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Abstract

The aim of this report is to study three approaches recommended for developing and supporting software process improvements, that is, the Goal-Question-Metric (GQM) technique, the Capability Maturity Model (CMM), and the Balanced Scorecard framework. A special focus study will be on the last one. A description of the nature of the two first approaches is presented. A detailed description for the key characteristics and for the nature of the Balanced Scorecard (BSC) and its variants for the IT and IS fields are described. An indicator measurement for the ICT world Balanced Scorecard is introduced. A comparison between the three approaches is presented.

Introduction

Software Engineering is a discipline that is making exceptional progress in the development of new paradigms, methods, tools and techniques for the production of information systems. A weakness is that the academic development of the theory underlying these advances is often "out of synchronization" with current usage. The use of metrics is a key factor in the establishment of a scientific basis for Software engineering and the reduction of the gap between academics and practitioners.

‘Software metrics' is the term used to describe the wide range of activities concerned with measurement in software engineering. These activities range from producing numbers that characterize properties of software code (these are the classic software `metrics') through to models that help predict software quality.

The major reason for using metrics is to improve the software engineering decision-making process from a managerial and technical perspective.

Systematic measurement is necessary for the formal modeling and evaluation of the new techniques and their optimal use within industry. A number of approaches have been advocated for the systematic design and introduction of software metrics for the purposes of process improvement and capability assessment in an organization.

Some of these approaches are the Capability Maturity Model (CMM), the Goal Question Metrics (GQM), and the Balanced Scorecard.

A software development process can be defined as “a set of activities, methods, practices, and transformations that people use to develop and maintain software and the associated products (e.g., project plans, design documents, code, test cases, and user manuals)” [1].

The underlying premise of software process management is that the quality of a software product is largely determined by the quality of the process used to develop and maintain it. Thus, the role of process is to tie together the people developing the software and the technology used (e.g. tools and methods), as well as the product complexity and environmental characteristics (e.g. schedule pressure).

To observe and quantify the impact of software process improvement, we must measure the performance of a software organization over time. Thus, measurement plays a key role for incremental improvements to the software development process.

The first section of my report outlines an overview of software measurement using the Goal Question Metrics approach. I have presented a description of the nature of that approach and some of its difficulties.

In the second section, I gave a description of a software process assessment and capability evaluation approach, which is the Capability Maturity Model (CMM). In the same section, I have presented some of the work done in the literature that discuss how to use the CMM correctly and effectively in any business environment.

The third section provides an overview of a multi-level management tool, which is the Balanced Scorecard (BSC) framework. The key characteristics and variants for the IS and IT field are described. An indicator measurement for the ICT world Balanced Scorecard is introduced. A comparison between the three approaches is presented in the last section of this report.

Goal Question Metric (GQM)

Introduction

Measurement is an ideal mechanism for feedback and evaluation that are needed by any engineering process. Some people thought that measurement must be focused upon goals and models. Goal-Question-Metric (GQM, see Figure1) is an approach for goal-oriented measurement in software projects that has proven to be a particularly effective approach to selecting and implementing measures and indicators. In this section I will provide a quick review of the GQM model.

The technique

The idea of GQM is that quality goals can not be assessed directly, but their meaning is circumscribed by questions that need to be answered when evaluating the quality. These questions are used to extract the appropriate information from the models of software process and products. Such questions again can usually not be answered directly but rely on metrics applied to either the product or process in question, as illustrated in Figure1. Specific techniques and algorithms are then applied to derive the answer of a question from the measurements.

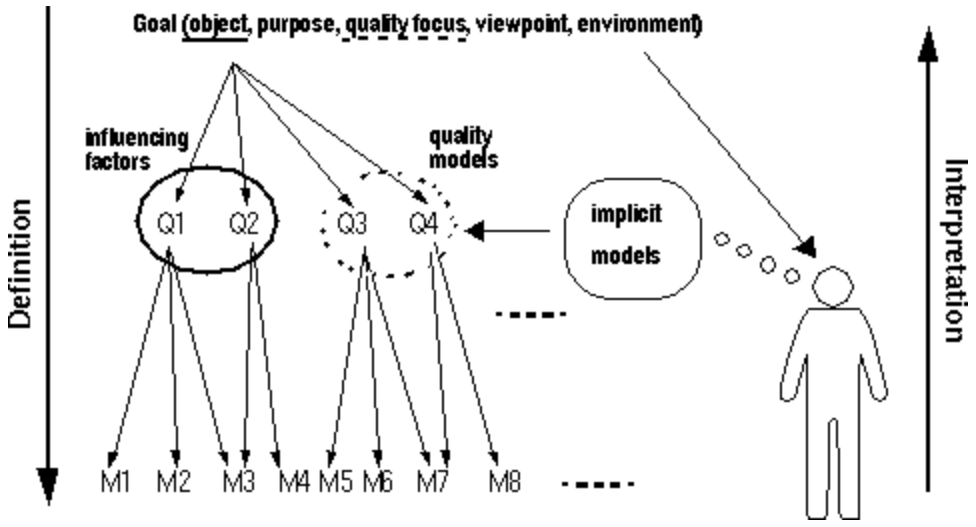

Figure 1: the GQM approach to goal-oriented measurement

The three levels of A GQM Model

Conceptual level (Goal)

[2] A goal is defined for an object, for a variety of reasons, with respect to various models of quality, from various points of view, relative to a particular environment. Objects of measurement are [3]

- Products (e.g., specifications, designs, programs, test suites).
- Processes (e.g., specifying, designing, testing, interviewing).
- Resources (e.g., personnel, hardware, software, office space).

A goal can be refined into several other sub-goals. A set of questions is used to characterize the way the assessment/achievement of a specific goal is going to be performed based on some characterizing model. Questions try to characterize the object of measurement (product, process, resource) with respect to a selected quality issue and to determine its quality from the selected viewpoint.

A goal coordinates are:

- Issue (e.g. Timeliness).
- Object (e.g. Change request processing).
- Viewpoint (e.g. project manager).

And a purpose:

- Purpose (e.g. improve).

The Issue and the purpose of the Goal are obtained from the policy and the strategy of the organization (e.g. by analyzing corporate policy statements, strategic plans and, more important, interviewing relevant subjects in the organization). The object coordinate of the Goal is obtained from a description of the process and products of the organization, by specifying process and product models, at the best possible level of formality. The viewpoint coordinate of the Goal is obtained from the model of the organization.

Operational level (Question)

A set of questions is used to characterize the way the assessment/achievement of a specific goal is going to be performed, based on some characterizing model. Questions try to characterize objects of measurement with respect to a selected quality issue, and to determine its quality from the selected viewpoint. Types of questions are

- Group 1. How can we characterize the object (product, process, or resource) with respect to the overall goal of the specific GQM model? E.g.,
    - What is the current change request processing speed?
    - Is the change request process actually performed?
- Group 2. How can we characterize the attributes of the object that are relevant with respect to the issue of the specific GQM model? E.g.,
    - What is the deviation of the actual change request processing time from the estimated One?
    - Is the performance of the process improving?
- Group 3. How do we evaluate the characteristics of the object that are relevant with respect to the issue of the specific GQM model? E.g.,
    - Is the current performance satisfactory from the viewpoint of the project manager?
    - Is the performance visibly improving?

Quantitative level (Metric)

Metrics is a set of data that is associated with every question in order to answer it in a quantitative way. The data can be:

- Objective (E.g., number of versions of a document, staff hours spent on a task, size of a program).
- Subjective (e.g., readability of a text, level of user satisfaction).

The development of metrics is a customized process! Suggestions for this development include:

- Try to maximize the use of existing data sources if they are available and reliable.
- Apply objective measures to more mature measurement objects, and more subjective evaluations to informal or unstable objects.
- The measures we define must help us in evaluating not only the object of measurement but also the reliability of the model used to evaluate it.

Steps of the GQM process

- Identify a set of quality and/or productivity goals, at corporate, division or project level; e.g., customer satisfaction, on-time delivery, improved performance.
- From those goals and based upon models of the object of measurement, we derive questions that define those goals as completely as possible.
- Specify the measures that need to be collected in order to answer those questions.
- Develop data collection mechanisms, including validation and analysis mechanisms.

Difficulties with GQM

The difficult part of using GQM is to derive a good set of questions that will allow the organization to collect the most important and useful metrics.

The personnel at the site where the GQM will be used must receive adequate training in GQM approach.

The Capability Maturity Model (CMM)

Introduction

Another approach for software metrics is the CMM. The basic concept of maturity framework weas inspired by Crosby's quality management maturity grid and its five evolutionary stages in adopting quality practices. This maturity framework was adapted to software by Radice et al. at IBM [4]. Humphrey brought the maturity framework from IBM to the software Engineering Institute (SEI) in 1986, adding the concept of maturity levels. After several years of experience with the initial process maturity framework, the SEI evolved the framework into the Capability Maturity Model (CMM) for software [1].

The technique

CMM describes the practices of software engineering and management that characterize organizations as they mature their process for developing and maintaining software. CMM guides software organization in selecting process improvement strategies by determining current process maturity and identifying the few issues most critical to software quality and process improvement. CMM will determine the current process maturity of the organization according to 5 maturity levels it defines (is shown I Figure2). Each maturity level indicates a level of a process capability, which describes the range of expected results that can be achieved by following a software process. The maturity of an organization's software process helps to predict a project's ability to meet its goals. Achieving each level results in an increase in the process capability of the organization.

The five levels

The following characterizations of the five maturity levels highlight the primary process changes made at each level [1]:

1. Initial

   The software process is characterized as ad hoc, and occasionally even chaotic. Few processes are defined, and success depends on individual effort.

2. Repeatable

Basic project management processes are established to track cost, schedule, and functionality. The necessary process discipline is in place to repeat earlier successes on projects with similar applications.

3. Defined

   The software process for both management and engineering activities is documented, standardized, and integrated into a standard software process for the organization. All projects use an approved, tailored version of the organization's standard software process for developing and maintaining software.

4. Managed

   Detailed measures of the software process and product quality are collected. Both the software process and products are quantitatively understood and controlled.

5. Optimizing

   Continuous process improvement is enabled by quantitative feedback from the process and from piloting innovative ideas and technologies.

A software organization operating at level 1 is likely to do very little measurement, level 1 measurements will, however, provide a baseline for comparison as an organization seek to improve its processes and products. At level 2, the organization will use a minimum set of data needed to control and manage a software project, while level 3 measures the intermediate and final products produced during development. The measurements at level 4 capture characteristics of the development process itself in order to allow control of the individual activities of the process. At level 5 the process is so mature and carefully managed that it allows measurements to provide feedback for dynamically changing the process during a particular project's development.

Each maturity level has its own goals which can be achieved by using the defined Key Process Areas (KPA) for that level. A KPA contains useful Key Practices which describe the implementation in detail.

However, to be able to improve and manage the process correctly, a model is not enough. You need to get information out of the process. As a consequence, when using the CMM, it is necessary to evaluate and assess the process. The primary objective of the assessment is to help organization to identify ways to improve. There are several methods for assessment that the organization can choose from.

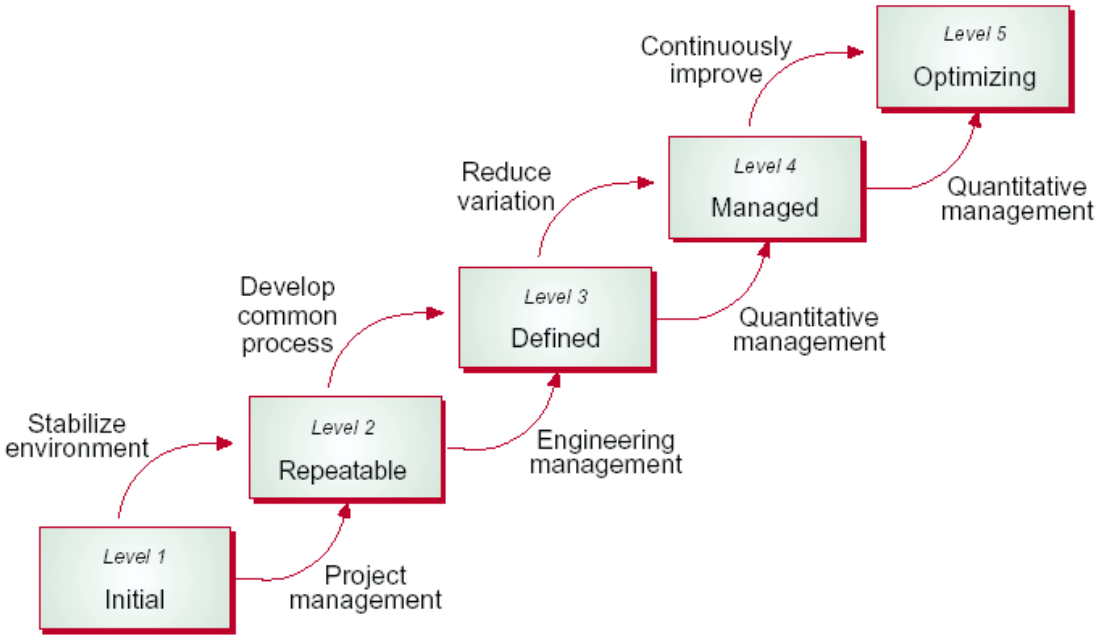

Figure2: The five levels of the CMM

CMM Applications

CMM is used in

- Software process assessments.
- Software capability evaluations.
- Process improvement programs.

Using the CMM

Although the CMM has been widely adopted, there remain many misunderstandings about how to use it effectively for business-driven software process improvement, particularly for small organizations and small projects. The paper of Mark C. Paulk [6] discusses how to use the CMM correctly and effectively in any business environment, with a focus on small organizations but also including examples for rapid prototyping projects, maintenance shops, R&D outfits, and other environments. This

paper summarizes the observations and recommendations of the author, based on over a decade of experience in CMM-based assessments and process improvement. The author presented the recommendations for effective software process. He recommended that process maturity should be included in risk assessment during source selection, rather than using maturity levels to filter offerors, because what is adequate in one environment may not suffice for a new project. Also he suggested that maturity levels should be measures of improvement, not goals of improvement. He concluded that the challenges in interpreting the CMM appropriately for different environments differ in degree rather than in kind.

The CMM is a proven tool to support process appraisal and software process improvement in a wide range of environments, but it must be used with professional judgment and common sense to be truly effective. The conclusion is that the issues associated with interpreting the Software CMM are essentially the same for any organization interested in improving its software processes – the differences are of degree rather than kind. Using the Software CMM effectively and correctly requires professional judgment and an understanding of how the structure of CMM is, to be used for different purposes.

The Balanced Scorecard (BSC)

Introduction

In the literature it is frequently argued that performance measures should be derived from strategy, that is, they should be used to reinforce the importance of certain strategic objectives.

"Strategy is the theory of organization. It reflects the organization's conception of its intended long-term goal and the approach to achieving it". [7]

Interest among both academics and practitioners in performance measurement systems as a tool for delivering strategic objectives is well established in the management literature.

Traditional performance measurement systems appear not to be providing managers with the information they need to measure and manage the all-important competencies that drive competitive advantage.

Traditional financial measurement systems (like the return on investment, (ROI) and payback period) are proving to be of increasingly limited use to managers who want to manage and improve critical business processes, that is because financial measures tend to shape manager's behavior to focus on short term results [8]. Many organizations are realizing that the traditional financial orientation of their performance measurement systems is no longer adequate.

Therefore, performance measurement incorporating non-financial measures has been a topic of great interest. This is because non-financial measures overcome the limitations of just using financial performance measures. In addition, in today's global economy total customer satisfaction is seen by academics and industrialists alike as one of the key indicators of competitive success. "Soft" issues, "those areas of the discipline which are generally difficult to measure and assess", are becoming more widely recognized as having an impact on business performance. They include issues such as employee and customer satisfaction.

For public organizations with increasing demands for providing a valuable customer service, non-financial measures are becoming more important.

Since the financial dimension proved to be insufficient and hid the relations (e.g. cause-and effect) among processes, an improvement step was suggested which would introduce additional dimensions (or perspectives) of analysis. In 1993, Robert S. Kaplan of the Harvard School of Business and consultant David Norton developed the Balanced Scorecard (BSC), an evolution of the concepts included in the *Tableau de Bord* which emerged in France at the turn of the 20th century. The aim of the *Tableau* had been to translate each company's unitary vision and mission into a set of objectives, through the identification of Key Success Factors and Key Performance Indicators. The basic argument of the BSC system is that an organization has to have a good, well-balanced measurement system.

Balanced Scorecard definition

Kaplan and Norton defined the Balanced Scorecard (BSC) as a multi-dimensional framework for describing, implementing and managing strategy at all levels of an enterprise and by linking objectives, initiatives and measures to an organization's strategy. [9]

The BSC is a set of financial and non-financial measures relating to a company's critical success factors.

The BSC allows the managers to look at the business from four perspectives [10]: customer perspective, internal perspective, innovation and learning perspective, and financial perspective.

According to Kaplan and Norton, the BSC includes four management processes:

- Translating the vision helps managers build a consensus of opinion about the organization's vision and strategy.
- Communicating and linking helps management tie overall objectives and strategies to department and individual objectives.
- Business planning helps organizations integrate their business and financial plans.
- Feedback and learning helps management direct the organization toward strategic learning.

During the above management processes, the BSC measurement system with ratios is the means of informing the organization about the focuses of the company.

Through BSC systems, organizations are gathering critical non-financial data to help pin-point problems, improve processes and achieve organizational goals in ways that can be understood and used by all levels of the corporation, from line managers to senior executives. The name of the BSC reflects an intent to keep score of a set of items that maintain a balance between short and long term objectives, between financial and non-financial measures, between lagging and leading indicators, and between internal and external performance perspectives.

It must be noted that the BSC is not a static list of measures, but rather a framework for implementing and aligning complex programs of change, and, indeed, for managing strategy-focused organizations. In summary, a scorecard is to be used to facilitate the translation of strategy into action.

A good BSC

A good BSC should tell the story of the organization's strategy. Three criteria help in determining whether or not this objective has been achieved. Kaplan and Norton [10] stress the importance of adhering to these three principles in order to develop a balanced scorecard that is more than a group of isolated and eventually conflicting strategies and measures:

Build in cause-and-effect relationship: A strategy is a set of assumptions about cause-and-effect. These cause-and-effect relationships can involve several or all four of the perspectives in the BSC framework. For example, better staff skills (future readiness perspective) will reduce the frequency of bugs in an application (internal operations perspective). An application with fewer bugs will be more likely to meet end-user expectations (user orientation perspective). This in turn will enhance the support of core business processes (business value perspective).

Include sufficient performance Drivers: the drivers of performance (lead indicators) tend to be unique since they reflect what is different about the strategy of a company. They should be properly mixed with lag indicators. Outcome measures like programmers' productivity (number of function points per person per month) without

performance drivers like staff education (number of educational days per person) do not communicate how the outcomes are to be achieved. Furthermore, performance drivers without outcome measures may enable the achievement of short-term operational improvements, but will fail to reveal whether the operational improvements have been translated into enhanced financial performance.

Provide a linkage to financial indicators: while there is a proliferation of new strategic goals such as quality, customer satisfaction and innovation, these goals must also translate into measures that are ultimately linked to financial measures.

Why a Balanced Scorecard?

Balance is necessary for efficient and effective movement, for the achievement of a rich sound, and for assisting in maximizing potential. In the same way, performance measurement systems must achieve a balance, which supports progress against pre-determined objectives, without sub-optimization.

Over the recent past, organizations have tried various methods to create an organization that is healthy and sound. By requiring strategic planning and a linking of program activities and performance goals to an organization's budget, decision making and confidence in the organizational performance are expected to improve. Major changes are taking place in the way businesses are managed. Resources are diminishing, regulations are being cut and the traditional role of overseer is being redefined into a more positive one. This uncertainty, coupled with a continually changing environment, has forced managers to pursue new ways to meet the future demands of organizations.

In viewing a company from four vital perspectives, the BSC is intended to link short-term operational control to the long-term vision and strategy of the business. The idea of the BSC is to describe the essential ingredients of business success. The primary function of the score-card is to control organizational operations. It furnishes a language for describing expectations and performance, thus laying the foundation for discussions on how each individual can contribute to fulfilling the organization's vision.

The four perspectives of the balanced score-card

The BSC provides a framework for studying causal links based on internal performance measurement through a set of goals, drivers and indicators or measures (lag

and lead types) grouped into four different perspectives. Perspectives reflect the different views that can be taken of an organization. The four perspectives of BSC are illustrated in Figure 3.

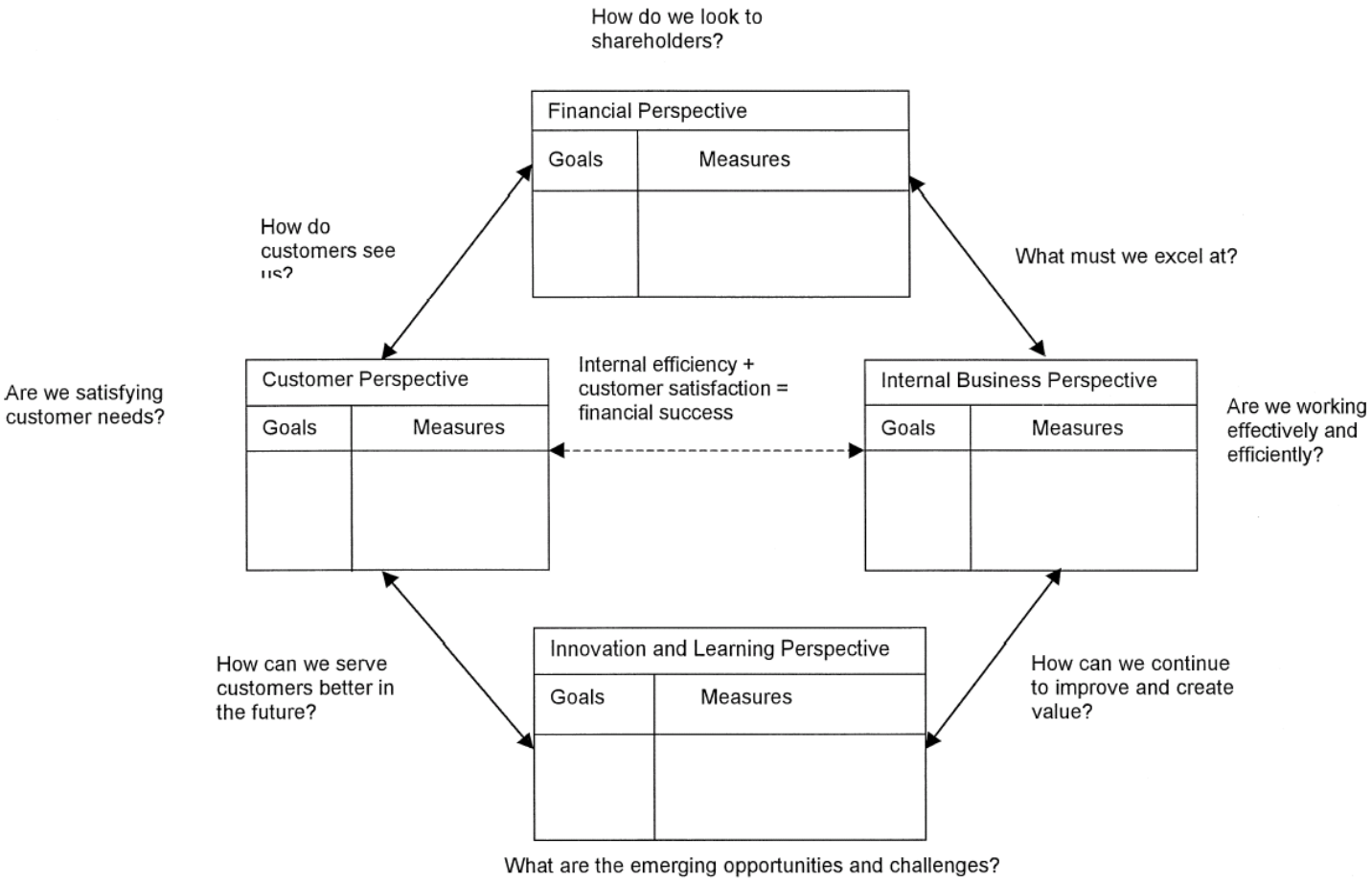

Fig.3. Relationships between the four perspectives in the balanced scorecard.

Customer perspective

This perspective captures the ability of the organization to provide quality goods and services, the effectiveness of their delivery, and overall customer service and satisfaction. To this effect, many organizations today have a mission focused on the customer and measuring how an organization is performing from its customers' perspective has become a priority for top management (Kaplan and Norton, 1992). The BSC demands that managers translate their general mission statement on customer service into specific measures that reflect the factors that really matter to customers. In a

public organization model, the principal driver of performance is different from in the strictly commercial environment; namely, customer and stakeholder interests take prominence over financial results. In general, public organizations have a different, perhaps greater, stewardship/fiduciary responsibility and focus than private sector entities (Procurement Executives Association, 1998).

Internal business processes perspective

The business processes perspective is primarily an analysis of the organization's internal processes. Internal business processes are the mechanisms through which organizational performance expectations are achieved. Customer-based measures are important, but they must be translated into measures of what the organization must do internally to meet its customers' expectations. This perspective focuses on the internal business results that lead to financial success and satisfied customers. Therefore, managers need to focus on those critical internal operations that enable them to satisfy customer needs (Kaplan and Norton, 1992). Organizations should decide at what processes and competencies they must excel and specify measures for each. Key internal processes are monitored to ensure that outcomes will be satisfactory. The measures should also link top management's judgment about key internal processes and competencies to the action taken by individuals that affect overall corporate objectives. This linkage ensures that employees at lower levels in the organization have clear targets for actions, decisions and improvement activities that will contribute to the organization's overall mission (Kaplan and Norton, 1996).

Innovation and learning perspective

Customer and internal business process measures identify the parameters that the organization considers most important for competitive success. The targets for success keep changing and intense competition requires that organizations make continual improvements to their existing products and processes and have the ability to introduce entirely new processes, which expand capabilities (Kaplan and Norton, 1992). In this context, this perspective looks at such issues, which include the ability of employees, the quality of information systems and the effects of organizational alignment in supporting accomplishment of organizational goals. Processes will only succeed if adequately skilled

and motivated employees, supplied with accurate and timely information, are driving them. In order to meet changing requirements and customer expectations, employees may be asked to take on dramatically new responsibilities, and may require skills, capabilities, technologies and organizational designs that were not available before, and learning and growth issues enable the organization to ensure its capacity for meeting customer needs, a pre-requisite for long-term survival (Kaplan and Norton, 1996).

Financial perspective

Financial performance measures indicate whether the organization's strategy, implementation and execution are contributing to bottom-line improvement. It shows the results of the strategic choices made in the other perspectives. By making fundamental improvements in their operations, the financial numbers will take care of themselves, according to Kaplan and Norton (1992). In the public arena, the ``financial'' perspective differs from that of the traditional private sector. Private sector financial objectives generally represent clear long-range targets for profit-seeking organizations , operating in a purely commercial environment (Procurement Executives Association, 1998). Financial considerations for public organizations should be measured by how effectively and efficiently they meet the needs of their constituencies. Therefore for the government the financial perspective emphasizes cost efficiency, i.e. ability to deliver maximum value to the customer.

Realizing the true potential of the balanced score-card

A BSC properly deployed to manage the organization can result in several critical accomplishments:

- Alignment of strategy with key performance objectives at all levels of the organization;
- More effective measurement and management of business performance against plan; and
- Strategic feedback and an organization wide communication platform.

The balanced scorecard building process

As described above, the BSC provides organizations with the opportunity to identify their mission and strategy under the four perspectives identified above. Once the critical

success factors are derived under the perspectives, measures need to be identified. The process of developing a BSC has been summarized as follows [11]:

1. Establish and confirm the organization's vision based on shared vision and communication.
2. Establish the perspectives.
3. Break the vision down according to each perspective and formulate overall strategy goals.
4. Identify critical success factors moving on from the descriptions and strategies outlined above to discuss what is required for the vision to succeed and which factors will have the greatest effect on outcome.
5. Develop relevant key measures to satisfy the critical success factors and study the feasibility of taking such measurements. Simultaneously check the structure for logical consistency (cause and effect).
6. Establish the comprehensive score-card.
7. Break down the score-card and measures by organizational unit (the company, the business unit, the department or function, the workgroup and the individual).
8. Formulate goals - goals must be set for every measure, as the company needs both short- and long-term goals, so that it can check its course continually and take the necessary corrective action in time.
9. Develop action plans aligned to the goals and vision.
10. Implement the score-card - it is necessary to follow it up on a continuous basis, so that it fulfils its intended function as a dynamic tool of management. It is also important that the score-card be used throughout the organization in the everyday aspects of management.

Towards a learning organization

The ultimate objective of any organization must be to achieve self-managing workers, who are motivated to achieve high quality, capable of achieving high quality and able to exhibit "self-control", and such objectives can be attained by creating "learning organizations". Olve *et al.* [11] describe a learning organization as an organization, which is constantly developing and changing in a way that will keep it competitive in the future.

In this context, in addition to tracking progress on past results, managers of organizations can use the performance measurement concept to learn about the future. Managers gain the opportunity to discuss not only how they achieved past results but also whether their expectations for the future remain on track. If an organization followed established strategies, but did not achieve target results, managers then should examine internal capabilities and assess whether the underlying strategies remain valid. Based on such analyses, managers may adjust or redirect their strategies or identify new strategies. This focus serves as a foundation for effective process improvement and risk management. It also completes a feedback loop that supports decision making at all levels of the organization.

Kaplan and Norton [10] see performance measurement systems as enablers of a circle of learning (see Figure4).

Therefore, it could be argued, one of the main purposes of the performance measurement applications using the BSC concept is to develop and support this concept of ``learning organizations''.

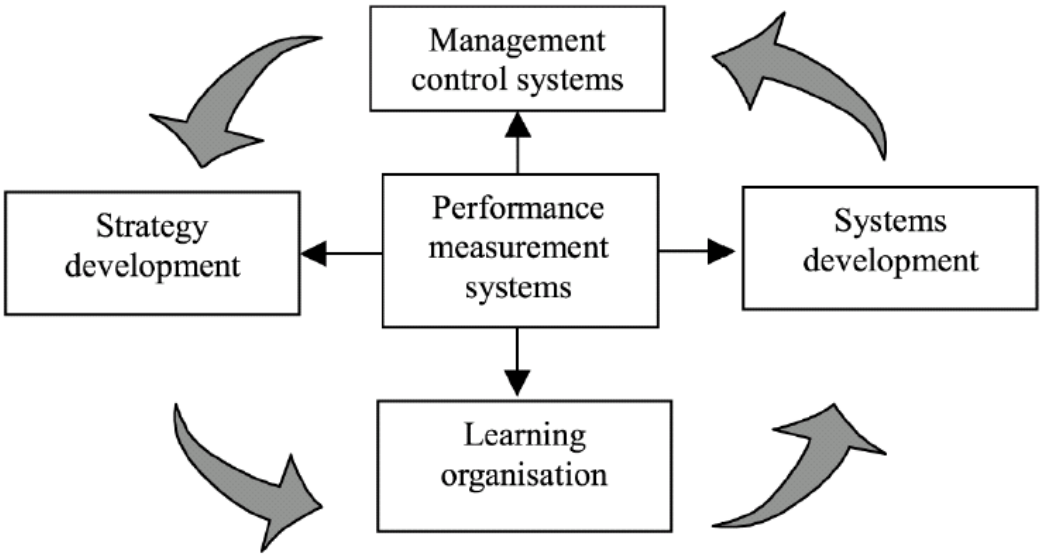

Figure4: performance measurement as an organizational enabler [10].

To encourage support for performance measurement improvement

An organization can take several steps to encourage support for performance measurement improvement efforts based on the BSC concept within its organization [10], [11], [12]:

- Maintain communication at all levels.
- Develop organizational goals.
- Offer training in improvement techniques.
- Establish a reward and recognition system to foster performance improvements.
- Break down organizational barriers.
- Co-ordinate responsibilities.
- Demonstrate a clear need for improvement.
- Make a realistic initial attempt at implementation.
- Integrate the performance measurement system into the organization.
- Change the corporate culture.
- Institutionalize the process.

Some of the research in the literature on the BSC

The application of the BSC concept to IS activities

Many methods and techniques have been suggested over the years to evaluate the investments made in information technology (IT) and information system (IS). Traditional methods focus on well-known financial measures, such as the return on investment (ROI), net present value (NPV), the internal rate of return (IRR), and the payback period. These methods are best-suited to measure the value of simple IT applications, such as transaction processing and office automation systems.

Unfortunately, evaluation methods that rely on financial measures are not as well-suited for newer generations of IT applications. These computer-based IS typically seek to provide a wide range of benefits, including many that are intangible in nature. For example, it is difficult to quantify the full value of a decision support system or a knowledge-based system. So, there is a need for new approaches to measure and evaluate IT-related investments.

The BSC concept can be applied to measure, evaluate and guide activities that take place in specific functional areas of a business. It can even be used to shed greater light on performance at the individual project level. Maris, et al. [13] have illustrated the application of the BSC concept to IS activities. They develop a BSC framework to

measure and evaluate IT application projects and the IS department or functional area as a whole.

The BSC-for-IS framework they have presented is structurally similar to the BSC framework at the corporate management level. However, they have made substantial modifications to the perspectives and measures proposed by Kaplan and Norton. The changes stem from Maris and the others view that:

- The IS department is typically an internal (rather than external) service supplier.

And

- IS projects are commonly carried out for the benefit of both end-users and the organization as a whole (rather than individual customers within a large market).

They have suggested the following four perspectives for a balanced IS scorecard:

1. User orientation.
2. Business value.
3. Internal processes.
4. Future readiness.

They have proposed other modifications to the framework that is the reanalysis of the internal business/process perspective such that it focuses on efficiency.

They claimed that operational effectiveness more naturally belongs to the user orientation perspective, i.e., are we doing the right things and thereby satisfying customer needs. The relationships between them are illustrated in Fig5.

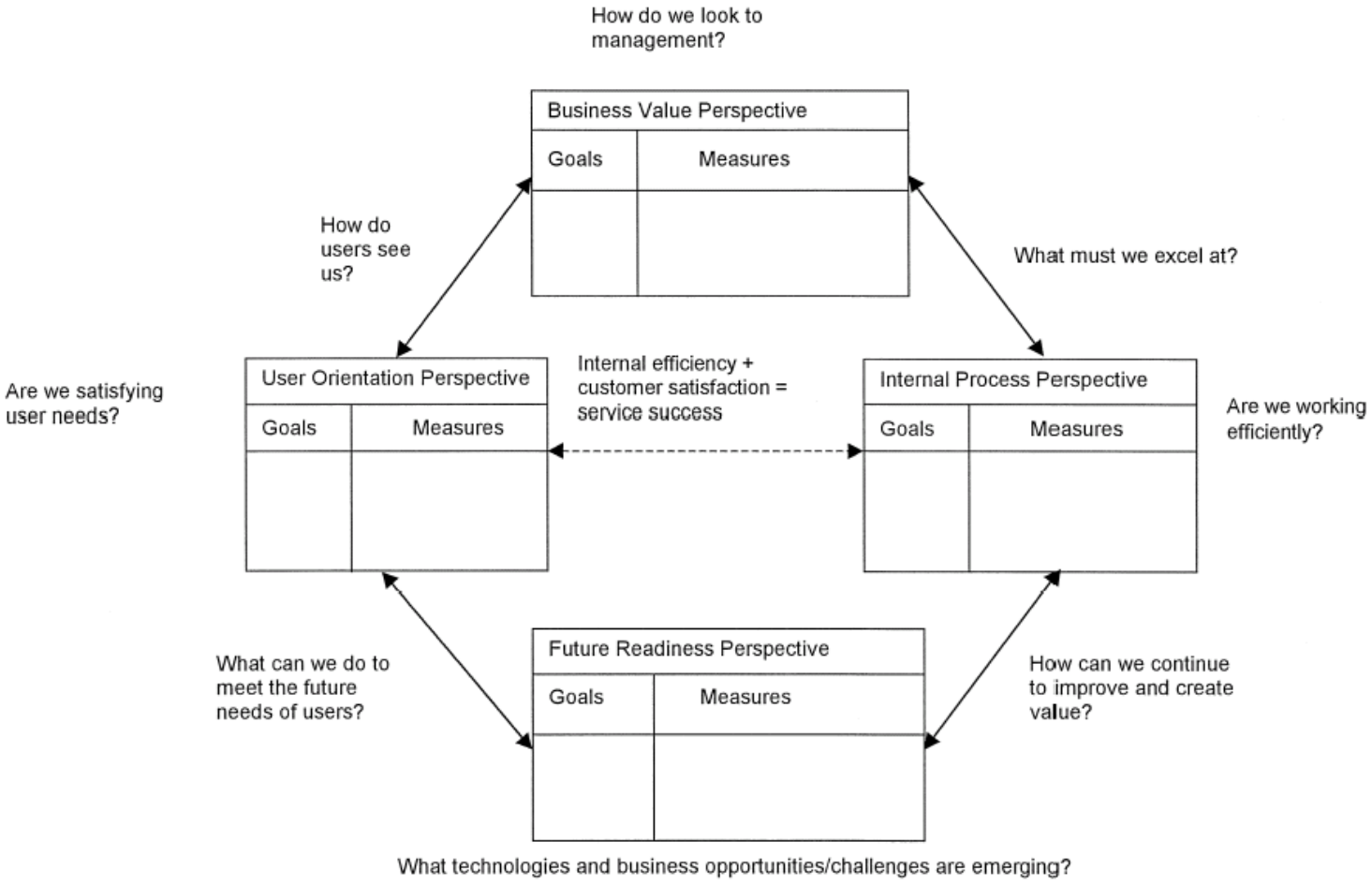

Fig5. Relationships between the four perspectives in the balanced IS scorecard

The approach they have presented augment the traditional IS, that focus on internal process and business value, with the user orientation and future readiness perspective.

Each of the four perspectives should be translated into corresponding metrics and measures that reflect strategic goals and objectives. The perspectives should be reviewed periodically and updated as necessary.

The metrics they have proposed are extracted from the mainstream IS management literature as well as the emerging literatures on information economics and IS success.

The balanced IS scorecard does not only integrate these different approaches; it also extends them in two important ways: (1) by adding a future readiness perspective

that incorporates concepts such as innovation and learning; and (2) by proposing that the monitoring and control of all the key measures be undertaken on an on-going basis.

Building a balanced IS scorecard

The following steps are recommended in building a company-specific balanced IS scorecard:

1. Create an awareness for the concept of the balanced IS scorecard among top management and IS management;
2. Collect and analyze data on the following items:
    - Corporate strategy, business strategy, and IS strategy.
    - Specific objectives and goals related to the corporate, business and IS strategy.
    - (Traditional) metrics already in use for IS performance measurement.
    - Potential metrics related to the four balanced IS scorecard perspectives.
3. Clearly define the company-specific objectives and goals of the IS department or functional area from each of the four perspectives;
4. Develop a preliminary balanced IS scorecard based on the defined objectives and goals of the.
5. Receive comments and feedback on the balanced IS scorecard from management, and revise it accordingly;
6. Achieve a consensus on the balanced IS scorecard that will be used by the organization; and
7. Communicate both the scorecard and its underlying rationale to all stakeholders.

The authors have observed the implementation of balanced IS scorecards in three large companies in Hong Kong. The evidence from these cases suggests that several common errors must be avoided when implementing this concept. Three of these errors are:

1. Failure to include specific long-term objectives;
2. Failure to relate key measures to performance drivers by means of cause-and-effect relationships.
3. Failure to communicate the contents of, and rationale for the balanced IS scorecard.

The effectiveness of a BSC for IS will be enhanced by including stretch goals that require significant improvements in key areas.

The proposed framework does represent a strategic IS management tool that can be used to monitor and guide specific projects as well as general performance improvement efforts.

The balanced IS scorecard will allow managers to see the positive and negative impacts of IT applications and IS activities on the factors that are important to the organization as a whole.

ICT-tailored scorecard for SIO

The Balanced IT Scorecard (BITS)

Some software organizations have recently tried to use the BSC for achieving better results. Thus, There have been a few attempts to build an ICT scorecard for Software Intensive Organizations (SIOs), such a scorecard is The Balanced IT Scorecard (BITS) [14] that was proposed by the European Software Institute (ESI).

The ESI has adapted and extended the principles of the Balanced Scorecard to provide a well-defined approach to quantitatively managing Software Process Improvement (SPI) programs in SIOs and to validate their effect on organizational business goals. The technology is specially oriented towards SIOs which are aimed at introducing a quantitive management system to monitor business performance and to support the decision-making process with quantitive evidence. It provides an easy-to-use and widely applicable method for quantitively managing SPI programs and validating their effect on organizational business goal. More specifically, BITS supports:

(a) The identification and prioritization of software process improvement needs derived from the organization's business goals.

(b) The agreement and communication of the business strategy among the SIO's manager, sponsor and software engineers, thereby strengthening the required commitment from all parties.

(c) The identification of the critical set of factors affecting the achievement of the SIO's business goals.

(d) The selection of the minimum set of indicators to monitor the performance of the software processes.

Therefore, BITS provides a new version of the four original perspectives and adds a fifth perspective. The five distinct perspectives of BITS, derived from the original scorecard, are:

- **Financial Perspective**: How do our software processes and SPIs add value to the company?
- **Customer Perspective**: How do we know that our customers (internal and external) are delighted with our product?
- **Process Perspective**: Are our software development processes performing at sufficiently high levels to meet customer expectations?
- **People Perspective**: Do our people have the necessary skills to perform their jobs and are they happy doing so?
- **Infrastructure & Innovation Perspective**: Are process improvement, technology and organizational infrastructure issues being addressed with a view to implementing a sustainable improvement program?

They have added a new fifth perspective, the People perspective. Personnel are the "prime material" of software development. The knowledge and experience of people represents a most important asset and should not be relegated to the infrastructure level. Competence, satisfaction and retention are the three drivers to reaching higher productivity levels [15].

Measurement of indicators in an ICT-BSC

A key issue that needs to be addressed in the design and implementation of a BSC for ICT companies is measurement of the software itself.

To build a BSC, once the overall strategic direction has been identified, Goals, Drivers and Indicators (GDI elements) must be selected for each perspective. The resulting tool of tailoring the BSC for the ICT world focused more on the structure of the framework (GD elements – Goals and Drivers – and perspectives used) than on the measures and indicators required to fill out the framework, that are defined as a content element, which must be specific to the selected drivers. That in return makes it difficult for organizations to operationalise the BSC in the ICT contexts.

Since the measurement of software functionality is significantly developing in the last 25 years, and now standardized at the ISO level. In this context, it is important to explore whether or not Functional Size Measurement could help operationalise a BSC in ICT organizations. [16]

LUIGI et al. have demonstrated in there paper that the usage of FSMs can have a wider on organizational issues, not only technical, properly fitting with the multi-dimensional philosophy of the BSC. They have attempted to identify which kind of contribution those software measures can provide in implementing an organizational framework such as an ICT BSC and which perspectives can be "touched" through the analysis of the main informative sources.

Functional size measures (FSM)

The field of software measurement has frequently been an arena where supporters of Functional Measurement Methods - Function Points, mainly – were opposed to supporters of Technical Measurement Methods – like the ones based on LOC, number of programs, modules, reports, screens, classes, objects, components, boxes, widgets etc.

Functional Size Measurement is a measure of the number of functionalities the software performers.

We might find an application which is very "large", functionally speaking, but which is relatively small in terms of technical items by which it is composed of (modules, programs, objects etc.) This can happen, for example, when the software application benefits from a significant level of reuse of technical items.

FSM has been used for a variety of purposes, such as quality assessment, benchmarking, "make vs. buy" decisions, outsourcing contracts and business process reengineering analysis. In 1992, IFPUG documented a wider approach to FSM usage.

Definition of FSM-based measures for ICT BSC

For the design of a generic ICT BSC with 5 perspectives a 3-step process was performed to analyze the content of the IFPUG document, map it to the BSC framework and then identify complementary measures to complete the required linkages to the underlying strategic dimension of a BSC:

1. Listing of the most relevant FSM-based measures and related audience(s).
2. Determination, for each measure, of the related candidate ICT BSC(Appendix A).

3. Determination of the ICT BSC most relevant perspectives for the use of a specific FSM-based measure.

In the table **of FSM-based measures for ICT BSC** various measures were classified in each of the five ICT BSC perspectives, and, in some instances, related goals/objectives and drivers and questions. Thy have used the IFPUG measures, and they have used additional derived measures that are defined to normalize other measures typically found in business contexts, but quite challenging to operationalise in ICT contexts.

Process (Pr) is the perspective impacted most in a direct way with the use of FSM-based measures, in terms of sizing, estimating and managing the software process.

Comparisons between the three approaches

The objective of the measurement activity in the BSC is the organization (an SIO in the IT field), while in GQM it is the project that is the object of measurement. In the CMM the maturity levels are based on the principles of product quality.

The GQM, BSC, and CMM are different in nature. The GQM can be defined as technique for obtaining and deriving quantitive measures from a list of goals. It is an important tool for data collection and analysis in process improvement. CMM is a framework for performance assessment, it aims at guiding software organizations in selecting process improvement strategies by first determining their current process maturity before identifying their organization's critical quality and process improvement issues. The BSC, on the other hand, can be viewed as a performance management framework. In fact the BSC is different from the other two approaches is that it is a multi-level management tool which helps an organization through the monitoring of four (or more) different perspectives which co-exist.

A third different is that the BSC takes into account the strategy of the organization. GQM by comparison, considers only the analysis of project data.

A GQM approach can be used for a project using the CMM framework to derive many of the goals for the analysis, and questions directly from the key process areas and practices. In the BSC, GQM-like technique is used to derive the indicators, but this represents just one element of the framework.

Conclusion

In this report I have presented three approaches that have been advocated for the systematic design and introduction of software metrics for the purpose of process improvement and capability assessment in an organization.

I have presented the Goal Question Metric Paradigm (GQM), which is a mechanism for defining and interpreting operational and measurable software goals. It works by translating goals into questions and those questions in turn are answered using metrics. One of the drawbacks with this approach is the difficulty deriving a good set of questions that will allow the organization to collect the most important and useful metrics.

I also gave a description of a "common sense engineering" approach to software process improvement, that is the Capability Maturity Model (CMM). The CMM describes the principles and practices underlying software process maturity and is intended to help software organizations improve the maturity of their software processes in terms of an evolutionary path from ad hoc, chaotic processes to mature, disciplined software processes.

An overview of a multi-level management tool, which is the Balanced Scorecard (BSC) framework is presented. The key characteristics and variants for the IS and IT field are described. An indicator measurement for the ICT world Balanced Scorecard is introduced. A comparison between the three approaches is presented in the last section of this report.

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Appendix

	GOAL/OBJECTIVE	DRIVER	INDICATOR	COMMENTS / EFFECTS
FINANCIAL (F)				
	Asset Management	Existing asset utilisation	• Total Assets (FSAV) / # employees ($)	
			• **FSAV – FS_{units} Asset Value**	
			• **PS – Portfolio Size**	
	Revenue & Profitability	Revenue Growth	• Revenues / FSAV (%)	
		Growth	• Revenues from new customers / Total Revenues (%)	• *New customers acquired using FSM as a contractual condition for measuring the project – Derived (Improve project governance)*
		Profitability	• Profits / FSAV (%)	
	Financial Management	Organisational Investments	• Investments in IT	
		Project Investments	• **PCFS – Project Cost per FS_{unit}**	
			• **ECFS – Enterprise Cost per FS_{unit}**	
			• **AMCFS – Application Maintenance Cost per FS_{unit}**	

Table 1 – *FSM-based measures: Financial Perspective*

	GOAL/OBJECTIVE	DRIVER	INDICATOR	COMMENTS / EFFECTS
CUSTOMER (C)				
	Customer partnership and involvement	Collaboration	• % projects using integrated teams	
			• **SR – Stability Ratio**	
	Customer satisfaction	SLA	• % SLA met	• *if the agreement uses FSM as a basis for the contract*
	Business Process Support	Innovation usage	• % IT solutions supporting process improvement projects	• *project measurement using FSM*
		Requirements Management	• Requirement Turnover Index [MELI01] $RTI = [(\Sigma_j CRFS_j)/ \text{Final } FS_{units}] * 100$ • CRFS = Change Request Function Size units	• *Showing the level of turbulence in requisites during the development phase*
		Problem Management	• **DR – Defect Ratio**	
			• **AR – Application Reliability**	
	Business Growth	Market Share	• % Market share	• *increasing % using FSM as an initial contract condition*

Table 2 – *FSM-based measures : Customer Perspective*

	GOAL/OBJECTIVE	DRIVER	INDICATOR	COMMENTS / EFFECTS
PROCESS (PR)				
	Application Development & Maintenance	Size	• **FS_{unit} – Functional Size unit,**	*According to the FSM method used, it can be expressed for instance by:* • ***FP** – Function Points* • ***C_{fsu}** - COSMIC functional size units –*
			• **PS – Portfolio Size**	
		Effort	• **WE – Work Effort**	
		Productivity	• **PDR – Project Delivery Rate**	
			• **EP – Enterprise Productivity**	
		Support	• **ASR – Application Support Rate**	
			• **DDR – Duration Delivery Rate**	
			• **AMPL – Application Maintenance Load per Person**	
		Defectability & Test	• **RCR – Repair Cost Ratio**	
			• **SR – Stability Ratio**	
			• **DR – Defect Ratio**	
			• **TPR – Testing Proficiency Ratio**	
			• **MTTR – Mean Time To Repair ratio**	
			• **AR – Application Reliability**	
			• **DER – Defect Detection Ratio**	
			• # defects / 100 FS_{unit} according to user acceptance	
		Reuse	• **FR – Functional Reuse %**	
			• **TR – Technical Reuse %**	

Table 3 – *FSM-based measures : Process Perspective*

	GOAL/OBJECTIVE	DRIVER	INDICATOR	COMMENTS / EFFECTS
PEOPLE (PE)				
	Core Competencies & Skills	Core Competencies & Skills	• Feedback from FSM-based courses (I&I)	
		Effects of Training	• **DER – Defect Detection Ratio**	

Table 4 – *FSM-based measures : People Perspective*

	GOAL/OBJECTIVE	DRIVER	INDICATOR	COMMENTS / EFFECTS
INNOVATION & INFRASTRUCTURE (I&I)				
	Workforce Improvements	Workforce Competency and development	• IT expended on Training / IT expenses (%)	• *Leverage on the increased forecasting ability of Project Managers (Process perspective) and on their increased satisfaction (People perspective)*
			• % of staff trained in relevant standards or new technologies	• *Training in functional measurement for planning and governance*
			• % employees skilled in advanced application measurement methods	
		Tools & Products	• Investment in new product support and training ($)	• *For FSM-based tools or for courses about FSM-based techniques*
	SPI Improvements	Methodology currency	• % projects measured using recognised methods	
		Support	• **PDR – Project Delivery Rate**	
			• **ASR – Application Support Rate**	
			• **DDR – Duration Delivery Rate**	
			• **AMPL – Application Maintenance Load per Person**	
			• **RCR – Repair Cost Ratio**	

Table 5 – *FSM-based measures: Innovation & Infrastructure Perspective*