

Utilizing GQM⁺Strategies for an Organization-Wide Earned Value Analysis

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Abstract—In this paper, we offer an approach for performing an organization-wide earned value analysis by taking advantage of the hierarchical structure of the GQM⁺Strategies grid. The merger enables us to create an integrated hierarchy of business goals, value goals, and strategies for achieving those goals and to monitor and evaluate those goals at all levels. It provides a means to expand the definition of earned value metrics to cover both the costs and benefits of achieving those goals through those strategies and provides measurement support for all concepts.

Keywords—Software Metrics, Business Value Analysis, VBSE, GQM⁺Strategies, Earned Value Tracking

I. INTRODUCTION

In recent years, the software industry has paid increasing attention to the business value aspects of software engineering. A special issue of *IEEE Software* [1] was dedicated to business value aspects in software engineering and ROI. The majority of papers report cases with a value analysis performed at the ends of the investment cycles in a variety of different aspects: software process improvement, software product lines, and software development. However, the concepts of business value and added value are not explicitly addressed in software engineering standards or its body of knowledge.

Earned value (management) is the result of positive experiences with Cost/Schedule Control Systems used in the 1960s and 1970s [2]. Earned value management (EVM) is focused on controlling a project's costs and schedule. However, the EVM does not take into account the stakeholders' view on value [3]; and quantifying the value of continuous project tasks can be challenging.

Boehm [4] proposed the Value-Based Software Engineering (VBSE) framework in order to integrate all aspects of the software creation process under the perspective of the value. Value-based monitoring necessitates defining and collecting productivity and quality metrics. At the organizational level, Boehm [4] suggests using a value-based version of the Experience Factory [5] and Goal Question Metric (GQM) [6] approach to align measures to business goals.

GQM⁺Strategies¹ [7] is an approach designed to help the software industry develop measurement programs that are aligned with business goals.

In this short paper, we explain how to perform earned value analysis with the GQM⁺Strategies approach. This approach merges the earned value analysis with the GQM⁺Strategies grid structure. The merger enables the analysis of earned value at different levels and integrates them throughout the grid. The utilization of the GQM graph makes measurable not only costs but also benefits of business goals.

The rest of the paper is structured as follows. Section II reviews related work on value-based earned value analysis and business value analysis with GQM⁺Strategies. Earned value analysis with GQM⁺Strategies is explained in Section III. Section IV presents our final remarks and concluding statements.

II. BACKGROUND AND RELATED WORK

The concept of value-based software engineering (VBSE) [3] emerged in the late 1990s in the areas of product line engineering and software economics. GQM⁺Strategies is the result of a 30-year-long evolution and use of the GQM method.

A. Value-Based SE and Earned Value Analysis

Boehm [4] introduced the seven key elements as the foundation of value-based software engineering. The *benefits realization analysis* means that all initiatives needed to realize the potential benefits of a system are identified and coordinated. Linking resources to outcomes increases the concreteness of a software project, and helps identify stakeholders who need to be involved in system development. *Stakeholder value proposition elicitation and reconciliation* involves identifying and documenting success-critical stakeholder value propositions [4]. *Business case analysis* involves determining the costs, benefits, and return on investment of a system during its life cycle. Unquantifiable benefits make business case analysis challenging. Analyzing

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uncertainties helps in identifying risks related to each development option. *Continuous risk and opportunity management* means that risk analysis and risk management should be carried out during the entire life cycle of the system. Risk management involves understanding and addressing people’s utility functions and using risk to determine how much is enough. The *concurrent system and software engineering* element stresses using iterative process models instead of waterfall style models. *Value-based monitoring and control* [3] deals with monitoring the realization of the business value of outcomes at the project and organizational levels [4]. Finally, the *change as opportunity* element means that the ability to adapt to change has business value, as the rate of change is continuously increasing. Companies that can react quickly will be more successful.

Boehm and Huang [3] integrated critical stakeholders’ views of value with EVM through the benefits–realization approach and risk/opportunity management practices.

B. Business Value Analysis with GQM+Strategies

GQM+Strategies [7] is an extension of the GQM approach [6] that provides a method for an organization or project to define goals, refine those goals down to specifications of data to be collected, and then analyze and interpret the resulting data with respect to the original goals. However, it does not provide a mechanism for linking high-level business goals to lower-level goals or for supporting and integrating *different* goals at different levels of the organization. Such a mechanism is provided by GQM+Strategies.

GQM+Strategies introduced several new concepts: multi-level goals, strategies, context/assumptions, and an enhanced multi-level interpretation model. Discernment is made between a *business goal* and *GQM goal*. The former is an objective for which strategies need to be developed to accomplish it. The latter is the associated measurement scheme (metrics and interpretation model). Strategies in turn generate lower-level business goals. Business goals are formalized using the *business goal template* with eight dimensions [7].

The *goal+strategies element* (Figure 1) represents a single goal and its derived strategies, including all context factors (facts about the business environment) and assumptions (predictions) that focus and bound the goal and corresponding strategies. The *GQM graph* is a single GQM goal that measures a GQM+Strategies element. The *GQM+Strategies grid* is an integrated collection of all GQM+Strategies elements, GQM graphs, and all links.

According to [8], business value is enunciated with the GQM+Strategies grid (Figure 1). The GQM+Strategies method provides a structure and process for deriving the goals in a given organizational context.

Business value analysis (BVA) is supported by the derivation of value goals [8]. Value goals form a hierarchy in the same way as business goals. The purpose of the value goals

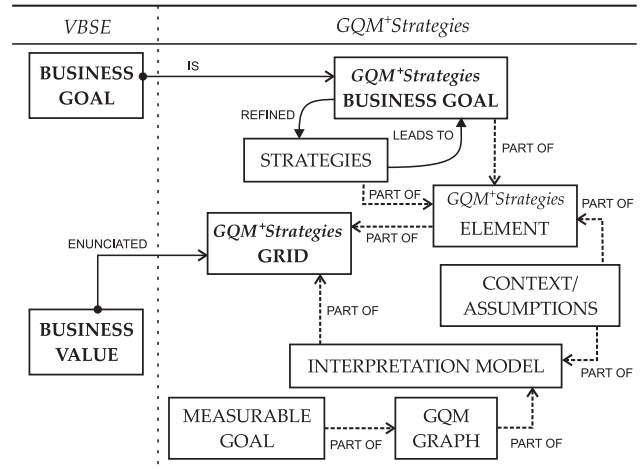


Figure 1. Terminology and GQM+Strategies concepts.

hierarchy is to propagate the rationale for investment-related decisions from the top- to the lower- levels, while at the same time integrating cost and benefits estimates from all levels.

The advantage of using GQM+Strategies is that it provides an explicit link to the different levels, from the top level to the lowest level. This implies that value goals exist on different levels, analyzing benefits and costs at those organizational levels. For an easier navigation through the hierarchy, goals are indexed with levels.

III. EARNED VALUE ANALYSIS WITH GQM+STRATEGIES

For selected strategies and business goals, the support and commitment is granted by providing real resources (e.g., financial). Each business goal B_i is supported by budget ($\hat{C}ost(B_i, t)$) and planned benefits realization schedule ($\hat{B}nft(B_i, t)$).

A. Tracking Actual Costs and Benefits

In order to measure actual costs and benefits, we have to define a cost–benefit GQM graph (Figure 2) and incorporate it into the grid. The process used for defining the cost–benefit graph is a typical GQM process², albeit with several differences. First, the assumption and context elements of the value goals and corresponding business goals are available, easing the process of defining metrics. Second, the costs and benefits structure has a built-in recursion that dominates and shapes the entire cost–benefit graph. Level- i GQM goal collects costs- and benefits- related data for the current level and all lower levels from the corresponding derived goals.

Each value goal (V_i) is linked to a GQM goal with the purpose of monitoring and tracking costs and benefits during the execution phase. The form of the GQM goal is given in Table I.

²For example, see: (van Solingen and Berghout, 1999).

Table I
GQM GOAL TEMPLATE FOR MEASURING VALUE GOALS

GQM goal	
Analyze For the purpose of with respect to point of view in the context of	Costs and Benefits Monitoring Business goal: Bi Business Corporation

A distinguishing characteristic of cost–benefit GQM goals is that the dimension of the *with respect to* is always a corresponding business goal (Bi) of the linked value goal (Vi). Further, the GQM goal is addressed by four questions. Two of them relate to costs: *What percentage of budgeted (estimated) costs have we spent? Are there any unplanned costs?* And, two of them relate to benefits: *Are we achieving planned (estimated) benefits? Are there any unplanned benefits?*

Once a goal is achieved, some resources are allocated for its maintenance:

$$Cost(Bi, t) = Cost(Bi(Strat), t)|_0^{T_{Bi}} + Cost(Maint(Bi), t)|_{T_{Bi}}^{T_{Vi}}$$

where $Cost(Bi, t)$ is the cost of a goal Bi up to the time t , $Cost(Bi(Strat), t)|_0^{T_{Bi}}$ is the cost of the strategies to realize a goal Bi in timeframe $(0, T_{Bi}]$ defined by the business goal, $Cost(Maint(Bi), t)|_{T_{Bi}}^{T_{Vi}}$ is the cost of maintaining goal Bi for time period $(T_{Bi}, T_{Vi}]$, and T_{Vi} is the timeframe defined by a value goal Vi .

For the proper collection of the metrics data, we have to consider the recursive behavior of costs (and benefits) [8]:

$$Cost(Bi(Strat), t) = \sum_j Cost(Bj, t)$$

where $Cost(Bi(Strat), t)$ is the cost of strategies for addressing goal Bi , and $Cost(Bj, t)$ are costs of the next lower-level-derived goals Bj up to moment t . In the same way, the equation $Bnft(Bi, t)$ can be written to address the benefits-related questions.

B. Earned Value Metrics

Earned value analysis (EVA) [2] is a simple and powerful tool that helps managers to analyze the progress of their projects. Initially, EVA focuses on the budget (cost) and schedule. The analysis is done by calculating three basic indicators (metrics): BCWS, ACWP, and BCWP (Table II).

The GQM+Strategies grid with the cost–benefit graph enables tracking of not only cost-related metrics, but also benefit-related metrics. Therefore, we extended the set of basic earned value metrics with PBRs, ABRM, and PBRM (Table II).

Let us define $\hat{C}ost(Bi, t)$ as budgeted costs of a goal Bi ; therefore:

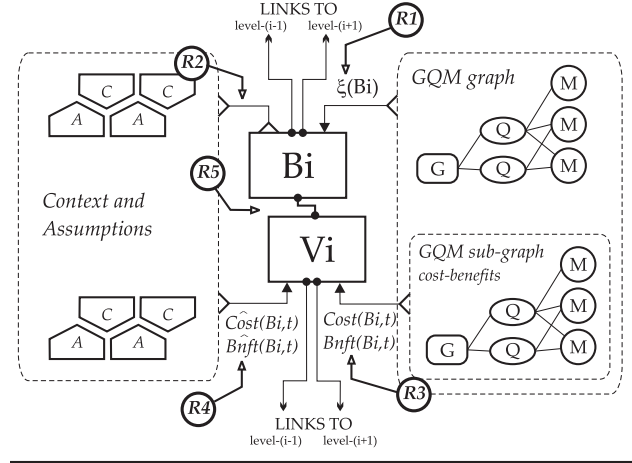


Figure 2. Tracking actual costs–benefits and goal realization. R1 – tracks goal realization, R2 – identifies Bi 's success-critical assumptions and context factors, R3 – tracks actual costs and benefits, R4 – estimates (budgeted) costs and (planned) benefits, and R5 – analyzes the level of acceptable risk.

Table II
THE EXTENDED SET OF BASIC EARNED VALUE METRICS WITH BENEFITS RELATED METRICS.

Metric	Description
BCWS	BUDGETED COST OF WORK SCHEDULE: the total budgeted cost up to the analysis date.
ACWP	ACTUAL COST OF WORK PERFORMED: this is what it actually cost to accomplish all the work completed as of the analysis date.
BCWP	BUDGETED COST OF WORK PERFORMED: the cost originally budgeted to accomplish the work that has been completed as of the analysis date. This is the earned value.
PBRs	PLANNED BENEFITS REALIZATION SCHEDULE: the total planned benefits realization up to the analysis date
ABRM	ACTUAL BENEFIT REALIZATION MATERIALIZATION: this is what it actually materialized of the planned benefits realization as of the analysis date.
PBRM	PLANNED BENEFIT REALIZATION MATERIALIZATION: the benefits realization originally planned to materialize by the work that has been completed as of the analysis date.

$$BCWS_{Vi}(t) = \hat{C}ost(Bi, t) \quad (1)$$

where $BCWS_{Vi}(t)$ is the budgeted cost of a value goal Vi up to the moment t collected through R4 in Figure 2.

Actual costs are collected through cost–benefit graph (R3, Figure 2):

$$ACWP_{Vi}(t) = Cost(Bi, t) \quad (2)$$

where $Cost(Bi, t)$ are costs of a goal Bi up to the moment t .

The main difference between “classical” EVA and our approach is how we define BCWP. The purpose of using earned value metrics is to analyze the progress of executing business strategies. Therefore, we are interested in the progress of realizing goals. Each goal goes through two phases. First,

the phase of implementing strategies in order to achieve the goal. And second, after the goal is achieved it has to be maintained. In other words, the objective is to bring goals in the maintenance phase. Resources are spent in both phases. The progress of realizing a goal is measured with a *goal realization indicator*. The goal realization indicator, $\xi(Bi)$, is assessed through GQM graph that measures a business goal Bi (R1, Figure 2). Therefore, we define the budgeted cost of work performed as:

$$BCWP_{Vi}(t) = \begin{cases} \xi_{Bi} \cdot \hat{C}ost(Bi, T_{Bi}), & \xi < 1 \\ \hat{C}ost(Bi, t), & \xi = 1, t > T_{Bi} \\ \xi_{Bi} \cdot \hat{C}ost(Bi, T_{Bi}), & \xi = 1, t \leq T_{Bi} \end{cases} \quad (3)$$

where T_{Bi} is a timeframe defined by a goal Bi , and $\xi_{Bi}, \xi \in [0, 1]$ is the goal realization indicator of a goal Bi . If the goal is achieved then $\xi = 1$ (also means that the goal is in the maintenance phase).

In the same way, we derive benefit-related earned value metrics: $PBRS_{Vi}(t)$, $ABRM_{Vi}(t)$, and $PBRM_{Vi}(t)$.

Analyzing earned value metrics can help us to determine if a goal realization is lagging behind (when $BCWP < BCWS$), exceeding budgeted costs (when $BCWP < ACWP$), or if the materialization of benefits is lower than planned (when $PBRM < ABRM$)³.

Costs and benefits manifest recursive behavior, meaning that budgeted costs for a goal at one level include budgeted costs of derived lower-level goals. Similar, but in a less obvious way, benefits from different levels are aggregated. In the literature we often find examples of situations where the measurement of the benefits in terms of their monetary equivalent is difficult, if not impossible. One such example is customer satisfaction. We agree that at a certain level, i.e. where the goal of increasing customer satisfaction is defined, it is not adequate to measure it in financial terms. But, if at a higher level, i.e. where the goal of increasing profitability is defined with the assumption that increasing customer satisfaction will increase profitability, then it is possible to measure the benefits of increasing customer satisfaction in terms of financial value in the context of the upper-level business goal.

IV. CONCLUSIONS

The approach presented here is fully aligned with VBSE concepts. The *benefits realization analysis* is carried out while analyzing the context of goals. The process of defining goals represents *stakeholder value proposition elicitation and reconciliation*. Refining business goals with strategies and documenting the relevant context/assumption elements is a way of doing *business case analysis*. Identification of the critical GQM+Strategies sub-grid with regular context and

assumption updates leads to *continuous risk and opportunity management*. *Value-based monitoring and control* is supported with earned value analysis. The GQM+Strategies grid structure enables us to act on changes by selecting the best possible opportunity, i.e., viewing *change as opportunity*. Furthermore, the GQM+Strategies structure helps to better understand the relationship between context and the value creation process. Documenting goal+strategies elements captures relevant information about a particular situation and offers an opportunity to study value-based decisions and actions for that situation. Such studies could be a part of the organizational learning process.

The most important contribution of this approach is the merger of earned value analysis with the GQM+Strategies grid structure. The approach establishes a working structure that integrates the various aspects of business value (expressed and defined by goal owners) and enables the analysis of earned value through the assessment of the goals achievement at different levels of an organization; also, integrating the cost and benefit analysis throughout the grid enables the definition and quantification of the compound phenomenon of business value. For example, in section Section III-B, we explained how the grid structure can be used to help us measure customer satisfaction in terms of financial value.

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³More detailed explanations of how to perform the analysis by calculating different indexes can be found in [2], [3].