Deriving Enterprise-Based Measures Using the Balanced Scorecard and Goal-Driven Measurement Techniques

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Abstract

This technical note describes the synergistic application of the balanced scorecard and goal-driven measurement methodologies to develop measures and associated indicators for measuring an organization's health and performance. Through this iterative approach, an organization's strategic goals and subgoals are mapped to the balanced scorecard and refined. The goal-question-(indicator)-measurement methodology is then applied to identify indicators and measures for each scorecard dimension. A hypothetical example of how to apply the methodology at a "typical" organization performing software development and maintenance activities is provided. The example yields typical indicators to illustrate the methodology.

1 Introduction

Many organizations, including government agencies, define enterprise-wide measures to reflect the relative health of their organization. These measures help guide an organization's overall performance and process improvement effort. Two methodologies often employed to develop enterprise-wide measures are the balanced scorecard [Kaplan 01] and goal-driven measurement[1] [Park 96] methodologies.

Both methodologies are well known, but usually applied separately. This technical note suggests an approach for combining the techniques, taking advantage of the best of each. The balanced scorecard encourages an organization to take an introspective look at its practices. From this, the organization can set enterprise-strategic goals and develop a set of indicators and measurements for the desired outcomes and performance drivers. The goal-question-(indicator)-measurement (GQ[I]M) approach then follows as a disciplined way for deriving the required measures and indicators. The approach is intended to help an organization determine the best measures and associated indicators for its unique environment. Using this approach, an organization can systematically set goals for each of the perspectives of the balanced scorecard and develop a set of strategic measures and indicators to determine and track the quality of outcomes and organizational performance.

This technical note begins with a description of the approach to combine the goal-driven measurement and balanced scorecard methodologies. Next, as an example, results from applying the approach to a "typical" software development and maintenance organization are provided, with the recommended measures and indicators that were defined to reflect that organization's health and performance. We note that these measures and indicators are examples only. Each organization must develop its own set of measures and indicators in the context of its business goals, which is precisely what the approach is designed to accomplish. We defer discussions on techniques to analyze resultant indicators and to develop plans to achieve the organization's business goals for subsequent technical notes.

1.1 The Balanced Scorecard Framework

The **balanced scorecard** is an industry-recognized best practice for measuring the health of an organization. It can be used as a management tool for translating an organization's mission and strategic goals into a comprehensive set of performance measures that provide the framework for an enterprise measurement and management system [Castro 02].

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[1] We use the word "measurement" instead of "metric" throughout this report. *Measurement* is defined as 1) a standard or unit of measurement; 2) a quantitative indication of the extent, amount, dimension, capacity, or size of some attribute of a product or process.

The balanced scorecard methodology is based on four perspectives of an organization's performance—customer, financial, internal process, and learning and growth. These perspectives are illustrated in Figure 1.

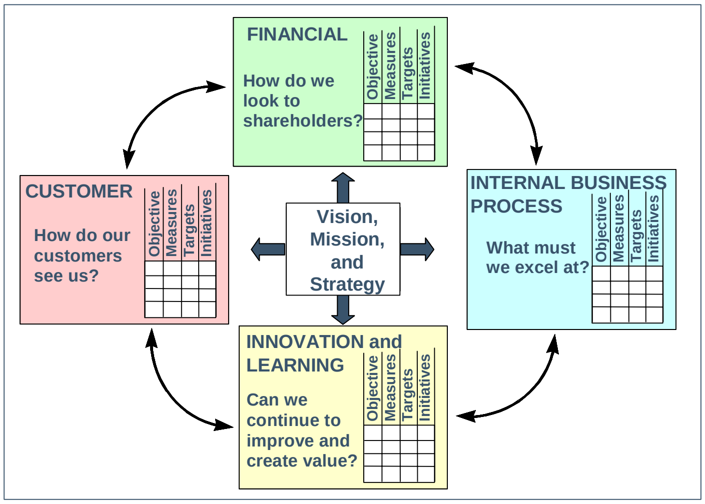
FINANCIAL
How do we look to shareholders?
Objective
Measures
Targets
Initiatives
CUSTOMER
How do our customers see us?
Objective
Measures
Targets
Initiatives
Vision, Mission, and Strategy
INTERNAL BUSINESS PROCESS
What must we excel at?
Objective
Measures
Targets
Initiatives
INNOVATION and LEARNING
Can we continue to improve and create value?
Objective
Measures
Targets
Initiatives

Figure 1: The Balanced Scorecard

Using the balanced scorecard framework, an organization can systematically set enterprise strategic goals for each perspective and develop a set of indicators and measurements for the desired outcomes and performance drivers that will enable the achievement of the enterprise outcomes. The result is a set of interconnected goals and measurements with defined cause-and-effect relationships.

As a template, the balanced scorecard can be applied to most businesses. It ensures that a resultant set of measures will provide coverage of the basic elements of organizational performance. Different market situations, product strategies, motivations, and competitive environments require different scorecards. Therefore, a scorecard should be developed to fit the organization and its mission. Every organization is unique and follows its own path to develop a balanced scorecard.[2]

Companies including Mobil Oil Corporation's North American Marketing and Refining Division, CIGNA Corporation's Property & Casualty Division, Chemical Retail Bank and Brown & Root Energy Services' Rockwater Division, Xerox, and Motorola have used the balanced scorecard approach [Kaplan 01]. Federal agencies, such as the U.S. Department of Energy, use the Balanced Scorecard for Government Procurement.

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[2] To better reflect how the balanced scorecard was used in this work, we have added "mission" as part of the central driving point and changed "Learning and Growth" to "Innovation and Learning" as a more descriptive heading. Figure 1 is derived from a balanced scorecard figure presented in "A Management Guide for the Deployment of Strategic Metrics" developed at Raytheon Corporation.

1.2 GQ(I)M Methodology

The goal-driven measurement process aligns measures and indicators with goals, thus ensuring that the measures and indicators selected will be used to show success in achieving these goals.

In our elaboration of Basili's process [Park 96], we have added an intermediate step to assist in linking the questions to the measurement data that will be collected. The importance of linking data to the questions they answer is clear in the success Basili has had with the GQM approach. Our experience suggests that identifying questions and measures without visualizing an indicator is often not sufficient to get a successful measurement program started. The displays or reports used to communicate the data (called *indicators* in our variation of the GQM methodology) are a key link that can determine the success or failure of a measurement program. These indicators serve as a requirements specification for the data that must be gathered, the processing and analysis of the measurement data that must take place, and the schedule by which these activities occur.

In the methodology, business or enterprise strategic goals are translated into measurement goals [Basili 84], [Briand 96] by first identifying high-level business goals and then refining them into concrete operational statements or subgoals with a measurement focus. This refinement process involves probing and expanding each high-level goal by using it to derive quantifiable questions whose answers would assist managing the organization. The questions provide concrete examples that can lead to statements that identify the type of information needed. From these questions, displays or indicators are postulated that provide answers and help link the measurement data that will be collected to the measurement goals. The displays or reports used to communicate the data are a key link to understanding just why the specific data are being collected. The overall process is illustrated in Figure 2. The figure assumes that vision and mission statements exist.

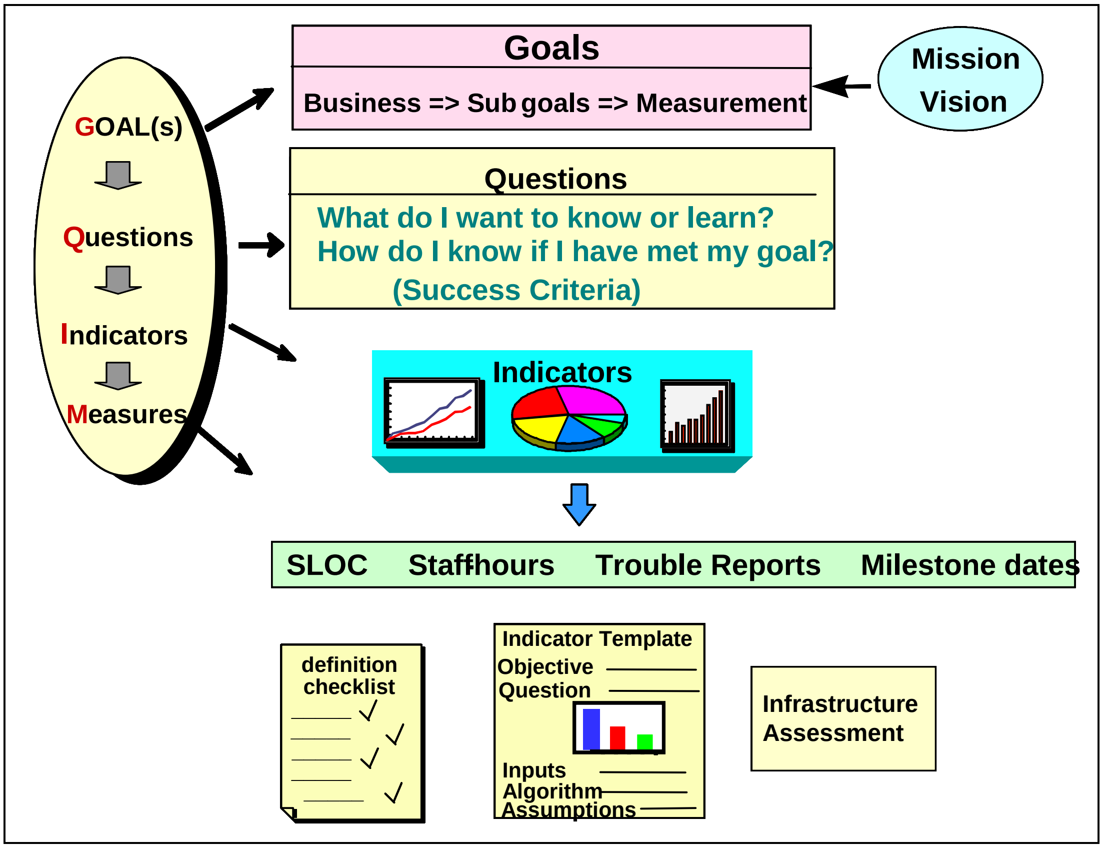
GOAL(s)
Questions
Indicators
Measures
Goals
Business => Sub goals => Measurement
Mission
Vision
Questions
What do I want to know or learn?
How do I know if I have met my goal?
(Success Criteria)
Indicators
SLOC
Staffhours
Trouble Reports
Milestone dates
definition
checklist
Indicator Template
Objective
Question
Inputs
Algorithm
Assumptions
Infrastructure
Assessment

Figure 2: Goal-Driven (Indicator) Measurement Process

The goal-driven measurement methodology as implemented at the Software Engineering Institute (SEI[SM]) is presented in Appendix A.

Note that the organization's strategic goals are used in both the GQ(I)M and balanced scorecard methodologies. In this way, the two methodologies seem redundant. However, the use of the balanced scorecard forces an introspection of the organization against a standard way of examining the health of an organization and organizing the purpose of the eventual measures and indicators. The GQ(I)M then follows as a disciplined way to derive the specific measures and indicators needed.

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2 Suggested Approach

Figure 3 illustrates our suggested process/approach for developing enterprise-wide measures and associated indicators that reflect an organization's health and performance. The process is typically iterative and contains the following four steps:

1. obtain and clarify mission and vision statements
2. derive strategic goals and subgoals using GQ(I)M
3. map subgoals to balanced scorecard
4. apply GQ(I)M to:
    a. define success criteria for each subgoal
    b. pose relevant questions and postulate indicators that address each subgoal in each quadrant of the BSC
    c. determine requisite measures or data elements that allow indicators to be crafted

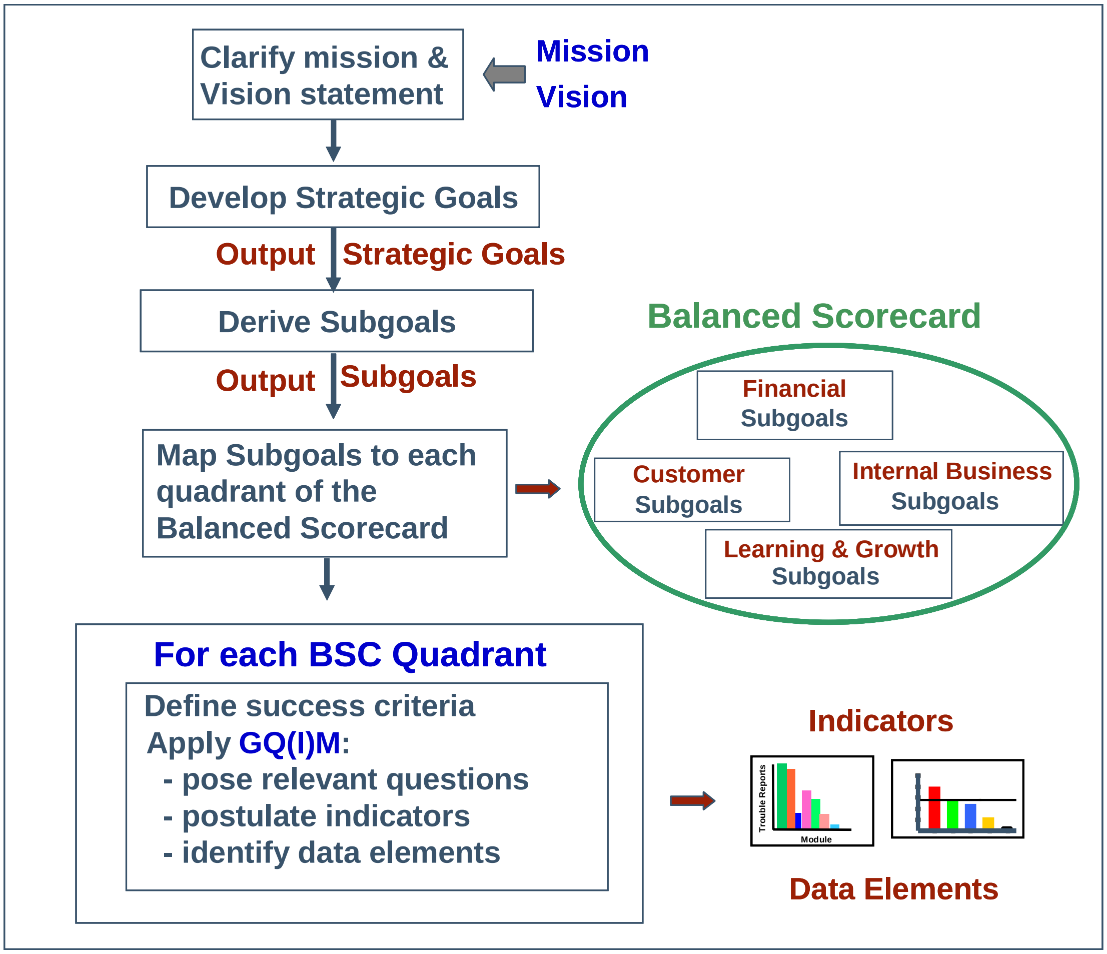
Clarify mission &
Vision statement
Mission
Vision
Develop Strategic Goals
Output
Strategic Goals
Derive Subgoals
Balanced Scorecard
Output
Subgoals
Financial
Subgoals
Map Subgoals to each
quadrant of the
Balanced Scorecard
Customer
Subgoals
Internal Business
Subgoals
Learning & Growth
Subgoals
For each BSC Quadrant
Define success criteria
Apply GQ(I)M:
- pose relevant questions
- postulate indicators
- identify data elements
Indicators
Trouble Reports
Module
Data Elements

Figure 3: Overview of the Approach

2.1 Obtain and Clarify Mission and Vision Statements

The **mission statement** describes the organization's statement of purpose; what it is doing and why. The **vision statement** describes what the organization wants to aspire to, the organization's special task, and what specific motivation binds together the organization's stakeholders—including members, leaders and anyone else affected by the issue. Vision reflects the realization of the organization's values. The understanding of values provides motivation and community. Appendix B contains more detailed advice for generating mission and vision statements.

Advice:

- Use an iterative approach to create clear and meaningful mission and vision statements that describe the organization’s unique purpose. The approach described here provides for this iterative technique.
- Avoid immediate “wordsmithing.” Work out the basic concepts first, then refine.

2.2 Apply GQ(I)M to Derive Strategic Goals and Subgoals

Once an organization understands its mission and vision and sets its sights on what it wants to aspire to, it can develop its strategic goals. **Strategic goals** are analogous to operational requirements, from which an organization can derive more detailed goals and activities for achieving its vision. Strategic goals lay the foundation for this planning and help outline the approach. One example of a strategic goal is the statement: “Increase customer satisfaction to get a bigger market share.” Here, the goal has quantitative expression of achievement—“to get a bigger market share.” In this example, as is typically the case, there are dependencies within the goal statement itself. That is, one goal statement combines concepts from more than one goal. Here, the goal is to increase customer satisfaction. But the second part is also a goal “to get a bigger market share.” As stated, these seem like two distinct goals.

Advice: Use structured brainstorming or the nominal group technique (NGT) to generate a list of the strategic goals [Scholtes 90]. Merge similar goals and sort the results into a prioritized list.

Because the strategic goals are purposely at a high level of abstraction, it is necessary to derive subgoals using the GQ(I)M methodology in combination with the vision, mission, and strategic goals. **Subgoals** are analogous to functional requirements, which an organization must plan and implement to satisfy not only its subgoals but its strategic goals as well. For example, “Increase market share by 15% in the next fiscal year” is a subgoal.

For the most part, when subgoals are articulated with a quantitative component, and possibly an element of timing, this provides the requisite picture of success. It is important to realize that there may be many subgoals. It is beneficial for the organization to prioritize them to develop a meaningful and efficient strategy for achieving them, rather than trying to achieve every subgoal.

Advice: Goals are often a function of where you sit [Lynch 91]. Since the goals in hierarchical organizations are related, ensure traceability of subgoals back to the primary strategic goal. The interpretation of the goal will differ at different places in the organization. It is important to understand these different perspectives and trace the subgoals back to the primary strategic goal.

2.3 Map Subgoals to Balanced Scorecard

In this step, the subgoals are “mapped” or allocated into the quadrants of the balanced scorecard. The four quadrants are inherently linked together. In allocating the subgoals, some quadrants may have some of the same subgoals assigned to them. This mapping is iterative since the initial mission, strategic goal statements, and subgoal statements may not seem to fit the balanced scorecard. However, in achieving this step, an organization can determine if its mission, goals, and subgoals are stated correctly. This iterative potential is crucial for developing effective measures and indicators that reflect the health of the organization and are clearly linked to its strategic goals.

In performing this mapping we asked questions appropriate to each scorecard quadrant.

From a **Customer Perspective**, how do customers see the organization? Typically, concerns fall into four categories: time, quality, performance, and service. But each of these categories must be defined or translated into the organization’s terminology and the way it conducts its business. For example, *time* may mean the response of the organization to the customer needs or the time it takes to process a customer order and deliver a product. Then we asked what subgoals contribute directly or indirectly to these categories.

From an **Internal Business Perspective**, what must we excel at to support our customer focus? That is, which internal strategies or operations have the greatest impact on customer satisfaction? Typically, the factors considered are cycle time, quality of work products or services, employee skills, and productivity. These categories must be defined or translated into the organization’s terminology and the way it conducts its business. As before, we can ask which subgoals have we defined that contribute directly or indirectly to these categories.

For the quadrant of **Innovation and Learning**, are we interested in our ability to improve and create value? Typical concerns include: How much is invested in Innovation and Learning? Does it take more or less time for an employee to achieve a level of fluency in his job? How many new products have we introduced? What increase in revenue is due to new products? This focuses on an organization’s ability to innovate, improve, and learn. It is directly tied to the organization’s value, in both product and process innovation.

In the **Financial Perspective** quadrant, the question is how do we look to shareholders? (For many organizations, where profitability is defined as revenue, shareholders may be replaced by stakeholders.) Here we look at profitability, growth, and value to stakeholders.

Table 1 presents an additional set of questions for each quadrant of the balanced scorecard. Answers to these questions provide further insight into the appropriate mapping of subgoals and, ultimately, the needed measures and indicators. These questions should be generated by the organization.

Table 1: Questions for Each Quadrant of the Balanced Scorecard

Balanced Scorecard Quadrant	**Questions**
Customer	What is important to our customers? What are their “hot buttons?” How do customers evaluate our timeliness? What do customers consider a quality product? Are there any standards or goals currently set by our customers? How and what do customers currently evaluate our organization? In the financial area, what is important to our customers? What does *responsive* mean to our customers? Are any goals or standards set?
Internal Business	How do we define *quality*—a product with few deficiencies? How do we define *success*—a quality product? How we know we’re successful? How do we define the *completion* of a trouble report? Are any goals set on the length of time it should take to close/fix trouble reports? How are process improvement requirements determined and how is their impact currently measured? How is productivity measured? Is it important? Are goals or targets set? How do we define and measure “cycle time?” Are improvement goals or targets set? How do you do, and who does, the Quality/Schedule/Cost tradeoffs?
Innovation & Learning	What attributes of quality are currently measured? Are any goals set? Are there any ongoing process improvement activities? Any measurements being taken as to their impact? Are any targets or goals set? Is employee satisfaction currently measured? What activities are being modified to improve responsiveness?
Financial	How do you know if the organization has effective financial control? What defines success? How do we know if we are successful? How is the cost/performance tradeoff accomplished? Are there any ongoing improvement activities? Are any targets or goals set?

Advice: Use the iterative potential of mapping subgoals to the balanced scorecard to assist in determining if the mission, goals, and subgoals are stated correctly.

2.4 Specify Success Criteria

So far in the methodology, we have clarified the mission and vision statements, derived our strategic goals, further decomposed them into more definitive subgoals, and mapped them to the quadrants of the balanced scorecard. As part of the mapping step we need to articulate the success criteria for the subgoals. To aid in specifying the success criteria, it is very useful to visualize what success looks like before articulating the actual success criteria for each subgoal of the balanced scorecard. For the most part, if the subgoals are articulated with a quantitative component, and possibly an element of timing, this would provide the requisite picture of success.

For each subgoal, the following questions should be addressed:

- How do you define success?
- How do you know when you have reached success?
- What are the attributes of success?

Table 1 can also be used as a basis for formulating the success criteria.

Advice: Articulate clearly the criteria you will use to decide if the goal has been met.

2.5 Apply GQ(I)M to Derive Measures and Indicators

This step is subdivided into a number of smaller steps, which are described below. Again, these steps can be performed iteratively.

1. **Pose relevant questions and postulate indicators that address each success criterion for each subgoal in each quadrant of the balanced scorecard.**

When identifying questions and defining indicators, it is important to keep in mind the goal(s) you are addressing and how the measurement results will be used. For each subgoal, develop questions related to the subgoal and that would assist in determining if the success criteria have been met. Phrase these questions in a manner that elicits a quantitative response. Using the answers to these questions, some general indicators can be described.

The specific indicators that should be used in each of the four balanced scorecard dimensions depend upon the specific questions or issues addressed. Once the questions or issues are known, a specific indicator can be designed. It is recommended that one indicator be developed for each question. After doing this, it may be possible to combine indicators. This should only be done after careful analysis of the individual indicators. The indicators in this document are examples of some indicators that have been found useful in other organizations with similar questions and concerns. They are only examples to illustrate the methodology and should not be adopted as-is by organizations.

See Appendix C for additional information about using indicators.

2. Determine requisite measures or data elements that allow indicators to be crafted.

In this substep, the data elements or measures required to construct the indicators are identified.

3. Document results.

Consistent with the GQ(I)M methodology [Park 96], **indicator templates** are used to document items such as why, what, who, where, when, and how for each indicator.[3] The completed templates are collected in a measurement or indicator handbook. The template includes fields for

- precise objective of the indicator
- visual display
- inputs
- algorithms
- assumptions
- data collection information
- data reporting information
- analysis and interpretation of results

This template is part of the SEI methodology described in Appendix D. Organizations tend to tailor the template to fit their environment by adding, modifying, or deleting fields in advance of specifying a set of indicators.

Many organizations have recognized the importance of using precise communication and collecting measurements based on need rather than capability [Augustine 99]. While the steps described in this approach seem daunting, they provide a structured way for ensuring that an organization uses the balanced scorecard and GQ(I)M methodologies correctly and to their full potential.

> **Advice:** Follow the steps in the described methodology to better understand to formulate meaningful measures.

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[3] This information is extracted from the Implementing Goal-Driven Software Measurement course offered by the SEI.

3 Example Approach

This section describes how the above approach can be applied to a “typical” organization. Here, *typical* is defined as an aggregate of several organizations with similar characteristics. In this example, the organization is a government agency consisting of 300 management, administrative, and technical personnel. (Please note that the overall approach is not dependent on any single organization type.) The indicators presented here are just examples to illustrate the methodology. They should not be adopted as-is by organizations.

3.1 Obtain and Clarify Mission and Vision Statements

The stated mission after clarification is:

> **Develop and maintain information technologies and integrated software-intensive <xyz> systems for the government.**

Here, *development* is the “in-house” development of software and systems to be fielded; *maintenance* is the maintenance and enhancement of the system components of these fielded systems. <xyz> is a domain such as Command and Control.

The stated vision after clarification is:

> **We are recognized as the premier government organization in the development and maintenance of superior information technologies and integrated software-intensive <xyz> systems.**

3.2 Apply GQ(I)M to Derive Strategic Goals and Subgoals

Using the mission and vision statements, the organization’s strategic goals as initially stipulated by senior management are

- provide the best value system/software engineering environment and processes
- improve the organization’s financial posture
- provide on time delivery of high-quality systems
- provide leadership for the government in technology development and insertion to accomplish the mission
- provide a world-class quality of life for employees

These are qualitative views of goals that senior management believes will lead to a strategy for improving the organization's performance. These must be further refined to eventually provide the organization, at various levels, targets for fulfilling its vision. Following the suggested approach in applying the GQ(I)M methodology, the subgoals are derived from the strategic goals, vision, and mission. Note the quantitative aspect embedded in some of these subgoals:

- provide the best value system/software engineering environment
  - improve processes. Improve the quality of internal processes and work products by achieving Capability Maturity Model® Integration (CMMI®) maturity level 5 in the next year.
  - improve communications (internal). Improve communication mechanisms within the organization and with external stakeholders.
  - minimize rework. Reduce the mean of the distribution of deficiencies detected per development life-cycle phase by 15%.
- improve the organization's financial posture
  - effective financial controls. Develop and improve mechanisms to provide visibility into the organization's financial situation on a weekly basis.
  - funding stability. Develop methods to mitigate and accommodate funding variations of 15%.
  - delivered costs. Decrease costs of delivered products and services by 10%.
  - increased mission funding. Increase mission funding by 10%.
  - customer funding. Increase funding from customers by 10% over the next year and expand the customer base to at least two private corporations.
- provide on-time delivery of high-quality systems
  - quality of delivered products. Quality deficiencies detected in the delivered product over one year period decrease by 10%. *Quality* is defined as increased compliance with customer requirements and increased on-time delivery (less than 10% late delivery).
  - timeliness. Reduce the time needed to transition from concept to operational capability by 10% in the next delivery over the current expected time (reduced cycle time).
  - communications (external). Improve communication mechanisms with customers to ensure that responses to requests are made within two working days.
  - resources. Increase availability and capability of internal resources to ensure that customer needs are satisfied 90% of the time.
  - relationships. Understand and anticipate our customers' needs and exceed their expectations.
- provide leadership for the government in technology development and insertion to accomplish the mission
  - improve business. Become an integral part of government transformation and homeland defense this fiscal year.
  - process improvement. Achieve CMMI maturity level 5.

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  - new technologies. Develop and implement technologies that provide the capability to increase efficiency of operations by 5%.
- provide a world-class quality of life for employees
  - process improvement. Improve the quality of internal processes and work products by achieving CMMI maturity level 5 in the next year.
  - enhance staff capability. Recruit, develop, and retain a well-trained, competent, diverse, value-based workforce in an environment that fosters innovation and is intolerant of discrimination.
  - improve communications (internal). Improve communication mechanisms within the organization and with external stakeholders.
  - quality of life (employee satisfaction). Provide upwardly mobile careers for employees and lower the turnover rate by 15% in the next year.
  - new technologies. Develop and implement technologies that provide the capability to increase efficiency of operations by 5%.

3.3 Map Subgoals to Balanced Scorecard

The following figure shows the results of mapping the organization's subgoals to each quadrant of the balanced scorecard where indicators need to be postulated. Only the titles of the subgoals are shown for clarity.

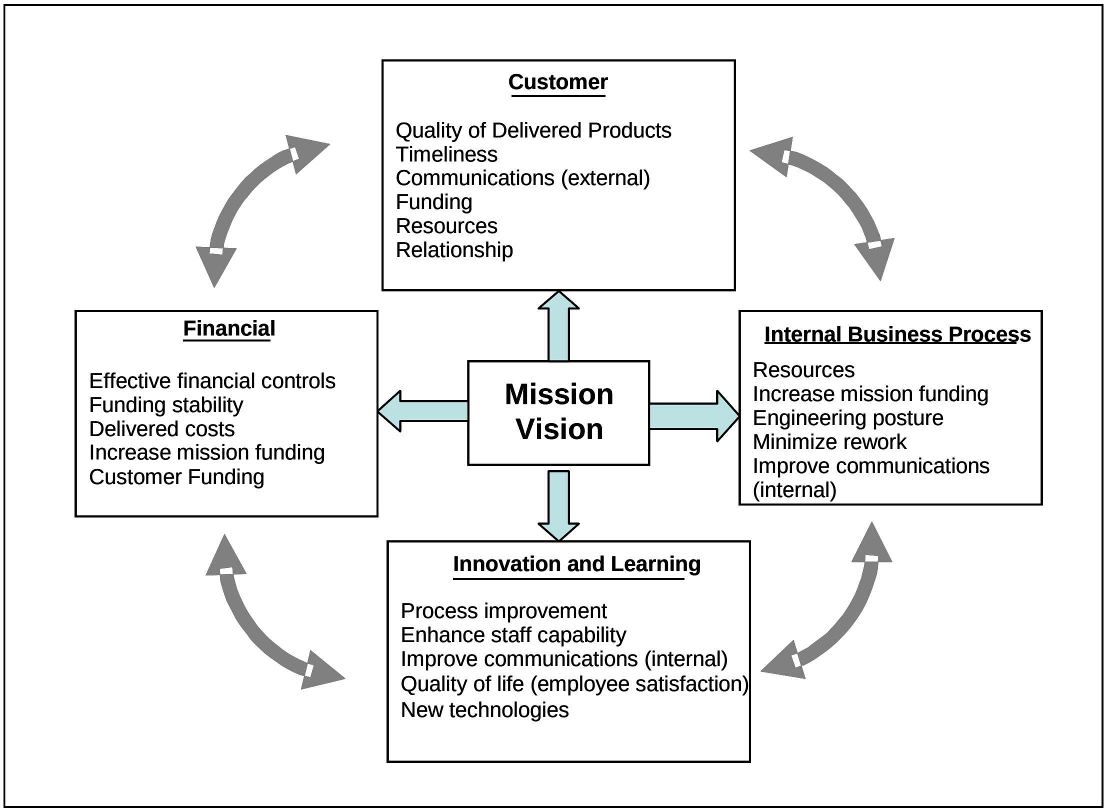

Customer
Quality of Delivered Products
Timeliness
Communications (external)
Funding
Resources
Relationship
Financial
Effective financial controls
Funding stability
Delivered costs
Increase mission funding
Customer Funding
Mission
Vision
Internal Business Process
Resources
Increase mission funding
Engineering posture
Minimize rework
Improve communications (internal)
Innovation and Learning
Process improvement
Enhance staff capability
Improve communications (internal)
Quality of life (employee satisfaction)
New technologies

Figure 4: Mapping Subgoals to the Balanced Scorecard

As part of this mapping, we are also required to define success criteria. Here, we reexamine the subgoals to see if they address the following questions:

- How do you define success?
- How do you know when you have reached success?
- What are the attributes of success?

Generally, if the subgoals are articulated with a quantitative component, and possibly an element of timing, this would provide the requisite picture of success. The subgoals derived for this example have the needed quantitative and timing aspects to answer these questions. In this example, please note that every subgoal does not map to the balanced scorecard. This only indicates that a particular subgoal might not be appropriate or might need to be reconsidered.

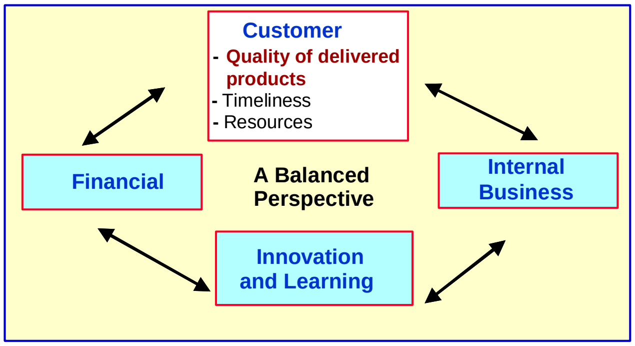
3.4 Pose Relevant Questions and Postulate Indicators

With the mapping to the balanced scorecard to ensure the full spectrum of the organization's business posture is addressed, the GQ(I)M method is applied to develop relevant questions and postulate indicators. This section presents indicators for the **customer** quadrant of the balanced scorecard. Quantifiable questions are developed for each of the subgoals. Indicators in the form of tables, charts, graphs, etc. that address the questions are postulated.

The following subgoals will be addressed to illustrate the methodology for the **customer** quadrant of the balanced scorecard:

- quality of delivered products
- timeliness
- resources

3.4.1 Subgoal: Quality of Delivered Products



The subgoal of quality of delivered products for the customer quadrant is shown below.

Subgoal: quality of delivered products. Quality deficiencies detected in the delivered product over a one-year period decrease by 10%. *Quality* is defined as an increase in compliance with customer requirements and an increase of on-time delivery (less than 10% late delivery).

Quality, as defined in this subgoal, has two main components:

1. compliance with customer requirements
2. on-time delivery of customer requirements

To illustrate the methodology, the following section presents questions and indicators for the compliance with customer requirements component of the quality of delivered products subgoal for the **customer** quadrant of the balanced scorecard.

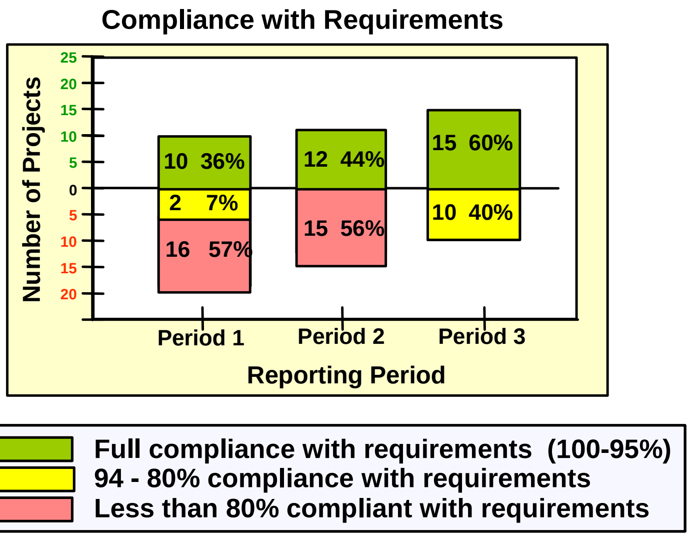
Quality Component 1: Compliance with Customer Requirements

The following questions pertain to compliance with customer requirements:

1. What is our level of compliance with implementing customer requirements?
2. What percentage of systems is in full compliance with stakeholder requirements (needs satisfied equated to requirements implemented).
3. Is there a difference in compliance with customer requirements for small, medium, and large systems or projects?
4. Are all the functional requirements desired by our customers being delivered?
5. Is the level of compliance a function of the size of the project? (Is there a difference among small, medium, and large projects?)
6. What is the level of customer satisfaction for completed projects?

Indicator 1: Compliance with Requirements

This indicator addresses question #1: What is our level of compliance with implementing customer requirements?

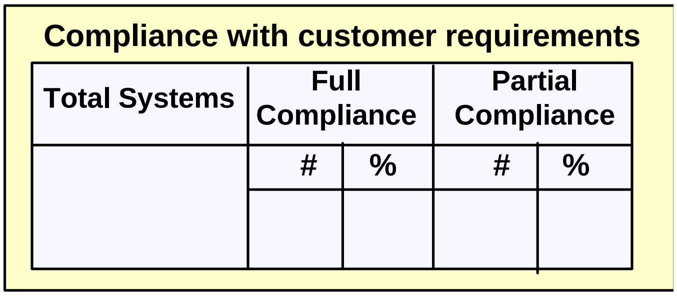


The proposed indicator shows the level of compliance of implementing customer-specified requirements for completed projects per reporting period. Completed projects in a specific time period are rated using the management-specified assessment values as shown in the box below the indicator. Full compliance of customer requirements is defined as 100-95%. For each reporting period, the numbers in each box indicate the number of completed projects that fall into each grouping. For example, in period 1, 10 projects were in full compliance with the requirements. This represents 36% of the projects completed during that reporting period.

Since multiple periods can be presented on the chart, a trend can be determined if the organization is improving its compliance with customer requirements. If the number of completed projects per reporting period is low, this indicator can be easily modified to show the number of completed projects per year.

Indicator 2: Degree of Compliance of Customer Requirements

This indicator addresses question #2: What percentage of systems is in full compliance with stakeholder requirements?



Compliance with customer requirements

Total Systems	Full Compliance		Partial Compliance	
	#	%	#	%

This display presents an alternative way to present a breakout of the number of functional requirements delivered to the customer compared to the number of requirements promised. Since it only presents a snapshot in time, no trend can be determined.

Indicator 3: Functional Requirements by Product Size

This indicator addresses question #3: Is there a difference in compliance with customer requirements for small, medium, and large systems or projects?

		Compliance with Customer Requirements							
Size of Systems	**Total # of Systems**	**100-95%**		**94-85%**		**84-75%**		**75% >**	
		#	**%**	**#**	**%**	**#**	**%**	**#**	**%**
SMALL									
MEDIUM									
LARGE									

This indicator is a more detailed breakout of the information in the previous indicator. Not only does this indicator break out the level of compliance with customer requirements for small, medium, and large system, it provides an easy overview of management-specified assessments on how the organization is doing in this dimension. If the compliance with customer requirements for the system is 100-95%, it is rated as green; 94-85% compliant with requirements is rated yellow, and less than 84% compliant with requirement is rated red.

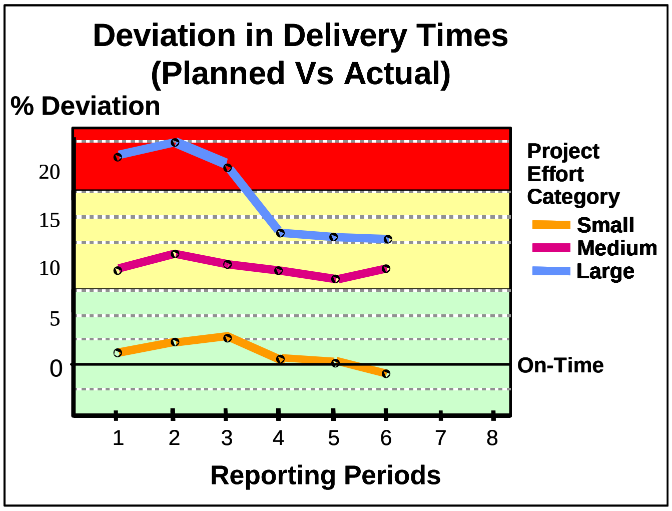
Quality Component 2: On-Time Delivery of Customer Requirements

The following questions pertain to the on-time delivery component of the quality of customer requirements subgoal:

1. Are we improving our delivery times for small, medium, and large projects?
2. What has been the trend in delivery time?
3. How far are our schedule plans from actual delivery dates?
4. How many completed projects exceed the original delivery schedule by more than 10%?
5. Is there a difference meeting delivery times in small, medium, and large projects?

Indicator 1: Timeliness of Delivery of Customer requirements

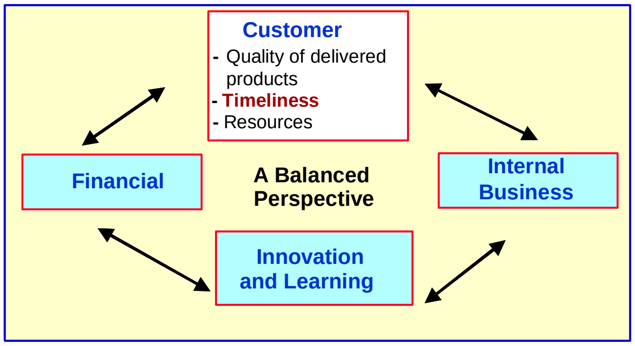
This indicators address question #1: Are we improving our delivery times for small, medium, and large projects?



This display provides an overview on the trend of the delivery time for completed projects segregated into three size categories—small, medium, or large. These size categorizations are specified by the organization guidelines. For each delivered product, the difference between the schedule and actual delivery date is calculated and placed into the appropriate size category. For each size category, the average deviation in delivery time is calculated and plotted.

A management assessment of red, yellow, and green can also be coded into the display. As shown above, deviation of delivery times for large projects has improved by going from red to yellow while both the medium and small projects have remained relatively constant.

3.4.2 Subgoal: Timeliness



Customer
- Quality of delivered products
- Timeliness
- Resources
Financial
A Balanced Perspective
Internal Business
Innovation and Learning

Subgoal: Timeliness. Reduce the time needed to transition from concept to operational capability by 10% in the next delivery (reduce cycle time).

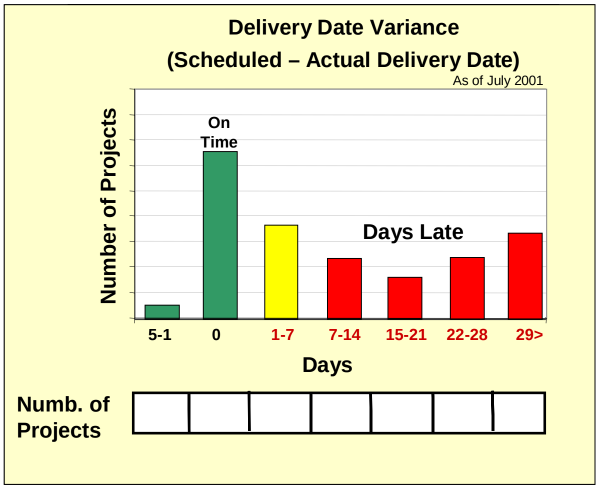
Questions:

1. What have been the delivery times of completed project for this year?
2. What has been the trend in delivery time the last couple of years? Are we improving?
3. Are projects being delivered on time?
4. Has there been an improvement in meeting delivery dates?
5. What is the delivery time trend (cycle time trend) for small, medium, and large projects? Are the trends the same for the different project effort categories?
6. What is our current history in delivering projects on time?

The following section provides some examples of indicators that address some of these questions.

Indicator 1: Delivery Time Variance

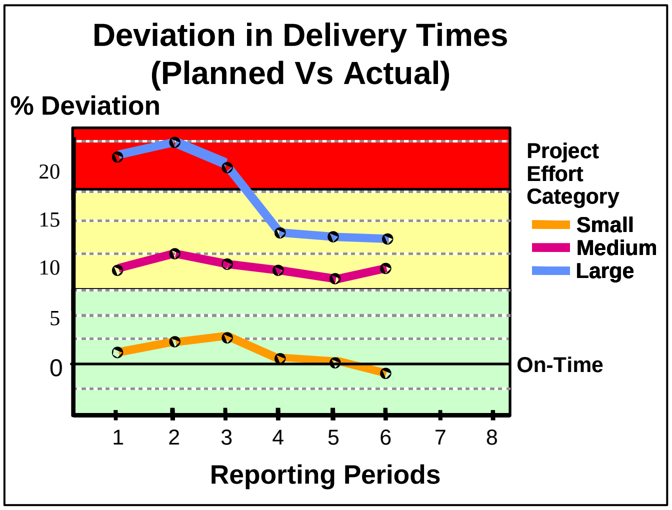
This indicators address question #1: What have been the delivery times of completed project for this year?



This display provides an overview of the variance between planned and actual delivery times for completed projects. As each project is completed, the variance in delivery time is calculated. The project is then added to the appropriate variance grouping. Periodically the number of projects in each variance grouping is summed and plotted on the chart. A green, yellow, or red assessment for delivery time variance can be defined by the organization and indicated as shown on the display.

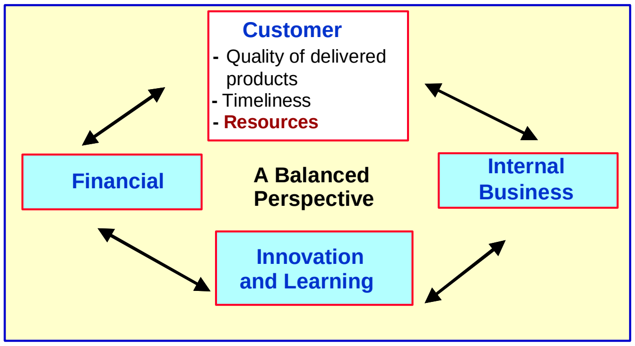
Indicator 2: Delivery Time Trends

This indicators address question #5: What is the delivery time trend (cycle time trends) for small, medium, and large projects?



The same indicator for addressing the timeliness of delivery of customer requirements can be used here. This is an example of how one indictor can answer multiple questions.

3.4.3 Subgoal: Resources


Customer
- Quality of delivered products
- Timeliness
- Resources
Financial
A Balanced Perspective
Internal Business
Innovation and Learning

Subgoal: Resources. Increase availability and capability of internal resources to ensure customer needs are satisfied 90% of the time.

This subgoal is composed of two components:

1. availability and capability of internal resources (staff, hardware, software, tools, etc.)
2. customer needs satisfaction (In this report, needs satisfaction are treated as requirements implemented.) This component of the subgoal was addressed earlier.

Resources Component 1: Availability and Capability of Internal Resources

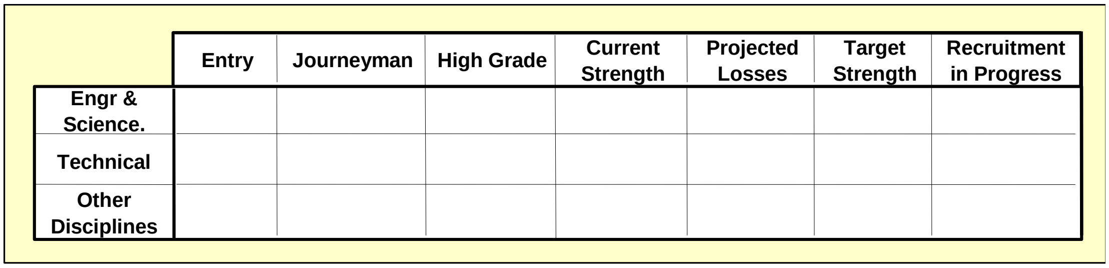
Questions (availability and capability of internal resources):

1. What are the current levels of personnel assigned? Are they adequate?
2. Are sufficient experienced personnel available to accomplish the mission (number, skill mix, types)?
   - skills: entry-level, journeyman, high grade
   - types: engineering & science, technical, other disciplines
   - workforce: contractor, civilian, military
3. What is the skill level of the current staff?
4. What are the personnel availability trends?
5. Is the recruiting/hiring activity sufficient to overcome shortfalls? Are we attracting and retaining key skills?
6. Is the experience level sufficient to accomplish the job? Will additional training be required?

A large number of indicators can be postulated to address these questions. Some typical ones are shown below.

Indicator 1: Skill Mix Indicators

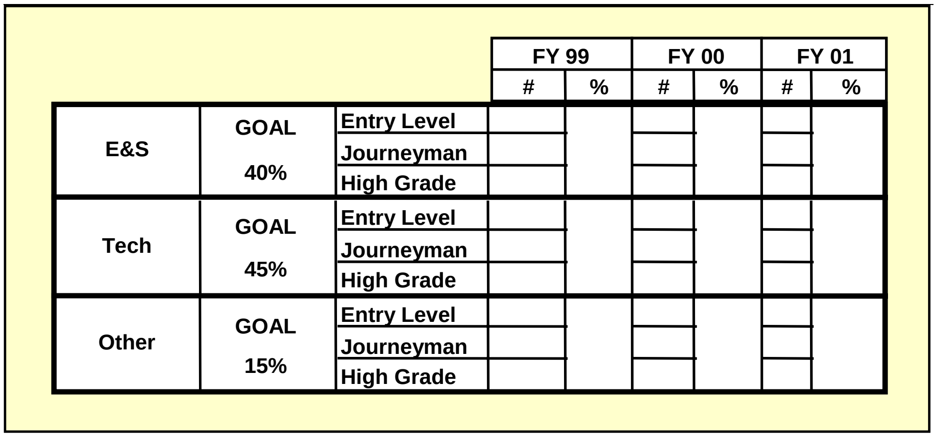
This indicator addresses questions such as: “Are sufficient experienced personnel available to accomplish the mission?” and “What is the skill level of the current work force?”



	Entry	Journeyman	High Grade	Current Strength	Projected Losses	Target Strength	Recruitment in Progress
Engr & Science.							
Technical							
Other Disciplines							

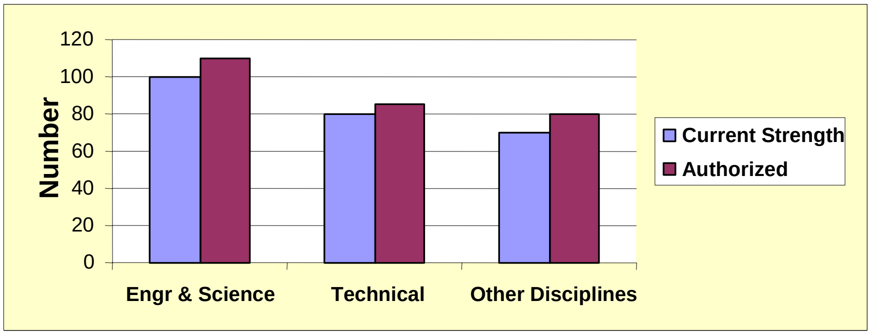
In this indicator, the staff has been divided into three major groupings (engineers & scientists, technical, and other disciplines). Each of these groups was also divided by skill level (entry-level, journeyman, or high grade). The indicator provides a summary view of current and desired strength level as well as recruitment activity.

The following indicator displays the current numbers for entry-level, journeyman, and high-grade personnel as compared to their target values (engineering & science 40%, tech 45%, other 15%) and trend values.

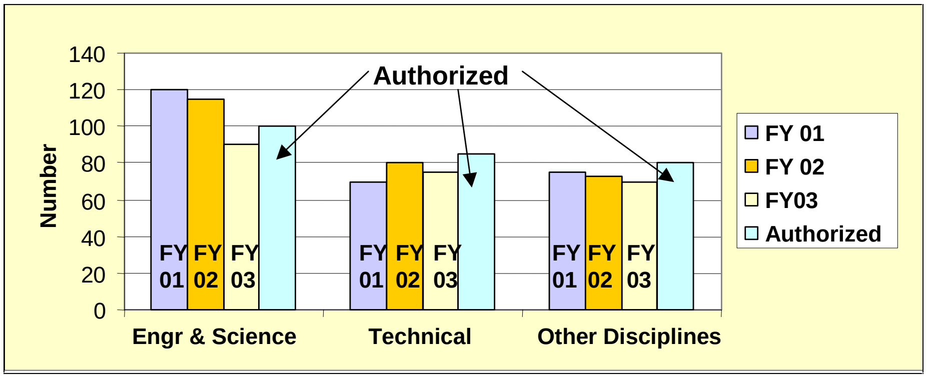


			FY 99		FY 00		FY 01	
			#	%	#	%	#	%
E&S	**GOAL** **40%**	**Entry Level**						
		Journeyman						
		High Grade						
Tech	**GOAL** **45%**	**Entry Level**						
		Journeyman						
		High Grade						
Other	**GOAL** **15%**	**Entry Level**						
		Journeyman						
		High Grade						

This indicator addresses question such as: What are the comparisons of current staff numbers to the numbers that are authorized?

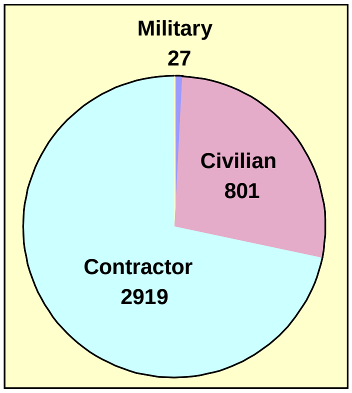


This indicator addresses the same question as above but also presents trend information, such as the number of staff for fiscal years 2001 through 2003.



Indicator 2: Current Breakout of Workforce

This indicator provides a snapshot of the current workforce and addresses the question: “What is the staffing breakout of the current workforce?” This type of information could also be presented in table form.



4 Summary

The balanced scorecard and GQ(I)M methodologies provides a systematic way to obtain measures and indicators reflecting the health and performance of an organization. The approach described here uses an organization's vision and mission statements to identify and clarify strategic goals and subgoals. In this iterative approach, these goals and subgoals are mapped to the balanced scorecard and refined as necessary. The GQ(I)M methodology then is used to identify measures and indicators for each dimension of the scorecard.

An example application of the approach was discussed for a "typical organization." From this example application, sample indicators for the customer quadrant of the balanced scorecard were derived and presented. For the purpose of brevity, measures and indicators for the other quadrants were not presented here.

Again we note that the measures and indicators resulting from the example application are only examples to illustrate the methodology and should not be adopted as-is by organizations.

Since the number of potential measures and indicators may be large, we recommend that a minimum set be used as a starting point. The approach proposed here contains numerous steps that allow the set of measures and indicators to be prioritized and thereby reduced to a minimum number consistent with an organization's business needs and goals. We believe that such a recommended set still provides a general overview of the issues being addressed in each quadrant of the balanced scorecard to accurately portray an enterprise-wide indication of the health of an organization.

There are two additional activities to be considered. First, the measures need to be "normalized." For example, the measure "on-time delivery of products" in our typical organization makes sense if there is a planned delivery schedule to compare it against. Each of the measures should be augmented similarly. In addition, the measures are only useful if the organization institutes a program or methodology to collect data required for the measures.

We defer discussions on techniques to analyze resultant indicators and to develop plans to achieve the organization's business goals for subsequent technical notes.

Appendix A GQ(I)M Methodology

Methodology

The goal-driven measurement methodology as implemented at the SEI consists of the following steps:

Identify Goals

1. identify your business goals
2. identify what you want to know or learn
3. identify your subgoals
4. identify the entities and attributes related to your subgoals
5. formalize your measurement goals

Define Indicators

1. identify quantifiable questions and the related indicators that you will use to help you achieve your measurement goals
2. identify the data elements that you will collect to construct the indicators that help answer your questions
3. define the measures to be used, and make these definitions operational

Create an Action Plan

1. identify the actions that you will take to implement the measures
2. prepare a plan for implementing the measures

The goal-driven software measurement approach is described in the SEI's *Goal-Driven Software Measurement Guidebook* [Park 96].

Figure 5 depicts the general steps we use to derive the indicators and measures.

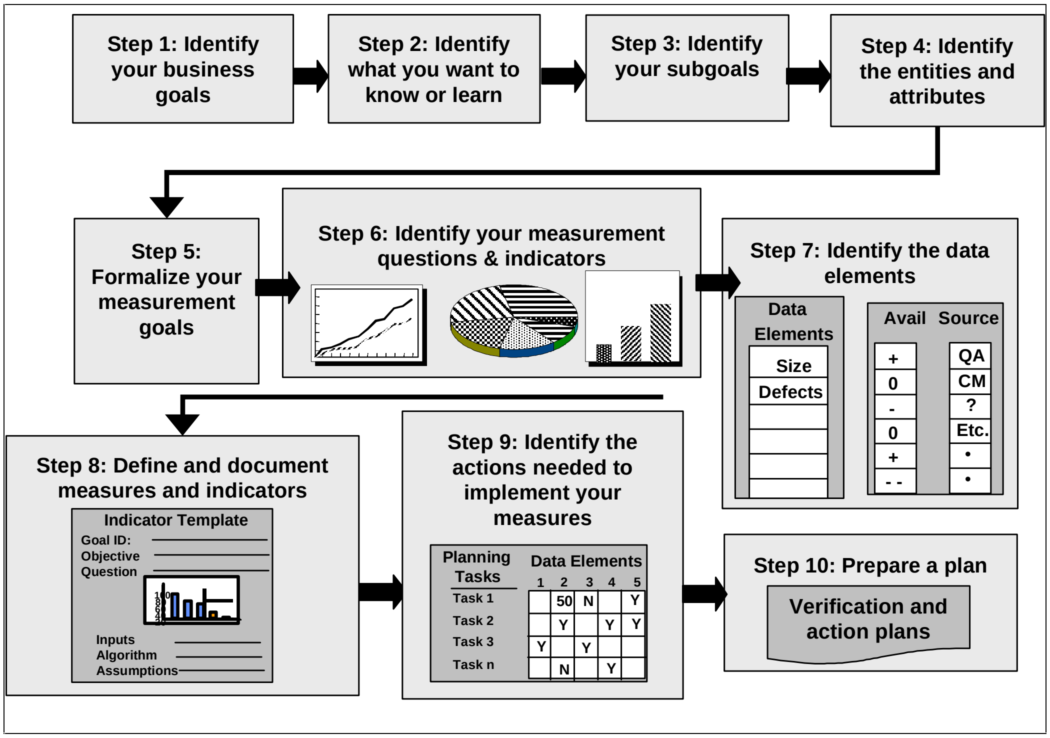

Step 1: Identify your business goals
Step 2: Identify what you want to know or learn
Step 3: Identify your subgoals
Step 4: Identify the entities and attributes
Step 5: Formalize your measurement goals
Step 6: Identify your measurement questions & indicators
Step 7: Identify the data elements
Data Elements
Size
Defects
Avail
Source
+
0
-
0
+
- -
QA
CM
?
Etc.
•
•
Step 8: Define and document measures and indicators
Indicator Template
Goal ID:
Objective
Question
Inputs
Algorithm
Assumptions
Step 9: Identify the actions needed to implement your measures
Planning Tasks
Data Elements
1 2 3 4 5
Task 1
Task 2
Task 3
Task n
50
N
Y
Step 10: Prepare a plan
Verification and action plans

Figure 5: Goal-Driven (Indicator) Measurement Methodology

The following is a brief description of each step.

Step 1: Identify Business Goals. In this step, the business goals that drive your organization's effort are identified. Without a clear sense of the organization's strategic goals and the objectives and responsibilities for each work unit or position, there is a risk that measures will not be aligned with important issues in your organization.

Step 2: Identify What You Want to Know or Learn. If measurement activities are to be aligned with your goals, then we must translate the goals into operational statements. In this step the goals are linked with knowledge of the organizations business strategies and processes.

Step 3: Identify Your Subgoals. The preceding step usually generates many questions. By analyzing the questions and seeking commonality among them, subgoals can be derived. The subgoals provide a refinement of the goal and serve as a summary for the questions to which you would like answers.

Step 4: Identify the Entities and Attributes. The subgoals and related questions define the focus for the measures. Analysis of the questions will identify what needs to be measured.

Step 5: Formalize Your Measurement Goals. In this step, a measurement goal is crafted that merges the purpose and perspective derived from the business goal with the possibilities for measurement as they exist within the organization's work processes. In addition, the goal statements express environmental or contextual factors that are important for those who will design and do the measurement and analysis activities.

Step 6: Identify Quantifiable Questions and the Related Indicators. In this step, indicators or displays to address the goal are sketched out. Sketching or drafting the table, chart, or report that needs to be produced helps to make sure the requirements for measurement are complete.

Step 7: Identify the Data Elements. In this step, the data elements required to construct the indicators are identified. The existence and sources of the needed data are assessed.

Step 8: Define the Measures. Definitions are critical for achieving proper interpretations of the data. The definitions need to be created with the purpose of the indicator in mind and should consistently provide an answer to the question that the indicator addresses. Developing a complete and unambiguous (minimally ambiguous) definition can be arduous. To aid this task, the SEI developed a series of measurement framework checklists for common software measures such as size, effort, milestones, and defects [Park et al. 92], [Goethert et al. 92], [Florac 92].

Step 9: Identify the Actions for Implementation. Knowing the data needed and having defined them, the existing situation within the organization is analyzed with respect to the measurement needs.

Step 10: Prepare an Action Plan. Once a gap analysis has been completed between the needed data and the existing measurement activities, an action plan can be prepared.

Appendix B Mission, Vision, and Goal Statements[4]

Mission Statements

Although not all authors may agree on the best form for an effective mission statement, most believe that it should define at least the following three items:

1. **The stakeholders of the group's work**. This is defined not in terms of some segment of the organization per se, but in terms of a basic defining *need premise* that leads that person (or entity) to consider using the products or services of your group.
2. **The value premise.** Define this not in terms of what your group does or produces, but in terms of the fundamental *value* it represents in matching the stakeholders' need premise.
3. **What makes you special.** This is your special *means for creating value* to have your stakeholders want to continue working with you and using your products and services.

After you draft the mission statement, it makes sense to evaluate it carefully using these criteria:

- **definitive**. It defines the stakeholders and their need premise, the value-delivery premise to be offered, and the means for putting the two together. It tells the story of your group's way of doing business.
- **concise.** It makes the point in one fairly simple paragraph. A basic mission statement should be something you can easily write on the back of a business card.
- **actionable.** It gives a person reading it some idea of what it looks like in operation, and what kinds of actions are involved in delivering it.

Vision Statements

Creating a meaningful vision statement seems to be one of the most challenging and frustrating tasks that a group faces when coming together as a team. But it's a mistake to just push on without a clear statement of vision.

The description of that end-state is called a vision statement. The vision may be revised as times goes on. A vision is an image of what the people in the group aspire for it to become.

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[4] This appendix is drawn from a white paper authored by Mark Kasunic titled "Vision, Mission, Goals, Objectives, Activities" and a paper by Tom Keenze, dated October 17, 2000, available at http://staff.ed.uiuc.edu/rthomas/oetmission/statement.html.

Note that the key word is image. It must be something that you can describe and that people can see in their mind's eye.

If the group can't come to consensus on a statement that expresses the meaning of their group, then what can they hope to say to the rest of the organization that will make any sense? If all they have are platitudes, then they have no message. In many ways, the vision statement is a test of whether there really is a message.

Although the group may have a pretty good idea of what they want to do to improve the organization, it is easy to lose sight of this when dealing with the day-to-day hassles that plague all organizations. The vision statement keeps the endpoint in sight. It also lets others know what the group stands for and what it wants to do. It helps to keep group members focused and bound together in common purpose.

Visioning begins with the future, not the present. It focuses on the end-state, not the means of getting there. It is a mental picture of the group, operating in an environment, performing to some criterion of excellence, and appreciated for what it contributes. A vision is not a plan. A vision is knowing what you want to do. The "how to" comes later.

What makes an effective vision statement? Three components help to make a vision statement valid and useful for people:

1. **A focused concept**—something beyond platitudes; a value creation premise that people can actually picture as existing.
2. **A sense of noble purpose**—something that is really worth doing; something that can create value, make a contribution, make the world a better place in some way, and win people's commitment.
3. **A plausible chance of success**—something people can realistically believe to be possible and, if not perfectly attainable, at least plausible to strive for.

Decide what you're not about and make sure your vision statement excludes it. A common mistake is to make the vision too broad just in case you want to expand it later. It is better to limit the vision and provide needed direction. Radical departures from the original vision can then be challenged effectively (which is the whole point), and the vision formally expanded to include them if necessary.

A quick hint for developing vision and mission statements: The most common cause of the frustrating wrangles that group members get into is confusing editing with thinking. When starting to draft a vision or mission statement directly, teams frequently fall into debates about the best choice of words around the idea. Separate the thinking from the "wordsmithing." The better way is to work out the basic idea of the vision and mission statements first, and then have somebody put some compelling words around the idea. You're not ready to start drafting the language of your vision or mission statement until you have settled on a driving idea, the organizing principle behind the way you want to do your work, and until you can write that idea down on the back of a business card. Once you have consensus on the core concept of your group, writing it out becomes a much more manageable process. There is always a sudden rise in energy and enthusiasm among group members at the point when they break through to the critical premise of the group. After that, they’re much more willing to push on with the process of getting the language right.

Goals

Goals typically represent an end state similar to the vision. However, this is not always true. There may be goals that represent an ongoing state such as “improve the communication internal to the organization.” However, goals should be achievable, which implies that there needs to be some way to realize or measure that the goals have been achieved. This means that the statement of goals should contain a qualitative or quantitative portion that allows their achievement to be measured in some meaningful way.

Appendix C Indicators

Indicators

An *indicator* is defined as a measure or combination of measures that provides insight into a process, a project, or a product. An indicator is usually a graph or table that you define for the organization’s needs. Indicators frequently make a comparison between two values, such as planned and actual values.

Classification of Indicators

There are three main classifications of indicators. These are defined as follows:

1. **Success Indicators:** These indicators are constructed from the defined success criteria and are used to determine if the goals have been met.
2. **Progress Indicators:** These indicators are used to track the progress or execution of the defined tasks. A Gantt chart is a good example. The successful execution of all the defined tasks does not necessarily guarantee that the goal has been successfully met.
3. **Analysis Indicators:** These indicators are used to assist in analyzing the output of each task. The analyses help test our assumptions about the data we are using to judge progress and success.

The following figure illustrates the difference among types of indicators:

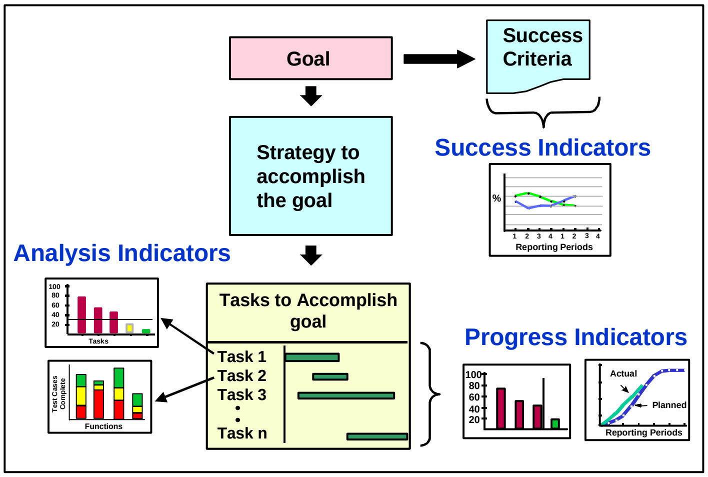

Goal
Success Criteria
Success Indicators
%
1 2 3 4 1 2 3 4
Reporting Periods
Strategy to accomplish the goal
Analysis Indicators
100
80
60
40
20
Tasks
Test Cases Complete
Functions
Tasks to Accomplish goal
Task 1
Task 2
Task 3
Task n
Progress Indicators
100
80
60
40
20
Actual
Planned
Reporting Periods

Figure 6: Classification of Indicators

Many organizations have difficulty deciding how to tell if or when their business goals have been achieved. While organizations are often able to articulate a strategy and define tasks for achieving their goals, they have difficulty understanding the difference between ***success indicators*** (indicators used to determine if the goals have been met) and ***progress indicators*** (indicators used for tracking the execution of tasks). Organizations often use these indicators to track the execution of tasks and as a proxy for measuring if a goal has been achieved. When all the tasks have been executed, organizations declare success—their goals have been met. But they often neglect to analyze the outcome of the tasks to determine if their goals have been met successfully. Execution of the defined tasks is a necessary but not sufficient condition for meeting the goal.

Guidance on Generating Indicators

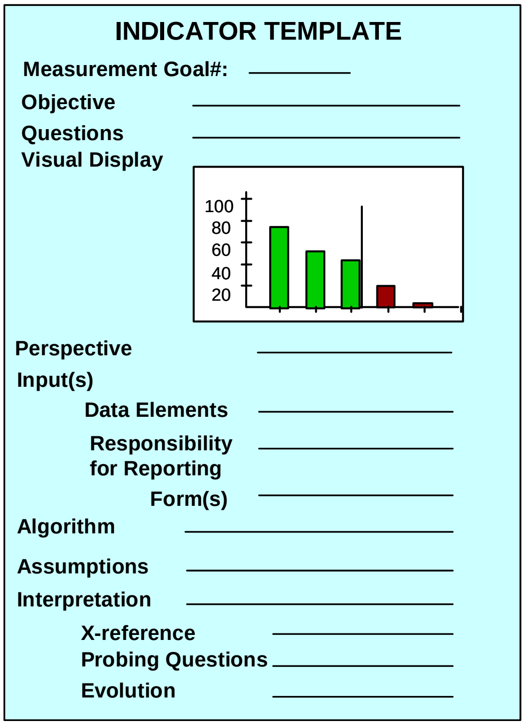
The following guidance should be kept in mind for generating useful indicators [PSM 00].

- Use consistent conventions
- Keep it simple; keep the message clear
- Unique titles should reflect insight and scope
- Include AS OF line or date
- Label each axis and provide scale markers
- Annotate with milestones and significant events
- Use same axes and scales if indicators will be compared

Appendix D Indicator Template

Indicator Template

Using the information identified during the workshop, a strawman indicator template for each identified indicator can be completed. The template addresses and documents the why, what, who, where, how, etc. for each indicator. Each indicator should be documented using the indicator template shown in the figure below.



INDICATOR TEMPLATE

Measurement Goal#: ______

Objective ______

Questions ______

Visual Display

100
80
60
40
20

Perspective ______

Input(s)

Data Elements ______

Responsibility for Reporting ______

Form(s) ______

Algorithm ______

Assumptions ______

Interpretation ______

X-reference ______

Probing Questions ______

Evolution ______

Figure 7: Indicator Template

A description of each field in the indicator template follows.

INDICATOR TEMPLATE

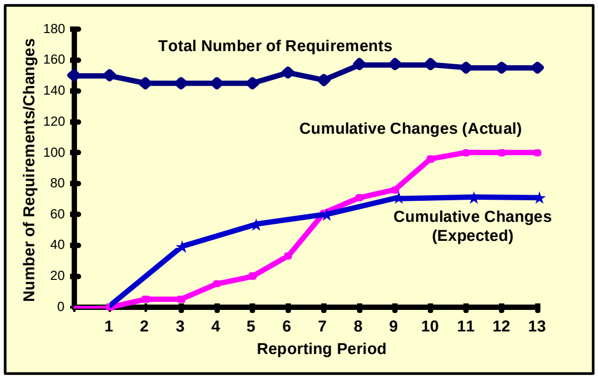
Date __________

Indicator Name/Title: ____________________________

OBJECTIVE Describe the objective or purpose of the indicator.

QUESTIONS List the question(s) the indicator user is trying to answer. Examples: Is the project on schedule? Is the product ready to ship? Should we invest in moving more software organizations to CMM maturity level 3?

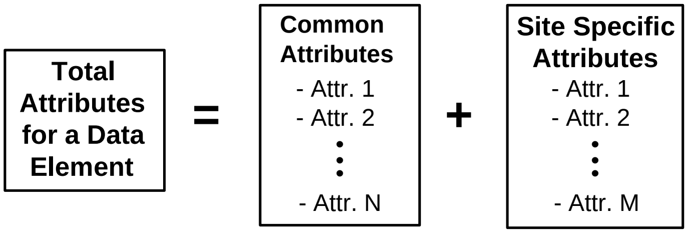
VISUAL DISPLAY Provide a graphical view of the indicator.



PERSPECTIVE Identify the target audience of this indicator. (Who is going to use this information?)

INPUT(S)

Data Elements List the data elements that are used in the production of the indicator. The description should be consistent to the degree that different individuals in different environments can reliably generate comparable numbers in the same units. In many cases, organizations will want to collect more detailed data (e.g., additional attributes of trouble reports) and the inputs should be described in such a way as to permit these additional attributes as well as the "common" attributes.



Total Attributes for a Data Element
=
Common Attributes
- Attr. 1
- Attr. 2
- Attr. N
+
Site Specific Attributes
- Attr. 1
- Attr. 2
- Attr. M

Responsibility for Reporting	Indicate who has responsibility for reporting the data.
Forms	Reference any standard forms for data collection (if applicable) and provide information about where to obtain them.
ALGORITHM	Specify the algorithm or formula required to combine data elements to create input values for the display. It may be very simple, such as Input1/Input2, or it may be much more complex. Include how the data is plotted on the graph.
ASSUMPTIONS	Identify any assumptions about the organization, its processes, life-cycle models, and so on that are important conditions for collecting and using this indicator.
INTERPRETATION	Describe what different values of the indicator mean. Make it clear how the indicator answers the "Questions" section above. Provide any important cautions about how the data could be misinterpreted and measures to take to avoid misinterpretation.
X-reference	If the values of other defined indicators influence the appropriate interpretation of the current indicator, refer to them here.
Probing Questions	List questions that delve into the possible reasons for the value of an indicator, whether performance is meeting expectations or whether appropriate action is being taken.
Evolution	Specify how the indicator can be improved over time, especially as more historical data accumulates e.g., by comparison of projects using new processes, tools, environments with a baseline; using baseline data to establish control limits around some anticipated value based on project characteristics.

Modified Indicator Template

A modified template for describing the indicators is shown below. This indicator template illustrates how an indicator template may be tailored to add other specific data requirements. New fields are shown in blue.

MODIFIED INDICATOR TEMPLATE

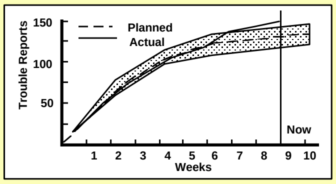
Date ____

Indicator Name/Title ____

Objective ____

Questions ____

Visual Display



Perspective ____

Input(s)

- **Data Elements** ____
- **Definitions** ____

Data Collection

- **How** ____
- **When/How Often** ____
- **By Whom** ____
- **Form(s)** ____

Data Reporting

- **Responsibility for Reporting** ____
- **By/To Whom** ____
- **How Often** ____

Algorithm ____

Assumptions ____

Interpretation ____

Probing Questions ____

Analysis ____

Evolution ____

Feedback Guidelines ____

X-reference ____

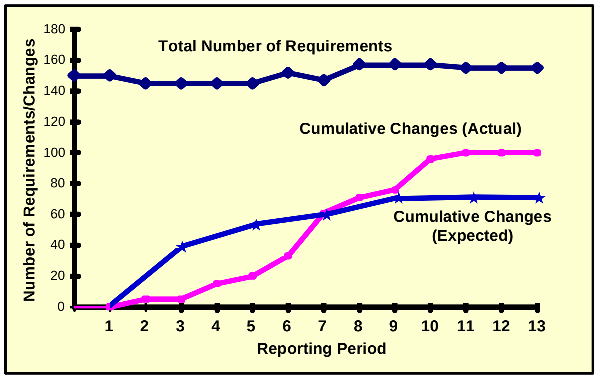
Date __________

Indicator Name/Title: ____________________________

OBJECTIVE Describe the objective or purpose of the indicator.

QUESTIONS List the question(s) the indicator user is trying to answer. Examples: Is the project on schedule? Is the product ready to ship? Should we invest in moving more software organizations to CMM maturity level 3?

VISUAL DISPLAY Provide a graphical view of the indicator.



PERSPECTIVE Identify the target audience of this indicator. (Who is going to use this information?)

INPUTS

Data Elements	**Definition**
List all the data elements in the production of the indicator.	Precisely define the data element used or point to where the definition can be found.
________________	________________________________
________________	________________________________
________________	________________________________
________________	________________________________
________________	________________________________

DATA COLLECTON

How	Describe how the data will be collected.
When/How Often	Describe when the data will be collected and how often.
By Whom	Specify who will collect the data (an individual, office, etc.)

Forms	Reference any standard forms for data collection (if applicable) and provide information about where to obtain them.
DATA REPORTING	
Responsibility for Reporting	Indicate who has responsibility for reporting the data.
By/To Whom	Indicate who will do the reporting and to whom the report is going. This may be an individual or an organizational entity.
How Often	Specify how often the data will be reported (daily, weekly, monthly, as required, etc.)
ALGORITHM	Specify the algorithm or formula required to combine data elements to create input values for the display. It may be very simple, such as Input1/Input2, or it may be much more complex. It should also include how the data is plotted on the graph.
ASSUMPTION	Identify any assumptions about the organization, its processes, life-cycle models, and so on that are important conditions for collecting and using this indicator.
ANALYSIS	Specify what type of analysis can be done with the information.
INTERPRETATION	Describe what different values of the indicator mean. Make it clear how the indicator answers the “Questions” section above. Provide any important cautions about how the data could be misinterpreted and measures to take to avoid misinterpretation.
PROBING QUESTIONS	List questions that delve into the possible reasons for the value of an indicator, whether performance is meeting expectations or whether appropriate action is being taken.
EVOLUTION	Specify how the indicator can be improved over time, especially as more historical data accumulates e.g., by comparison of projects using new processes, tools, environments with a baseline; using baseline data to establish control limits around some anticipated value based on project characteristics.

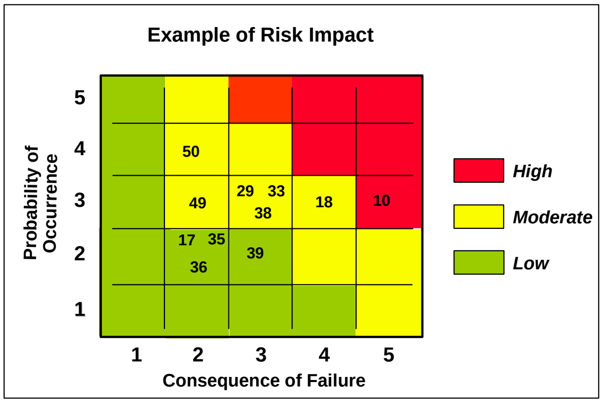
X-REFERENCES	If the values of other defined indicators influence the appropriate interpretation of the current indicator, refer to them here.

Appendix E Glossary

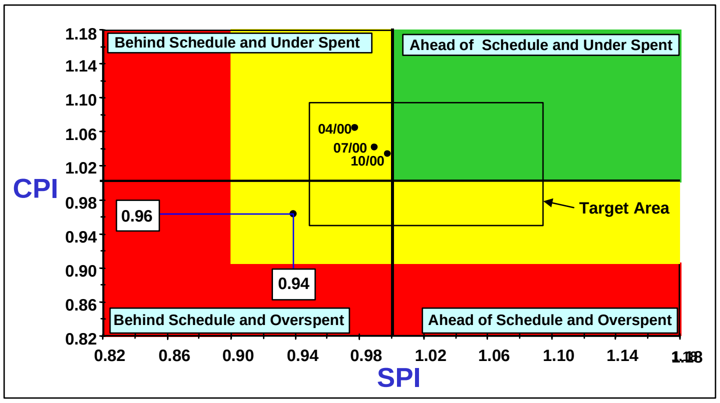
goal the objective to which an endeavor is directed

indicator a measure or combination of measures that provides insight into a process, a project or a product itself. An indicator is usually a graph or table that you define for your program needs. An indicator is a measure or a group of measures the provide information about a project issue. Indicators frequently make comparison between two values, such as planned and actual values.

indicator examples:



Earned Value Management



measurement	a standard or unit of measurement a quantitative indication of the extent, amount, dimension, capacity or size of some attribute of a product or process measurement examples: • CMM-Based Assessment for Internal Process Improvement (CBA-IPI) • function point counting • time reporting
measure	the process by which numbers or symbols are assigned to attributes of entities in the real world in such a way as to characterize the attributes by clearly defined rules[5] measure examples: • number of defects • source lines of code (SLOC) • person hours • dollars • number of requirements
metric	a quantitative measure of the degree to which a system, component, or process possess a given attribute[6] metric examples: • defects per 1,000 SLOC • number of change requests per phase • defects per phase

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[5] This is adapted from Fenton, Norman. *Software Metrics: A Rigorous Approach*. London: Chapman and Hall, 1991.

[6] This is adapted from the *I-EEE Standard Glossary of Software Engineering Terminology*.

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This technical note describes the synergistic application of the balanced scorecard and goal-driven measurement methodologies to develop measures and associated indicators for measuring an organization's health and performance. Through this iterative approach, an organization's strategic goals and subgoals are mapped to the balanced scorecard and refined. The goal-question-(indicator)-measurement methodology is then applied to identify indicators and measures for each scorecard dimension. A hypothetical example of how to apply the methodology at a "typical" organization performing software development and maintenance activities is provided. The example yields typical indicators to illustrate the methodology.

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