule Performance Index |

The prospective measures shown in the table are intended as examples, not an exhaustive list of candidates. The following sections explain these five perspectives and prospective measures in more detail.

3.1 FINANCIAL PERFORMANCE

Financial performance is the most obvious enterprise perspective. Over the long term, the goal of most enterprises is some combination of increasing market share and profitability. However, maximizing these performance measures also requires the ability to evaluate

business alternatives in terms of return on investment, net payback period, strategic value, and similar measurable concepts. Cost of Quality Analysis [8] provides a financial view of the benefits of process improvement.

These measures help to determine how effectively financial resources are being used. Many different measurement constructs may be defined for each measurable concept. For example, profitability might be measured in terms of return on equity, cash flow (per share), or earnings (per share). The best measure for a specific enterprise depends on the nature of its business and strategic objectives. Cash flow is often more important to organizations performing contractual services, while return on investment may be more important to enterprises selling software or systems products outright.

3.2 CUSTOMER SATISFACTION

The customer satisfaction perspective requires feedback from current customers as well as strategic information about prospective customers. Good financial performance cannot be maintained over the long run, without satisfying customers. The enterprise must identify the dimensions of operational performance and product quality that customers value most, then optimize those factors. Different marketplaces value different factors, so customer satisfaction may be defined differently in different markets. Four basic market discriminators were identified in [9]: time to market, price, quality, and innovation. This perspective also includes developing an understanding of the potential of different markets so that optimum benefit can be obtained from investments.

3.3 INTERNAL PROCESS PERFORMANCE

The internal process (or operational) perspective encompasses the processes and infrastructure that the enterprise uses to manage, develop, and deliver products and services to its marketplaces. The performance of these processes affects both customer satisfaction and financial performance, especially the market discriminators of time to market, price, and quality. Projects use these internal processes to deliver products and services.

Typical measures of internal process performance include unit cost, productivity, defect rates, and cycle time. The specific measures selected depend on the nature of the business and the processes employed.

3.4 LEARNING AND GROWTH

This perspective addresses the innovation and intellectual competence of the enterprise, including staff expertise and intellectual property. In some marketplaces, this dimension of enterprise performance is critical. Analyses of customer satisfaction and marketplace forces often lead to the identification of new skills and knowledge that must be acquired to compete effectively. Learning and growth has two dimensions:

- Competence – ability to accomplish the usual tasks
- Innovation – ability to create new solutions and offer new capabilities

Typical measures for this perspective include employee satisfaction and retention, skills inventories, publications patents, training delivery, and hiring success.

3.5 PROJECT OVERSIGHT

Projects use the internal processes and staff capabilities of the enterprise to deliver products and services to customers. Even an organization with effective processes and competent staff may fail to complete a project satisfactorily due to inadequate management at the project level or a confluence of negative external factors. Consequently, the executive of an enterprise whose business depends on critical projects must pay attention to the health of the individual projects, as well as overall Internal Process Performance and Learning and Growth. As shown in Figure 3, performance with respect to these perspectives also affects project performance.

The two most important dimensions of project oversight, from the enterprise manager's perspective, are:

- Risk exposure—potential damage from things going wrong
- Progress—attainment of budget, schedule, and quality objectives

That is, the enterprise manager needs to know the status of all significant projects with respect to risk exposure and progress. A significant project is one whose failure could materially harm the enterprise. The enterprise manager doesn't directly manage these dimensions of projects, but needs to understand their potential impact on the organization and ensure that any problems that arise are resolved as quickly as possible.

4. Integrating PSM and BSC

This section explains how a measurement process incorporating the Balanced Scorecard approach can be planned and performed using the PSM approach. Each of the two activities of the core measurement process, introduced in Section 3, are discussed in more detail. However, specific numerical techniques for analyzing enterprise-level performance are only suggested, rather than explained.

4.1 PLAN MEASUREMENT

The first major activity of the core measurement process is “Plan Measurement”. As shown in Figure 3, this activity involves identifying information needs, classifying them, selecting and specifying measures, and developing the measurement plan. The scope of the information needs addressed determines the scope of the measurement planning activity. It can be limited to either an enterprise or project perspective. However, considering all sources of information needs simultaneously results in the greatest economy.



Figure 3. Details of Plan Measurement Activity [2]

The following paragraphs discuss the significant changes that must be incorporated into the tasks of the Plan Measurement activity shown in Figure 3 in order to address enterprise measurement.

IDENTIFY AND PRIORITIZE INFORMATION NEEDS

The sources considered in defining information needs must be broadened to include business goals and critical success factors as documented in strategic plans. Critical success factors define capabilities or conditions that are essential to achieving business goals. Their role is analogous to that of “risks” at the project level.

The enterprise information needs can be mapped into the BSC perspective-based categories shown in Table 1. However, project-level information needs should be considered together with those at the enterprise level in order to minimize redundancy and inconsistency in measurement specification.

Table 2 shows how the PSM Information Categories map to the BSC Perspectives. This table helps to identify potential measurement constructs that can be applied directly or modified to support both enterprise and project information needs.

Table 2. BSC Perspectives Mapped to PSM Information Categories

| Balanced Scorecard Perspective | Measurable Concept | PSM Information Category Directly Mapped | PSM Information Category Influenced by Perspective |
|--------------------------------|--------------------|--|--|
| Financial | Market Growth | | |
| | Profit Growth | | |
| | Price | | |
| Customer | Satisfaction | Customer Satisfaction | |
| | Expectation | | |
| Internal Processes | Time to Market | Process Performance | Schedule and Progress |
| | Cost | Process Performance | Resources and Cost |
| | Quality | Process Performance | Product Quality |
| Learning and Growth | Innovation | | Technology Effectiveness |
| | Competence | | Resources and Cost |
| Project Oversight | Risk | | |
| | Progress | Schedule and Progress Product Quality Product Size and Stability Resources and Cost | |
| None | | Technology Effectiveness | |

The PSM Information Categories identified as “directly mapped”, are those where existing PSM measurement constructs can be used to satisfy enterprise information needs, perhaps by aggregating results across projects. The categories shown as “influenced”, are those where common base measures may be found, but substantially different indicators may be required.

Table 2 shows that the PSM and BSC views of information needs exhibit a high degree of commonality. However, the empty cells in the columns for Balanced Scorecard Perspective and PSM Directly Mapped indicate areas where the two approaches are complementary. Each contributes a different insight, not offered by the other. For example, PSM does not address the business perspective of BSC.

Enterprise measurement differs from project measurement in terms of the amount of involvement of supporting staff required. While lower level involvement always is desirable, at the enterprise level it is essential. The realization of enterprise level business goals depends on the achievement of critical success factors and strategic objectives by the various elements of the organization. These elements need to be involved to ensure that they understand their roles and that achievable objectives are established. Figure 4 shows a strategy for deploying objectives downward through an organization.

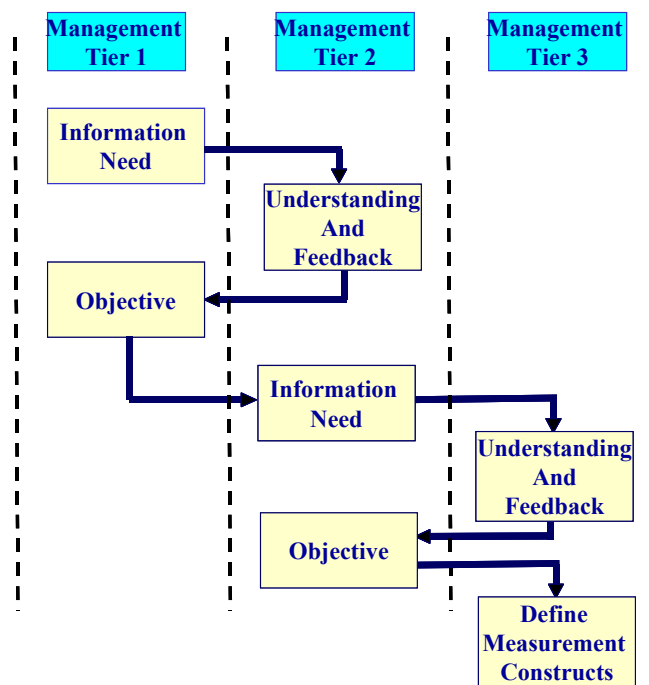


Figure 4. Communicating and Linking the Information Needs [8]

In Figure 4, the Tier 1 manager initiates the process by communicating a proposed information need to the Tier 2 manager(s) for understanding and feedback. Together, they discuss the nature of the need and how it might be addressed quantitatively. Having a better understanding of the information need, the Tier 2 manager can use that information

to develop proposed solutions in terms of measurement as well as a strategy for meeting the objective. In a similar manner, the Tier 2 manager passes the request for further resolution down to the Tier 3 level as an information need, and the process is repeated. This process may be repeated several times to the point that it reaches the management or working level that will define the base measures and collect the data. In this example, that is Tier 3. This process often is accomplished through a series of workshops.

SELECT AND SPECIFY MEASURES

The selection and specification of measures for enterprise management proceeds in much the same fashion as for project management. Typically, some new base measures are required as well as new indicators using the existing base measures. Many measurement planners mistakenly assume that an enterprise measurement process simply combines or rolls-up results from project measurement activities. As highlighted in the discussion of Table 2, the concerns of the enterprise manager differ in fundamental ways from those of the project manager.

A detailed treatment of the types of indicators and analyses that support enterprise decision-making falls beyond the intended scope of this report. A representative sample of appropriate techniques may be found in [7]. Topics include economic productivity, return on investment, and cost of quality analysis.

INTEGRATE INTO THE PROJECT PROCESSES

Planning an enterprise measurement program requires broadening the scope of processes with which the measurement process must inter-operate. Some data may originate from sources outside of projects (e.g., personnel and marketing organizations). Information products will be targeted at enterprise-level decision-making processes – beyond the concerns of typical projects.

Depending on the scope of information needs to be addressed, many different data sources and decision-making levels may become involved in the measurement program. However, the greatest economy is achieved by employing a common measurement process. While each measurement user may employ different indicators and analysis procedures, base measures and data collection procedures should be as common as possible. These should all be defined in a master plan or integrated planning elements. Update the plan(s) as the scope is modified (in order to add levels of decision-making, or to accommodate the changing information needs of existing decision-makers). Thus, the Plan Measurement activity, typically, is iterative.

4.2 PERFORM MEASUREMENT

The second major activity of the core measurement process is “Perform Measurement”. As shown in Figure 5, this activity involves collecting data, analyzing data, and reporting results. The Perform Measurement activity is driven by the measurement plan developed by the Plan Measurement activity (previously discussed in Section 4.1).

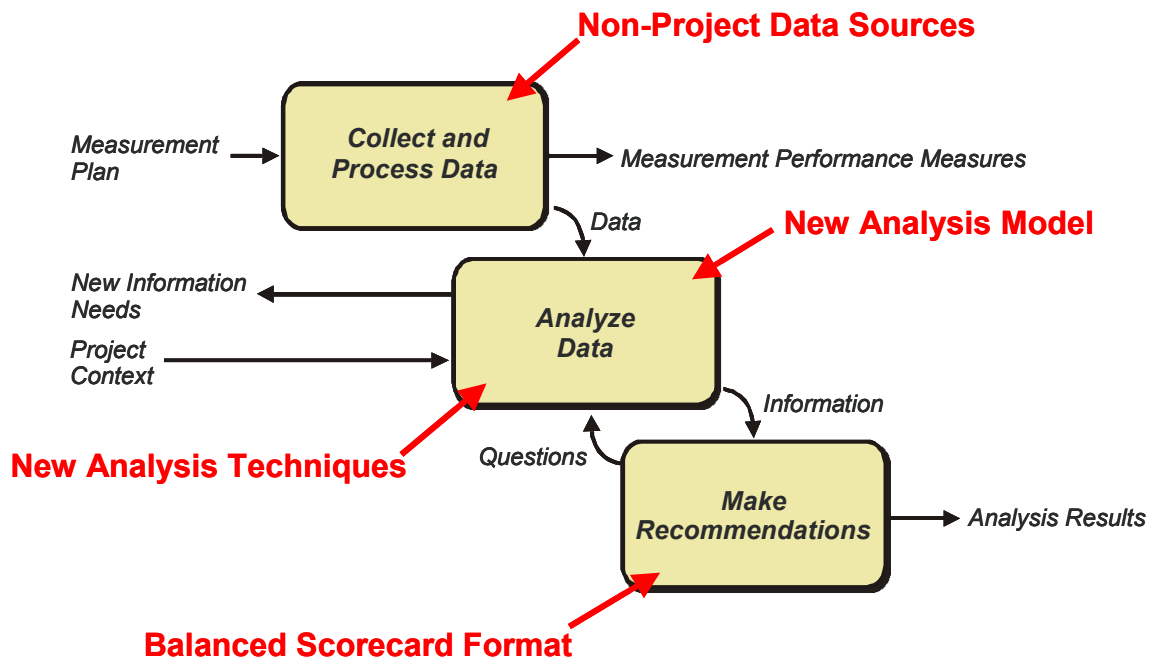


Figure 5. Details of Perform Measurement Activity [2]

The following paragraphs discuss the significant changes that must be incorporated into the tasks of the Plan Measurement activity shown in Figure 5 in order to address enterprise measurement.

COLLECT AND PROCESS DATA

The scope of data collection must increase to address the information needs of enterprise managers. Otherwise, the process of obtaining, verifying, and storing data doesn't change much.

ANALYZE DATA

The primary types of analysis of interest to the enterprise manager are those that support tracking the achievement of goals and evaluating alternative investments. Goals relate to business performance and the health of the enterprise. The BSC perspectives define the kinds of goals that enterprises typically adopt. Investments are intended to promote performance and health – that is, achievement of the goals. Goals often are produced in a strategic planning activity that falls outside of the measurement process.

Goal-setting takes the place of estimation in enterprise measurement. Goals must be reasonable, not necessarily feasible. Nevertheless, achievement of enterprise goals may be tracked using essentially the same steps as described in PSM for project performance

analysis. The prospective measures listed in Table 1 provide suggestions for how goals formulated in the various BSC perspectives might be tracked.

Figure 6 shows how these information categories and measurable concepts of Table 1 are related. For example, profitability is determined by how much is sold (market share) and the profit on each item sold. The unit profit depends on the cost to produce the item (one of the dimensions of operational performance) and the price at which it is sold (determined by the enterprise). Market share depends on customer satisfaction, which in turn depends on the enterprise's achievement of market discriminators (innovation, quality, cost, and timeliness [9]), as well as the customer's expectations. Even a "good" product may lead to dissatisfaction if the customer expected a "better" product.

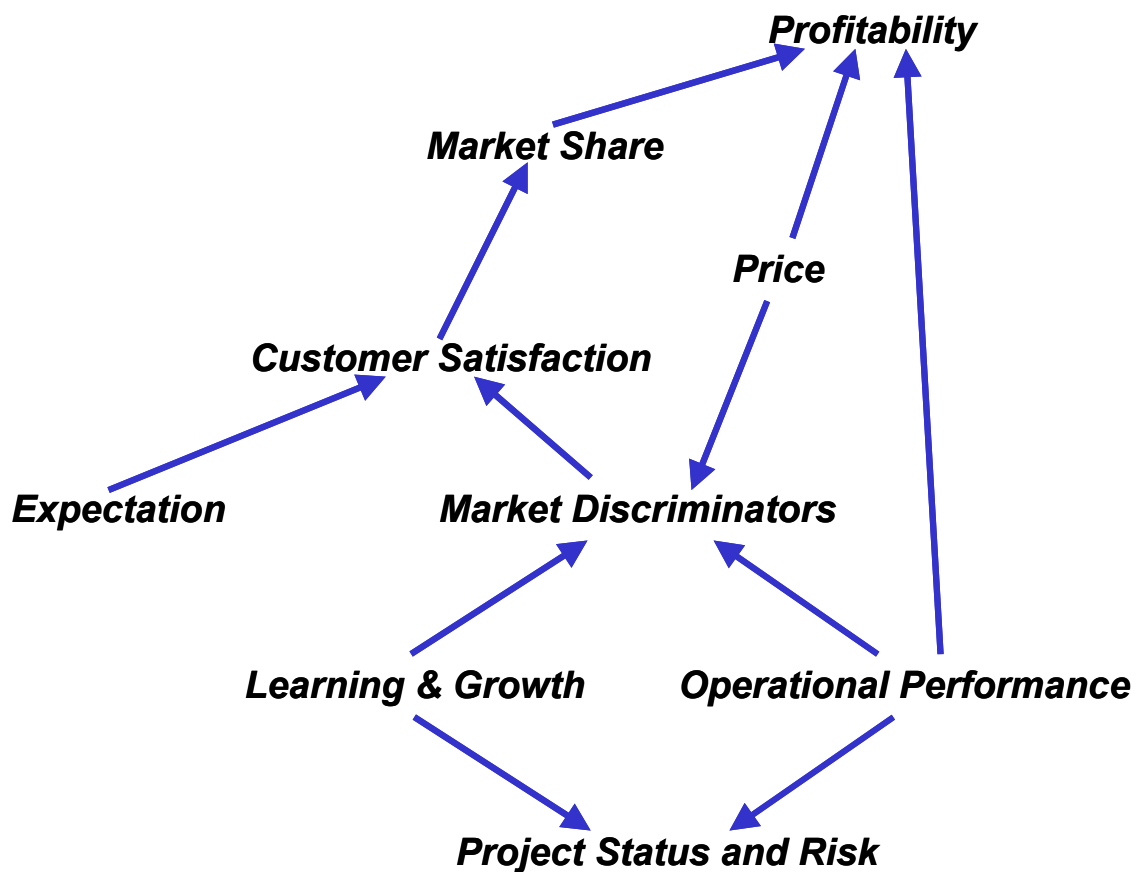


Figure 6 – Relationships Among Enterprise Measurement Concerns

The "market discriminators" element in Figure 6 is a composite of other factors represented in that diagram, as shown in Figure 7. Discriminators are the factors that determine the attractiveness of products and services to customers. The model shows that the importance of discriminators depends on the balance between supply and demand.

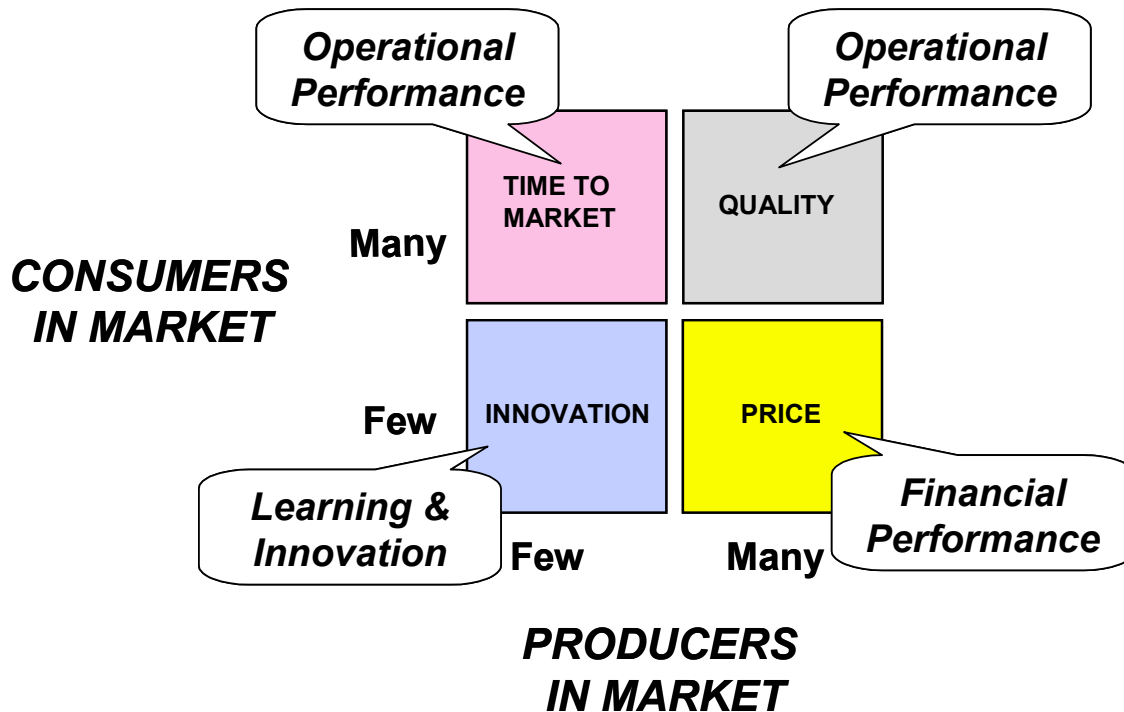


Figure 7 – Economic Model of Market Discriminators [9]

Figure 7 also shows the dimensions of organizational performance that affect the market discriminators. Time to Market and Quality discriminators are aspects of Operational Performance, closely related to the PSM information categories of “Schedule and Progress” and “Product Quality”. The Innovation discriminator is largely governed by Learning and Innovation, while Price is governed by the Financial perspective. This model of market discriminators highlights the fact that these BSC dimensions of organizational performance must be jointly managed in order to achieve customer satisfaction and success in the market place.

Business investments are intended to maximize the attractiveness of products in the marketplace (i.e., market discriminators.) This concern for investment differentiates the enterprise manager from the project manager in an essential way. Generally, the project manager is working from fixed starting conditions and has limited ability to invest in different project activities. On the other hand, selecting among alternative investments is a major activity of the enterprise manager.

Investments usually are evaluated using some form of calculation of return on investment or net payback period. These calculations help to choose the investments that will have the greatest impact on the value network shown in Figure 7. For example, investing in CMMI-based [10] process improvement should improve operational performance, one dimension of which is cost. Reducing cost makes it possible to achieve higher profits (assuming that the price is fixed) or to reduce price in order to increase sales. Improved operational performance may also make products and services more attractive in the marketplace leading, eventually, to increased sales and greater profit due to larger volume.

MAKE RECOMMENDATIONS

The primary change necessary in the Make Recommendations task involves engaging the enterprise manager as the user of the measurement results. This requires understanding the personal preferences and the process within which this decision-maker works. Different presentation formats may be necessary. For example, Balanced Scorecard measures often are supplied in a “report card” format that is quite different from what is recommended for project managers.

5. Summary

The preceding discussion has considered the relationships between the PSM and BSC approaches, as well as how best to incorporate BSC into the application of PSM for enterprise measurement. The generic PSM process and information models apply to enterprise measurement. Many base measures should be common.

Some of the key differences between PSM and BSC include:

- Decision-making process supported
- Nature of information needs and definition of information categories
- Types of indicators and analyses employed
- Analysis model – relationships among information categories and measurable concepts

This report attempted to show how the two approaches could be merged. Potential benefits of adopting this integrated approach include:

- Minimization of redundancy and inconsistency in measurement at different levels of the organization
- Reduction of the knowledge needed by measurement analysts and users due to employing a common process.
- Definition of a transition strategy from project-based measurement to enterprise measurement.
- Facilitation of objective communication between executives and project managers through use of common concepts and terminology.

Many details of this integrated approach remain to be worked out, especially the definition of appropriate measurement constructs using the information model. Nevertheless, this study has shown the Practical Software Measurement and the Balanced Scorecard are both compatible and complementary.

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