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Goals/Questions/Metrics Method and SAP Implementation Projects

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Abstract

During the last years some researchers have studied the critical success factors (CSFs) in ERP implementations. However, until now, no one has studied how these CSFs should be put in practice to help organizations achieve success in ERP implementations. This technical research report attempts to define the usage of Goals/Questions/Metrics (GQM) approach in the definition of a measurement system for ERP implementation projects. GQM approach is a mechanism for defining and interpreting operational, measurable goals. Lately, because of its intuitive nature the approach has gained widespread appeal. We present a metrics overview and a description of GQM approach. Then we provide an example of GQM application for monitoring sustained management support in ERP implementations. Sustained management support is the most cited critical success factor in ERP implementation projects.

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1 Introduction

The management of Enterprise Resource Planning (ERP) systems implementations is a thorny issue. Most cases of failure have been reported (Davenport 1998, Scott 1999). During the last years some researchers have studied the critical success factors (CSFs) in ERP implementations (eg. Bancroft et al. (1997), Brown and Vessey (1999), Clemons (1998), De Bruin (1997), Dolmetsch et al. (1998), Gibson and Mann (1997), Holland et al. (1999), Parr et al. (1999), Stefanou (1999) and Sumner (1999), Esteves and Pastor (2000)). However, until now, no one has studied how these CSFs should be put in practice to help organizations achieve success in ERP implementations.

The implementation of ERP systems ties up substantial corporate resources for a relatively long period of time. Generally, a company can therefore not afford to have an attempt fail. Efficient planning and execution of the implementation are very important to achieve success. Nowadays, views as: 'if you cannot measure it you cannot manage it', 'what gets measured gets done', or 'you need to know the score to win', are common views about the virtues of measurement in management. In Relation to ERP implementation projects, Radosevich (1999) mentions that "there is no substitute for a stellar project manager. But even the most experienced hands benefit from methodical measurements that let them spot variances and act before problems spiral out of control".

This technical research report attempts to define the usage of Goals/Questions/Metrics (GQM) approach in the definition of a measurement system for ERP implementation projects. GQM approach is a mechanism for defining and interpreting operational, measurable goals (Basili and Rombach 1988). Because of its intuitive nature the approach has gained widespread appeal. The fundamental idea is a simple one, managers proceed according to the following three stages (Basili and Rombach 1988):

- Set goals specific to needs in terms of purpose, perspective and environment.
- Refine the goals into quantifiable questions that are tractable.
- Deduce the metrics and data to be collected (and the means for collecting them) to answer the questions.

This report is structured as follows. First we present a metrics overview. Then we describe the GQM approach. Next, we propose a research framework to develop a measurement model for ERP implementation projects. Then, we describe in detail the definition step, the main step of GQM method, where the measurement model is developed. Next, we apply GQM approach to one critical success factor in ERP implementations, sustained management support and we present the GQM preliminary plan. Finally, we present some considerations.

2 Metrics Overview

2.1 Definition

A review of the literature on metrics and measurement showed there are many definitions of these terms. Some definitions of measurement:

- According to (Ellis 1966, p. 41) measurement "is the assignment of numerals to things according to any determinative non-generate, rule". Determinative means the constant assignment of numerals given constant conditions. Non-generate means allowing for the possibility of assignment of different numerals under varying conditions.
- According to Fenton and Hall (1997), "measurement is the process by which numbers or symbols are assigned to attributes of entities in the real world in such a way as to describe them according to clearly defined values" and that "we define measurement as a mapping from the empirical world to the formal, relational world".
- According to (Mendonça et al. 1998), measurement is "the process of assigning a value to an attribute and a metric is the mapping model used to assign values to a specific attribute of an entity class". A metric states how we measure something. It usually includes a measurement instrument, a value domain, and a scale.
- According to (DeMarco 1982) a metric is "a measurable indication of some quantitative aspect of a system. For a typical software endeavor, the quantitative aspects for which we most require metrics include scope, size, cost, risk, and elapsed time".
- According to (Bullen and Rockart 1981) measures “are specific standards which allow the calibration of performance for each critical success factor, goal, or objective”.

- According to Birch (2000) measuring "is the act of assigning numbers to properties or characteristics. You measure to quantify a situation, to regulate or to understand what affects things you see".
- According to Neely et al. (1996) performance measurement is the process of quantifying the efficiency and effectiveness of action. Effectiveness refers to the extent to which customer requirements are met, while efficiency is a measure of how economically the resources are used when providing a given level of customer satisfaction (Neely et al. 1996).

In our research we will follow the definition of Fenton and Hall (1997), because it is the more accurate definition that we found. Even though it is easily recognized that measuring performance is an important part of management, it can be difficult to select measurements that are consistent, acceptable, reportable, and meaningful. It is generally accepted that measurement is not an end in itself but a means to an end. The final objective must be improvement and measurement should be viewed as an infrastructure technology which is necessary to achieve systematic improvement. According to (Dymond 1995), metrics can be used to measure the status of activities, take a process view, and gauge the contribution of project management to the organization.

2.2 Types of Metrics

Metrics can be used for a number of different purposes. Such purposes can range from determining current performance levels to predict future ones to carefully controlling an existing process. Depending on the purpose, we can find different types of measures. A lot of categorizations and examples of metrics can be found in literature, some examples are (Conte et al. 1986, Hunter 1990, Grady 1992, Fenton and Pfleeger 1997, Pfleeger et al. 1997):

- Product and process metrics
- Objective and subjective metrics
- Direct and indirect metrics
- Explicit and derived metrics
- Absolute and relative metrics
- Dynamic and static metrics
- Predictive and explanatory metrics

The most common types of metrics are described below.

2.2.1 Product and Process Metrics

Generally within a software development project, software metrics can be classified into process metrics and product metrics (Conte et al. 1986, Hunter 1990):

- *Process metrics* quantify attributes of the development process and the development environment such as the number of defects found throughout the process during different kinds of reviews.
- *Product metrics* measure attributes of the software product. They focus on software requirements, design, or source code. Examples of such metrics are a size metric for the number of requirements, a complexity metric for the software code, etc.

2.2.2 Objective and Subjective Metrics

Objective metrics are absolute measures taken of the process or product, and count attributes or characteristics in an objective way (Humphrey 1989), such as number of lines of code, number of faults discovered. These metrics have a fundamental starting point, a natural zero.

Subjective metrics are measurements of a process or product that involve human, subjective judgement. Examples of subjective metrics are expected complexity and degree of conformance to coding standards. These measurements are classifications of observations.

2.2.3 Direct and Indirect Metrics

A direct metric is a measurement of a process or product characteristic that does not depend on the measurement of any other characteristic. Examples are the number of faults in a product, number of hours spent during certain process, etc.

An indirect metric, is a measurement of a process or product characteristic that involves the measurement of one or more other characteristics, such as productivity, fault density, etc. An indirect metric always contains a calculation of at least two other metrics.

2.3 Metrics in Project Management

Florac et al. (1997) determined specific characteristics of metrics in project management: performance, stability, capability, and improvement.

2.3.1 Performance Metrics

Performance measures or sometimes called performance indicators, are one of the multiple types of measures that exist (see section 2.3). According to O'Hara (2000), "metrics in this category emphasize performance to show the ability to deliver products and services with the qualities, timeliness, and costs that customers require". According to (Birch 2000, p. 5), a performance measure "is composed of a number and a unit of measure. The number gives us a magnitude (how much) and the unit gives the number a meaning (what). Performance measures are always tied to a goal or an objective".

According to Harbour (1997, p. 7) a performance measurement "is the process of measuring work accomplishments and output, as well as measuring in-process parameters that affect work output and accomplishments". Related with performance measurement is the concept of key performance factors and/or key performance indicators. Harbour defines key performance factors as those performance variables "that are especially critical in achieving a desired set of outcomes. Key performance factors are normally associated with customer expectations".

2.3.2 Other Metrics

- **Stability Metrics** - "Stability is central to each organization's ability to produce products and deliver services according to plan and to improve processes with better and more competitive products and services as the end result" (O'Hara 2000).
- **Compliance Metrics** - "Compliance means that the project management standards of knowledge and practice exist and are followed. It assesses adherence to the process; fitness and use of people, tools, technology, and procedures; and fitness and use of support systems and organizational factors, such as management support" (O'Hara 2000).
- **Capability Metrics** - "Capability is a necessary characteristic to see if performance satisfied customer requirements and whether it meets

business needs; any variations then need to fall within ranges required for business success. Project management should have predictable results" (O'Hara 2000).

- **Improvements Metrics** - "improvement metrics focus on the performance of the project management process. How can project management help move the organization to a level of greater profits? What are ways to determine if project management is working successfully throughout the organization, and if the changes that have been introduced are effective? In order to promote improvements, people must understand the business goals and strategies of the organization and also the priorities, risks, and issues associated with these goals and strategies" (O'Hara 2000).

2.4 Metric Scales

(Pfleeger et al. 1997, p. 35) described the different scales of measurement:

- Nominal scale – puts items into categories.
- Ordinal scale – ranks items in an order.
- Interval scale – defines a distance from one point to another, so that there are equal intervals between consecutive numbers.
- Ratio scale – information is presented in ratios and incorporates an absolute zero.

2.5 Key Performance Indicators

According to (KPIs manual, p. 10) Key performance indicators (KPIs) "represent a set of measures focusing on the aspects of organizational performance that are most critical for the current and future success of the organization". These performance variables are especially critical in achieving a desired set of outcomes. Key performance indicators (or factors) are normally linked to core products and services and associated customer expectations (Harbour 1997). In our research we adopt the concept of key performance indicators. The focus of KPIs, therefore is either on the aspects of organizational performance that require improvement or on the aspects that must be kept within a specified level to ensure the success of the organization, or in our case, the success of and ERP implementation project.

2.6 Reasons to Measure

Metrics vary enormously from project to project, but there are heuristics that are fairly universal. Those projects that have a measurement system have the advantage of more informed and timely decisions that will ultimately make them more successful. Measurement helps to understanding the effects of actions that are implemented in an ERP implementation project. According to (Basili and Rombach 1987) "metric based scheduling helps project teams make commitments; metric-based management helps project teams meet commitments.
To meet commitments, teams require right tools, processes, and methods as well as the capability to uncover and mitigate potential threats". Examples of results in the case of a development process are (Möller and Paulisch 1993, Pfleeger 1991):

- Increased understanding of the software development process;
- Increased control of the software development process;
- Increased capacity to improve the software development process;
- More accurate estimates of software project costs and schedule;
- More objective evaluations of changes in technique, tool, or methods;
- More accurate estimates of the effects of changes on project cost and schedule;
- Decreased development costs due to increased productivity and efficiency;
- Decrease of project cycle time due to increased productivity and efficiency;
- Improved customer satisfaction and confidence due to higher product quality.

Although these results are defined to software development processes, we empirically think that the same can be applied to software implementation processes. Birch (2000, p. 6) presents a list of seven benefits that result from the implementation of effective measurements. They are:

- "**Client intimacy** - measurements identify whether you are meeting client requirements. How do you know that you are providing the services and products that your clients require?
- **Establishment of knowledge limits** - measurements help you understand your processes, and confirm what you know and reveal what you do not know. Do you know where the problems are?

- **Improvement in decision making** - measurements ensure decisions are based on fact, not on emotion. Are your decisions based upon well-documented facts and figures, or on intuition and gut feelings?
- **Improvement in initiatives** - measurements show where improvements need to be made. Where can do you have a clear picture?
- **Monitoring of business performance** - measurements show if improvements have actually happened. Do you have a clear picture?
- **Uncovering of problems** - measurements reveal problems that bias, emotion and longevity cover up. If you have been doing your job for a long time without measurements, you might assume incorrectly that things are going well. (They may or may not be, but without measurements there is no way to tell).
- **Improvement of supplier performance** - measurements identify whether suppliers are meeting your requirements. Do your suppliers know if your requirements are being met?".

Iversen and Kautz (2000) present a set of key elements for the implementation of a metrics programs based in their experience and literature review (see fig nº. 1).

Area	Principle
Knowledge	Use improvement knowledge Use organizational knowledge
Organization	Establish a project Establish incentive structures
Design	Start by determining goals Start simple
Communication	Publish objectives and collected data widely Facilitate debate
Usage	Use the data

Fig. 1. Summary of key elements for the implementation of metrics programs.

Birch (2000) also presents some principles of a successful performance measurement system:

- Measure only what is important. Do not measure too much; measure things that impact client satisfaction.
- Focus on the needs of the client. You should ask your clients if they think this is what you should measure.
- Involve employees in the design and implementation of the measurement system. Give them a sense of ownership. This improves the quality of the measurement system.

According to (KPIs manual, p. 43), "the major contribution of KPIs at the team level is that they generate ownership of the improvement process. When a team of employees have established their own KPIs, within the broad context provided by the CSFs, they have declared what they believe is important". In addition to this benefit, team KPIs help employees:

- To clarify their team's objectives
- Set team goals or targets
- Provide a basis upon which to share roles and responsibilities within the team
- Focus on key processes for potential improvement
- Identify problem areas and determine improvement priorities
- Measure the success of their actions
- Provide a basis for recognizing and celebrating team achievements.

2.7 What Should Be Measured?

The typical dilemma confronting anyone introducing KPIs is determining what should be measured. In essence, effective KPIs target the critical issues confronting an organization and provide information that can be used to improve processes and performance. Too many KPIs - or conflicting indicators - can actually inhibit performance improvement. According to (KPIs manual) "before you can begin to select what should be measured by KPIs, you must be clear on what aspects of your organization's performance are critical for success in the context of the vision".

An important aspect is to keep things simple an easy to understand. Pfleeger (1993) mentions that people who collects the metrics need to know the relationship between the measurements they are collecting and the problems to be solved, "the greater the distance from measurement to problem, the less likely developers are to use the measurement" (Pfleeger 1993, p. 73). She also refers that if a problem can be understood with one piece of data instead of several, so much the better.

An important guideline that KPIs manual gives is that we must promote KPIs that measure key processes and outcomes. This guideline emcompasses the idea of measuring outcomes as well as performance in key processes that the project team impacts. As recommend by KPIs manual, when developing outcome indicators, it is best to measure KPIs of a total process that overlaps individual departments or functions.

Finally, KPIs manual mentions that there is no perfect number of KPIs. What you need to consider is (KPIs manual, p. 165):

- Have we introduced KPIs that cover all these CSFs?
- Can we easily sustain the number of KPIs we are proposing to use?
- Is each particular KPI in fact providing useful information that the team can use to analyze and improve the key processes for which they are responsible?

2.7.1 Guidelines for KPIs selection

KPIs manual presents a set of guidelines to develop and select KPIs:

1. **Resourcing the process** - "teams can select their own KPIs by reviewing what they do that affects the organization's critical success factors. However, to be successful, they will need training and assistance. Management's leadership role requires them to adequately resource the process".
2. **Encourage a balance in team KPIs** - "if the CSFs are clearly defined and related to the four aspects of organizational performance (customer focus, financial performance, people and innovation), then team KPIs developed in this context will generally reflect the required balance".
3. **Promote KPIs that measure processes and outcomes** - "this guideline encompasses the idea of measuring outcomes as well as performance in key processes that the team impacts. For example, a team in a service organization may be measuring customer satisfaction through survey methods".
4. **Permit KPIs to evolve** - "virtually no team will achieve a perfect set of KPIs at its first or even its second attempt. Further, once a set of KPIs exists, individual indicators may need to vary as the team improves performance and then moves on to other problem areas".
5. **Practicality, not perfection** - "encourage teams to pursue KPIs that:
    - Provide substantially valid information, given the collection processes available - that is, consistent accuracy - not absolute accuracy.
    - Encourage people to do positive things, as well as discouraging negative practices (e.g. measure things the team should try to do, instead of only things they should avoid such as errors or complaints.

- Provide a reasonable cost-benefit return (information is available in a time frame that allows corrective action to be taken, but does not require inordinate resources to collect or process."

6. **Never lose sight of ownership** - "remember that the overriding purpose of team KPIs is to assist and help the team to improve their performance. It follows that their KPIs represent what they want to collect in order to contribute to improvement in the identified CSFs".
7. **A limited, manageable number of KPIs** - "as a guide, a dozen KPIs is probably the upper limit of KPIs that a team should select four regular use. More than this number may lead to resource problems and loss of focus. In each case, the right number for a given team will depend on its size, its membership and the assistance available from existing information systems".
8. **Build the integrated system of kpis from the ground up** - "if it is your intention to develop KPIs in an integrated fashion at the four levels of your organization, start the process at the team level, then move to the global level, and then complete the development of KPIs at the divisional or departmental levels".

Next, we describe in detail GQM approach. The description is based mainly in the book of Solingen and Berghout (1999) and Basili and Rombach articles.

3 GQM Approach Overview

The GQM approach is a specific approach for goal-oriented measurement in software projects. It consists of three components:

- The GQM paradigm includes the basic idea that measurement should be goal-oriented as well as several principles to be followed when applying GQM-based measurement.
- A GQM plan or GQM model documents the refinement of a precisely specified measurement goal via a set of questions into a set of metrics. Thus, a GQM plan documents which metrics are used to achieve a measurement goal and why these are used - the questions provide the rationale underlying the selection of the metrics. On the other hand, the GQM plan is used to guide analysis tasks because it documents for which purpose the respective data were collected. Note: the terms GQM plan and GQM model are used as synonyms in the literature; we will use the term GQM plan here.
- The GQM method provides guidance for how to set up and perform GQM-based measurement programs.

3.1 Definition

GQM approach is a mechanism that provides a framework for developing a metrics program. It was developed at the University of Maryland as a mechanism for formalizing the tasks of characterization, planning, construction, analysis, learning and feedback. The GQM method was originally developed by V. Basili and D. Weiss, and expanded with many other concepts by D. Rombach. GQM is a result of many years of practical experience and academic research. It uses four parameters:

- A model of an object of study -e.g., a process, product, or any other experience model.
- A model of one or more focuses - e.g., models that view the object of study for particular characteristics.
- A point of view - e.g., the perspective of the person needing the information.
- A purpose - e.g., how the results will be used.

3.2 GQM Paradigm

The GQM paradigm is based on the idea that measurement should be goal-oriented, i.e. all data collection in a measurement program should be based on a rationale which is explicitly documented. This approach has several advantages:

- It helps in the identification of useful and relevant metrics as well as in the analysis and interpretation of collected data.
- It enables an assessment of the validity of the conclusions drawn and avoids resistance against measurement programs.

To yield these advantages GQM-based measurement programs should be set up and performed according to the following principles:

- the analysis task to be performed must be specified precisely and explicitly
- (explicit measurement goal)
- each metric must have an underlying rationale which is explicitly documented;
- the rationale is used for justifying data collection and for guiding data analysis and interpretation
- the people from whose viewpoint the measurement goal is formulated must be deeply involved in the set-up and execution of the measurement program
- (they are the real experts with respect to the analysis task at hand).

3.3 GQM Plan

A GQM plan documents the operational refinement of an analysis task. The task is precisely specified as a measurement goal which is refined via questions into metrics. The resulting hierarchical structure is shown in the figure below. Its three layers correspond to the three levels which are described due to (Basili et al 1994):

- Conceptual level: 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.
- Operational level: A set of questions is used to define in a quantitative way the goal and to characterize the way the specific goal is going to be interpreted. Questions try to characterize the object of measurement with

respect to a selected quality issue and to determine its quality from the selected point of view.
- Quantitative level: A set of data is associated with every question in order to answer it in a quantitative way.

Templates exist for the definition of a measurement goal and for structuring GQM plans by grouping questions according to predefined categories (Rombach 1991), (Basili 1992). CSFs are "the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization" (Rockart 1979) and goals should be used to determine whether a project has effectively implemented the critical areas.

The goal defines:
- which object is analyzed,
- the purpose of the analysis,
- the quality focus (i.e. the properties or qualities of the object to be analyzed),
- the viewpoint from which the analysis is to be done, and
- the environment of the analysis (e.g. the organization, the project, process model used).

The figure below shows the relationship between the two major question categories and the measurement goal. One major question category contains questions defining the quality focus of the measurement goal (labeled "quality model" questions in the figure 2). The other major category contains questions providing information on the object in a broader sense which is assumed to have an influence on the quality focus of the object (labeled "influencing factors" questions in the figure 2).

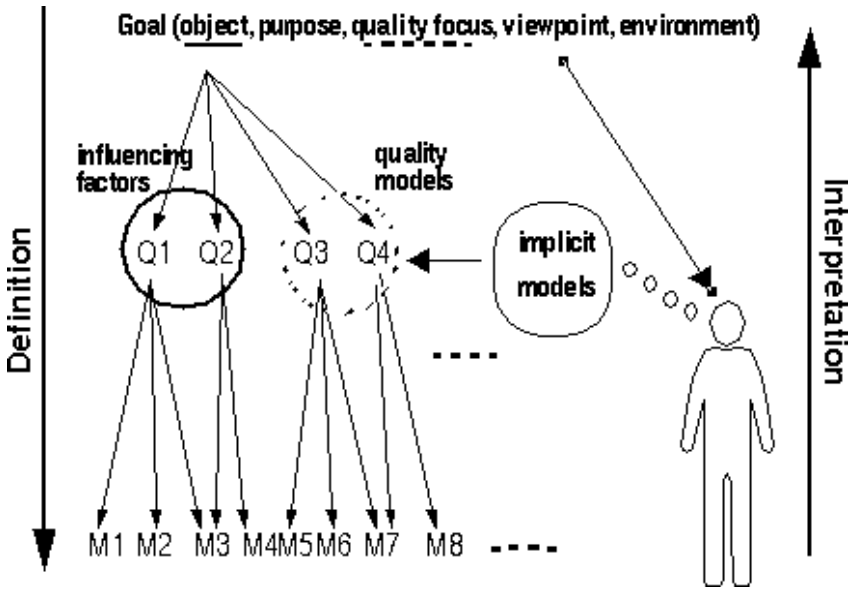

Fig. 2. GQM hierarchy (source Basili and Weiss 1984).

Deep involvement of the people specified in the viewpoint of the goal means that the implicit models of the respective persons are made explicit in the GQM plan.

3.4 GQM Method

The GQM method contains four phases:

- The planning phase, during which a project for measurement application is selected, defined, characterized and planned, resulting in a project plan.
- The definition phase, during which the measurement program is defined (goal, questions, metrics, and hypotheses are defined) and documented.
- The data collection phase, during which actual data collection takes place, resulting in collected data.
- The interpretation phase, during which collected data is processed with respect to the defined metrics into measurement results, that provide answers to the defined questions, after which goal attainment can be evaluated.

Next section describes in detail each phase of the GQM method.

4 GQM Method Stepwise

Fig nº. 2 shows the phases of GQM method. Next we will describe in detail each phase.

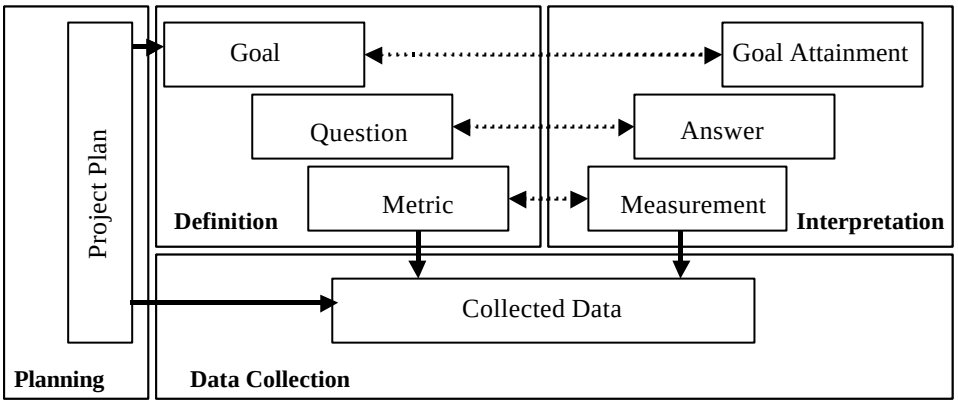

Fig. 3. The Four Phases of the Goals/Questions/Metrics Method (source: Solingen and Berghout 1999).

4.1 Planning Phase

The primary objectives of the planning phase are to collect all required information for a successful introduction, and to prepare and motivate members of an organization for a measurement program. A project plan is an important deliverable of a planning phase. Such a project plan documents procedures, schedules and objectives of a measurement program and provides a basis for promotion to and acceptance by management. Project plan should also contain a training of the developers involved. The planning phase consists of five steps which are:

- Establish GQM team
- Select improvement area
- Select application project and establish project team
- Create project plan
- Training and promotion

4.2 Definition Phase

This section describes the definition phase of GQM method. The definition phase is the second phase of the GQM method and concerns all the activities that should be performed to formally define a measurement program (Solingen and Berghout 1999). During this phase three documents are produced: GQM plan, measurement plan, analysis plan. These three plans contain all pertinent information regarding the measurement program. To complete the definition phase, Solingen and Berghout (1999) propose an eleven-step procedure. Next, we transcribe the eleven steps of GQM definition phase from Solingen and Berghout (1999):

Step	Deliverable(s)
Define measurement goals	List of GQM measurement goal specifications.
Review or produce software process models	Approved process models, suitable to identify measurements.
Conduct GQM interviews	Set of interviews reports and abstraction sheets.
Define questions and hypotheses	List of measurement questions and hypotheses, defined with respect to the measurement goals.
Review questions and hypotheses	List of approved measurement questions and hypotheses.
Define metrics	List of metrics suitable for supplying information to answer the questions.
Check metrics on consistency and completeness	Consistent and complete definitions of questions and metrics related to the measurement goals. Process models that are consistent and complete with the measurement goals, questions, and metrics.
Produce GQM plan	Preliminary GQM plan.
Produce measurement plan	Preliminary measurement plan
Produce analysis plan	Preliminary analysis plan.
Review plans	Approved GQM plan, measurement plan, and analysis plan.

4.3 Define Measurement Goals

The first step in the definition process is the definition of forma measurement goals. According to (Mendonça et al. 1998), a measurement goal is "an operational, tractable description of a user group in using the data". These measurement goals are derived from the improvement goals which were already identified in the preceding planning phase and are described in the

project plan. In our case, they will be derived from the CSFs by Esteves and Pastor (2000).

Measurement goals should be defined in an understandable way and should be clearly structured. For this purpose, templates are available that support the definition of measurement goals by specifying purpose (what object and why), perspective (what aspect and who), and context characteristics (Basili et al 1994). This template is illustrated in fig 5.

Analyze	The object under measurement
For the purpose of	Understanding, controlling, or improving the object
With respect to	The quality focus of the object that the measurement focuses on
From the viewpoint of	The people that measure the object
In the context of	The environment in which measurement takes place

Fig. 4. GQM goal definition template (Basili et al. 1994).

For instance,

Analyze	An ERP implementation project
For the purpose of	Understanding and controlling
With respect to	Adequate training plan
From the viewpoint of	Project team and end-users
In the context of	The company that implements the ERP system

A mechanism to support goal definition and selection in a meeting, is by asking 'seven questions' stated below:

1. What are the strategic goals of your organization?
2. What forces have an impact on your strategic goals?
3. How can you improve your performance?
4. What are your major concerns (problems)?
5. What are your improvement goals?
6. How can you reach your improvement goals?
7. What are possible measurement goals, and what are their priorities?

4.4 Review or Produce Software Process Models

In the case of a SAP implementation, the process model is the best practices model that SAP has. We also have the process model that an organization wants to implement and is developed in the second phase of SAP implementation project, the business blueprint phase.

4.5 Conduct GQM Interviews

To extract the knowledge from the project team with respect to the defined measurement goals, the GQM team should conduct structured interviews with the individual members. The interviews aim at capturing the definitions, assumptions and models of the project team related to the measurement goals, and therefore, the main purpose of these interviews is to make the implicit knowledge of the project members explicit.

4.5.1 Using Abstraction Sheets

To support the communication between a GQM team and a project team during interviews, a GQM team uses so-called 'abstraction sheets' (Latum et al. 1998). The use of abstraction sheets during interviews provides a structured approach to focus on relevant issues regarding the goal, and prevents issues being overlooked. An abstraction summarizes the main issues and dependencies of a goal as described in a GQM plan and is discerned in four sections. The four sections of an abstraction sheet are:

- Quality focus: what are possible metrics to measure an object of a goal, according to the project members?
- Baseline hypothesis: what is the project member's current knowledge with respect to these metrics? His or her expectations are documented as 'baseline hypotheses' of the metrics.
- Variation factors: which (environmental) factors does a project member expect to be of influence on the metrics?
- Impact on baseline hypothesis: how could these variation factors influence the actual measurements? What kind of dependencies between the metrics and influencing factors are assumed?

4.6 Define Questions and Hypotheses

With respect to the measurement goals, questions should be defined to support data interpretation towards a measurement goal. As goals are defined on an abstract level, questions are refinements of goals to a more operational level, which is more suitable for interpretation. By answering the questions, one should be able to conclude whether a goal is reached. Therefore, during questions definition, checks should be performed as to whether the definition questions have the ability to support conclusion of the goal in a satisfactory

way. For each question, expected answers are formulated as hypotheses. Hypotheses are formulated to increase the learning effect from measurement.

4.7 Review Questions and Hypotheses

To make sure that the right questions and hypotheses have been captured and correctly formulated, they should be reviewed. The questions are the basic translation from goals to metrics. When the data will be collected and presented to a project team, it should help in answering the questions of the project team. So, the questions take a central role, not only during definition, but also during interpretation.

4.8 Define Metrics

This step corresponds to the development of metrics that provide all the quantitative information to answer the questions in a satisfactory way (Solingen and Berghout 1999). After all the metrics have been measured, sufficient information should be available to answer the questions.

4.9 Check Metrics on Consistency and Completeness

The defined goals, questions, and metrics must be consistent and complete with respect to the models of the object under measurement. Special focus should be given to definitions and metrics should be analyzed if they are in fact possible to measure.

4.10 Produce GQM Plan

A GQM plan is a document that contains the goals, questions, metrics and hypotheses for a measurement program as defined in the previous steps. The GQM plan serves as a guideline for data interpretation, and provides the basis for the subsequently developed measurement plan and the analysis plan. The GQM plan describes the refinement from the measurement goals into questions and subsequently from questions into metrics. As some of these metrics may be indirect metrics, it also describes all direct metrics that should be collected for each indirect metric.

4.11 Produce Measurement Plan

A measurement plan describes the following aspects of each direct measurement that was identified in a GQM plan:

- It provides formal definition of direct measurements.
- It provides textual descriptions of direct measurements.
- It defines all possible outcomes (values) of the direct measurements.
- It identifies a person that collects a particular direct measurement, i.e. a program, engineer, project manager, tester, etc.
- It defines the particular moment in time when the person should collect the direct measurement.
- It defines by which medium (tool or form) that person should collect the direct measurement.

Furthermore, a measurement plan defines and describes both manual data collection forms and automated data collection tools.

4.12 Produce Analysis Plan

An analysis plan is a document that simulates data interpretation according to the GQM plan before actual measuring starts. Simulated outcomes of the metrics, graphs and tables are presented in this document that are related to the questions and goals as defined in the GQM plan. Again, its emphasized that the data should be presented in such a way that interpretation by the implementation team is facilitated.

4.13 Review Plans

The review plan should focus on:

- Do project members agree upon the defined goals, questions and metrics?
- Do project members identify any missing or unnecessary definitions?
- Do project members agree with the proposed definition of feedback material?

This means that review sessions focus more on the contents of the GQM plan and analysis plan, than on the measurement plan. Accordingly to Solingen and Berghout (1999), "the most important part of the measurement plan to be reviewed, is the part that describes the measurement tools and forms, because

all project members should understand how to use these tools and forms". The output, from this step of GQM method, is a hierarchy of goals, questions and metrics as shown by figure 6.

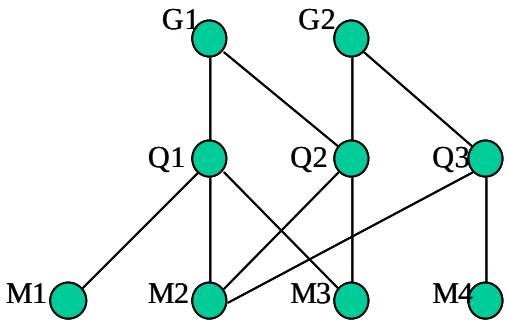

Fig. 5. A GQM hierarchy of goals, questions and metrics.

In this example there are two goals G1 and G2 which have a question, Q2 in common. Metric M2 is needed by three questions. The strength of GQM is that each metric identified is placed within a context, so metric M1 is collected in order to answer question Q1 to help achieve the goal G1.
Figure 7 illustrates an example of deriving metrics from GQM (source Agena 2000).

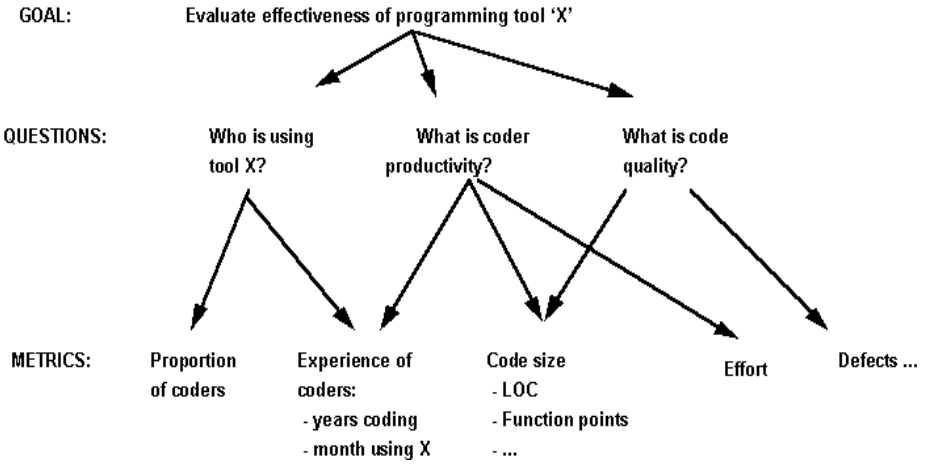

Fig. 6. Example of deriving metrics from GQM method (source: Agena 2000).

In practice, it is often helpful to introduce additional layers into the hierarchy so as to reduce the size of each refinement step. Rombach and Basili (1990)

describe some rules for adding further levels into the hierarchy. He suggests that sub-goals should address:

- the definition of the measurement object where the object is a product this should include quantitative characterization of both the product and the resources required to produce it;
- where the object is a process, this should include quantitative characterization of the process and the definition of the qualitative perspectives of concern, including the validity of any models employed and data collected;
- feedback from these quality concerns to facilitate improvement, e.g. to find measurable early indicators of potential problems.

4.14 Data collection Phase

The data collection phase corresponds to collect the data for each metric before the actual data collection starts, a certain period trial should be held. After the improvements of the trial have been included in the data collection procedures, a kick-off session is organized in which both project-team and GQM-team start data collection. If necessary, additional training is organized on how to use the data collection forms or tools. In parallel with the actual data collection, the GQM team develops a measurement support system (MSS), which will become the basis of the interpretation phase. The data collection phase is composed of the following eleven steps:

- Hold trial period
- Hold kick-off session
- Create metrics base
- Collect and check data collection forms
- Store measurement data in metrics base
- Define analysis sheets and presentation slides

4.15 Interpretation Phase

In this phase we will try to find answers to the questions underlying the measurement program. Results of a measurement program are discussed in so called feedback sessions. This phase is composed of the following steps:

- Prepare a feedback session
- Organize and hold a feedback session
- Reporting measurement results

5 Research Framework Proposal

We defined the following objective for this research:
Apply GQM approach to formalize the SAP implementation project's CSFs and identify a set of desire metrics to capture.

We present graphically our research framework proposal in fig nº. 4. We will use a unified CSFs model proposed by Esteves and Pastor (2000). Then, we will derive goals on the basis of the CSFs. Such goals, which may pertain to one or several CSFs, are characterized by (Spang 1993):

- Substance of the goal (e.g. minimize the number of changes to the scope of the project)
- Scope of the goal (e.g. reduction by 60%)
- Time period for reaching the goal (e.g. six months)

As Kirchmer (1999) mentions, " *an implementation does not become a success simply because it creates hundreds of color computer screens, but rather it reaches the defined business goals*". We must guarantee that ERP project goals are satisfied. And, these goals should be based in the CSFs previously defined.

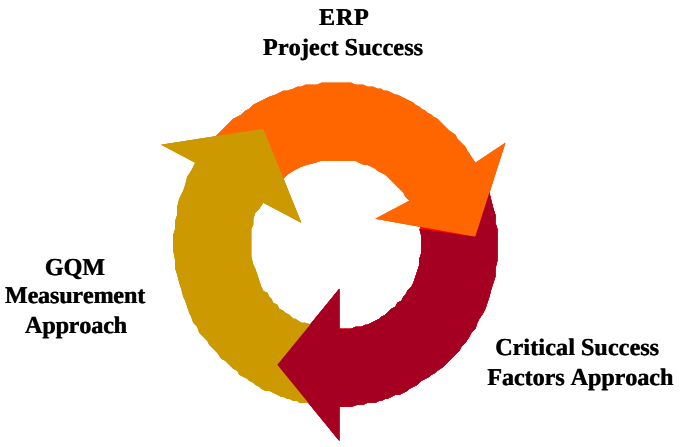

Fig. 7. Research framework proposal.

We will follow the steps of GQM to create the metrics model. First, we will focus on definition phase. The data collection phase will be done through case studies. In the future we attempt to define a complete measurement system

manual to help in the introduction of a system of this nature in an ERP implementation project. Next, we describe in detail the definition phase.

6 An Example: Sustained Management Support

In this section we applied GQM method to define a set of metrics to sustained management support CSF in ERP implementations. First, we present an overview of sustained management support. Next, we describe each of the components of the preliminary GQM plan: goals, questions and metrics. For each goal the following aspects are described: goal description and the refinement to questions, refinement from questions to metrics and direct measurements.

6.1 Sustained Management Support Overview

Green (1995) defines top management as the CEO and his/her direct subordinates, responsible for corporate policy. Top management is represented in a project in the figure of the steering committee and project sponsor. Welti (1999) considered a capable and powerful steering committee as absolutely crucial for a project, as it has to fulfil very important tasks and responsibilities, e.g. assuming ownership, managing the implementation of project policy, controlling project planning and progress, enabling fast decisions, deciding on organizational issues, making resources available, supporting the project manager, motivating the management. Project sponsor is considered as another CSF in an ERP implementation. Therefore, it will be analysed in the next phase of this research.

According to Esteves and Pastor (2000), sustained management support is related with "sustained management commitment, both at top and middle levels during the implementation, in terms of their own involvement and the willingness to allocate valuable organisational resources. Management support is important for accomplishing project goals and objectives and aligning these with strategic business goals". Top management support is needed throughout the implementation project (Esteves and Pastor 2001, Nah et al. 2001) and it must be committed with its own involvement and willingness to allocate valuable resources to the implementation effort (Jarvenpaa and Ives 1991, Holland et al. 1999). According to Purba et al. (1995, p. 178) top management has "an overall responsibility for accepting and approving the project initiatives outlined in the information technology

strategic plan, including funding and prioritisation of projects before they are initiated". Welti (1999, p. 137) mentions that "active participation by upper management is crucial to the adequate resourcing of the project, to taking fast decisions, and to promoting company-wide acceptance of the project".

One of the tasks of top management is to assist in project review meetings. According to (Jurison 1999, p. 31), the purpose of project review meetings is "to assess progress and identify areas of deviations from the plan so that corrective action can be taken". The author also refers that project review meetings provide visibility to plans and progress and create opportunities for obtaining and enforcing commitments from the participants. A review meeting "allows an active project to be examined to determine its overall health; actions ate then recommended to immediately address any significant problems that are identified" (Whitten 1999, p. 175).

Other important aspect is the commitment with the project. Case studies on ERP systems suggest that the commitment of top management to resources is key to facilitating implementation processes (Hirt and Swanson 1999). Top management needs to publicly and explicitly identify the project as a top priority (Wee 2000). The Capability Maturity Model (CMM) defined commitment as "a pact that is freely assumed, visible, and expected to be kept by all parties" (CMU 1994).

A more broadly definition is given by O'Reilly and Chatman (1986). They view commitment as a psychological state of attachment that defines the relationship between a person and an entity. Staw (1982) shares the same view defining commitment as a state of mind that holds people and organizations in a line of behaviour (Staw 1982). Commitment is also described as the degree to which an individual internalizes or adopts the goals and values of the organization (O Reilly and Chatman, 1986). In another definition, commitment is described as "an individual's affective attachment to the goals and values of an organization, to (his or her) role in relation to these goals and values, and to the organization for its own sake apart from its purely instrumental worth to the individual (DeCotiis and Summers, 1987). Dong and Ivey (2000) defined two types of top commitment: commitment to resource and commitment to change management.

6.2 A GQM Preliminary Plan

Next, we describe each of the components of the GQM preliminay plan: goals, questions and metrics. For each goal the following aspects are described: goal description and the refinement to questions, and finally, refinement from questions to metrics.

6.2.1 Goals of the GQM Preliminary Plan

The definition of goals was made using the template provided by Basili et al. (1994). We defined two goals based in our CSF: time spent on support activities and level of commitment:

Analyze:	Time spent by top managers on support activities and review meetings
For the purpose of	Analyzing
With respect to	The ERP implementation project
From the viewpoint of	The project team
In the context of	ERP implementation project

Analyze:	The support and commitment level of top managers
For the purpose of	Understanding
With respect to	The ERP implementation project
From the viewpoint of	The project team
In the context of	ERP implementation project

6.2.2 Questions

For each goal we defined a main question and then, we defined a set of sub-questions related with the goal. The question for goal one focuses on identifying objective and quantifiable aspects that were related to the baseline characteristics of the support activities performed along the project. Top managers are involved in two main activities: support meetings and review meetings. The question for goal two is related with the presence of top managers in the meetings and the actions they proposed along the ERP project, especially communication events. These activities give an idea about

the commitment with the project and how top managers show their commitment.

Goal	Question	Sub-question
One	What are the main characteristics of the support activities?	1. In which way is the support meeting requested (phone, email, etc.)? 2. For which domain is the support requested? 3. How long is the support meeting going to take? 4. How many support meetings were cancelled? 5. How many support activities were postponed? 6. How long takes the review meeting? 7. How many review meetings were cancelled? 8. How many review meetings were postponed? 9. What is the percentage of attendance in review meetings? 10. How many support meetings were done per phase? 11. How many review meetings were done per phase?
Two	What is the level of commitment?	1. How many support meetings were cancelled? 2. How many support activities were postponed? 3. What is the percentage of attendance in review meetings? 4. How many review meetings were cancelled? 5. How many review meetings were postponed? 6. How many events did top management propose? 7. Are reviews made speedy in decision processes? 8. What is the frequency of review meetings? 9. What is the percentage of scheduled review meetings done per phase?

6.2.3 Metrics Description

In this section we show the relationship between the questions defined above the metrics (see table 1). We also represented graphically the relationships (see fig. 8).

1	Support meeting request medium	Q1.1
2	Domain for the support meeting	Q1.2
3	Duration of support meeting	Q1.3
4	Support meetings cancelled in each phase	Q1.4, Q2.1
5	Support meetings postponed in each phase	Q1.5, Q2.2
6	Duration of the review meeting	Q1.6
7	Review meetings cancelled in each phase	Q1.7, Q2.4
8	Review meetings postponed in each phase	Q1.8, Q2.5
9	Percentage of attendance on review meetings	Q1.9, Q2.3
10	Number of support meetings per phase	Q1.10
11	Number of review meetings per phase	Q1.11
12	Number of events proposed by top managers	Q2.6
13	Undertaken time in decision making	Q2.7
14	Frequency of review meetings	Q2.8
15	Percentage of scheduled review meetings versus review meetings done	Q2.9

Table 1 - The relationship between questions and metrics.

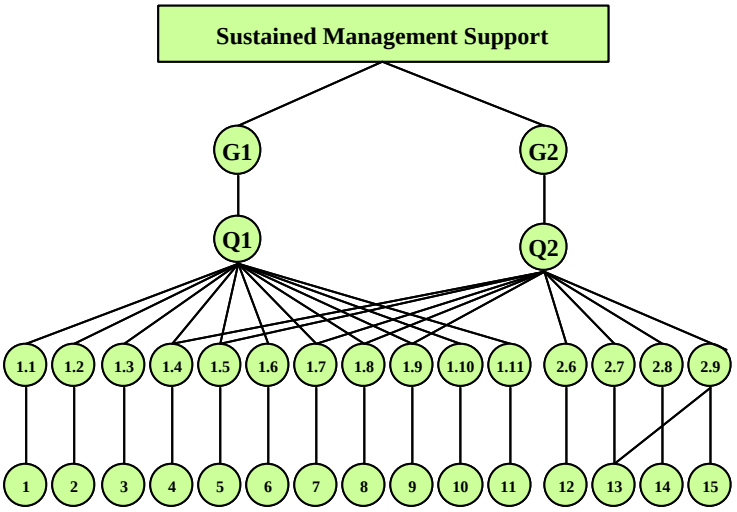

Fig. 8. Graphical representation of the GQM preliminary Plan.

Currently we are working in the metrics description. For each metric we will define the following aspects: what they are measuring, when they must be

measured, what possible values they could have, the metric scale, who will measure it, what medium is used for data collection. We created a special form for the metrics description (see table 2). The definition for all the metrics is provided in table 3. Most of the metrics proposed are direct measurements except the metrics related with percentages.

Metric Characteristics	
Name	Support meeting request medium
Definition	Medium that was used to reach the top manager(s).
Calculation method	-
Frequency	For each support meeting planned
Scale	Nominal
Values	Email, phone, paper
Who	Project manager
Collection	Manual

Table 2 - An example of a metric description form.

1	Support meeting request medium	Medium that was used to reach the top manager(s).
2	Domain for the support meeting	This measurement gave the name of the domain for which the activity was requested.
3	Duration of support meeting	This measurement gives the time that is spent to complete the support request.
4	Support meetings cancelled in each phase	Number of support meetings cancelled
5	Support meetings postponed in each phase	Number of support meetings postponed
6	Duration of the review meeting	This measurement gives the duration of each review meeting.
7	Undertaken time in decision making	
8	Review meetings cancelled in each phase	Number of review meetings cancelled
9	Review meetings postponed in each phase	Number of review meetings postponed
10	Percentage of attendance on review meetings	This metric is calculated in the following way: number of top managers presented/Estimated number of top mangers
11	Number of events proposed by top managers	Number of events proposed by top managers such as: special communication events, newsletters, meetings and forums.
12	Number of support meetings	Number of support meetings done in each phase

	per phase	
13	Number of review meetings per phase	Number of review meetings done in each phase
14	Frequency of review meetings	Frequency of review meetings
15	Percentage of scheduled review meetings versus review meetings done per phase	This metric is calculated in the following way: scheduled review meetings /review meetings done. This metric is related with metric 15.

Table 3 - Metrics definition table.

7 Considerations

It is now well accepted that genuine performance improvement in the CSFs of an organization or project requires rigorous and persistent effort (KPIs manual). Further, the biggest gains in performance result from analyzing key processes and CSFs and then doing something differently. This technical research report presents a proposal for develop a measurement system for SAP implementation projects based in a set of CSFs developed in previous research. We think that measurements need not be extensive or complicated. One of the dangers is that there are potentially so many things to measure that one can become overwhelmed by opportunities. We will try to avoid this by center in the CSFs analysis. It is our intention to develop metrics that should preferable be as automatic as possible and not put an extra burden on the staff involved. It is also useful to define when the metrics should be collected, by whom and how they are registered and stored for later retrieval and analysis.

We also think that monitoring a project progress without a project plan is very difficult. By creating a plan it is easier to identify the length of the project, its work breakdown structure, need of resources and to distribute responsibilities between staff. Therefore, we attempt to relate our metrics with CSFs in SAP implementation but also with ERP implementation project plans and subsequent ERP implementation methodologies. As an example, in this technical report, we applied GQM to define a set of metrics for sustained management support in ERP implementation projects.

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