Organizational Earned Value Analysis

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Abstract

We offer an approach for performing organization 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. We demonstrate the approach through an example application, inspired by a real-world situation, to illustrate the feasibility of the proposed approach.

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Chapter 1

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* [12] 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 [19], software product lines [5], and software development [15]. However, the concepts of business value and added value are not explicitly addressed in software engineering standards or its body of knowledge.

Boehm [7] 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. The stakeholders' viewpoint is essential in considering several of the key elements of VBSE. In addition to the reconciliation of stakeholder value propositions, stakeholders' values are the basis of risk management, monitoring, and change management [6, 8]. There is a need for tools that help in determining, documenting, and managing stakeholders' value goals and linking them to the other elements of the VBSE framework. A tool that enables value-based earned value tracking is particularly needed. However, according to Boehm [7], there are no such tools available today. The reason for the lack of such tracking systems could be that in some cases the value is difficult to measure as a scalar quantity [10].

Earned value (management) is the result of positive experiences with Cost/Schedule Control Systems used in the 1960s and 1970s [11]. 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 [9]; and quantifying the value of continuous project tasks can be challenging.

At the organizational level, Boehm [6] suggests using a value-based version of the Experience Factory [1] and Goal Question Metric (GQM) [2] approach to align measures to business goals. GQM$^+$Strategies[1] [3] is an approach designed

[1] *GQM$^+$Strategies*® is a registered trademark of the Fraunhofer Institute for Experimental Soft-

to help the software industry develop measurement programs that are aligned with business goals. The resulting structure, which aligns metrics (GQM goals) and business goals, is called a grid.

In this 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 true earned value of a business goal is the combination of earned value on the cost side and the earned value gained by materializing benefits.

The rest of the report is structured as follows. Chapter 2 reviews related work on business value analysis and value-based earned value. Earned value analysis with GQM$^+$Strategies is explained in Chapter 3. Chapter 4 depicts an example application of the approach. Chapter 5 presents our final remarks and concluding statements.

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Chapter 2

Background and Related Work

The concept of value-based software engineering (VBSE) [9] 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. The foundation of the GQM was laid out in the NASA/Software Engineering Laboratory (SEL) at the beginning of the 1980s [4].

2.1 Value-Based Software Engineering and Earned Value Analysis

The VBSE framework aims to integrate value considerations into all software engineering practices. The value-based approach helps focus and prioritize development efforts. For example, taking into account stakeholders' value propositions and considering the business value of each decision help ensure that effort is not wasted in implementing unneeded features. Thus, the value-based approach directs the effort towards artifacts with higher perceived stakeholder value. [6]

In what follows, we present an overview of the seven key elements that Boehm [6] introduced 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 [6, 13]. *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 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 [14]. The *concurrent system and software engi-*

neering element stresses using iterative process models instead of waterfall style models. *Value-based monitoring and control* [9] deals with monitoring the realization of the business value of outcomes at the project and organizational levels [6]. 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.

Brandon [11] defines *earned value* as the value, usually expressed in a monetary equivalent, of work accomplished up to a point in time based upon the planned (or budgeted) value for that work.

The earned value analysis (EVA) is composed of the following simple steps [9, 11]. Cost performance is measured by comparing the Budgeted Cost of Work Scheduled (BCWS) and Budgeted Cost of Work Performed (BCWP). The cost variance is calculated by comparing the earned value to actual cost. If actual cost is less than the earned value of completed tasks at a certain point in time, it means that the project is achieving its goals under budget. Similarly, if the earned value of completed tasks is higher than the planned value of the tasks, the project is ahead of schedule.

Boehm and Huang [9] integrated critical stakeholders' views of value with EVA through the benefits–realization approach [17] and risk/opportunity management practices. The benefits–realization approach enables identification of outcomes and assumptions related to the realization of the outcomes. A sequence of outcomes forms a results chain. The analysis of the results chain provides a basis for risk/opportunity management. Therefore, the value-based earned value monitoring and control is performed, as EVA contrasted with risk/opportunity management and analyzing benefits realization.

It is important to understand the links between technical decisions, context, and value creation in different situations in order to improve decision making. Furthermore, dynamic monitoring and control mechanisms taking into account these linkages and different sources of value are needed to guide decision–makers [8].

2.2 Business Value Analysis with GQM$^+$Strategies

GQM$^+$Strategies [3] is an extension of the GQM approach [2] 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* (Table 2.1).

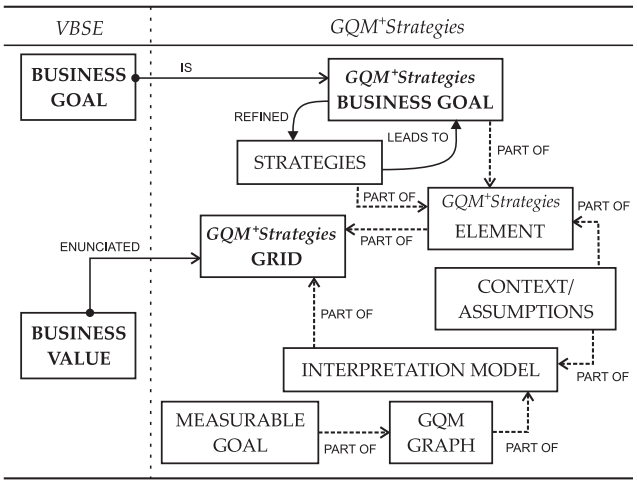

Figure 2.1: Terminology and GQM$^+$Strategies concepts.

The *goal$^+$strategies element* (Figure 2.1) 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.

Table 2.1: GQM$^+$Strategies goal formalization template with an example. The template specifies eight goal elements (dimensions).

Goal template	Example
Activity	Develop
Focus	The software product
Object	IP testing business
Magnitude	100% of the MUST and 30% of the SHOULD features
Timeframe	1 year (to have a beta version)
Scope	R&D department
Constraints	Resources, IP competence, compete with existing competitors
Relations	Competing resources, existing business

In what follows, we give the sequence of activities of a top-down grid derivation process, which is the way we deal with business value. However, the grid derivation can start at any level, moving up and down.

Elicit General Context and Assumptions: the organizational environment is defined by specifying context factors. Uncertainties are documented using assumptions. *Define Top-Level Goals*: an initial set of high-level goals is identified. The goals have to be prioritized and analyzed for potential conflicts. The selected goals are then formalized using the GQM$^+$Strategies goal template (Table 2.1). *Make Strategy Decisions*: a list of potential strategies for achieving the business goals is identified. The most promising strategies are selected. *Define Goals*: the strategy is refined by another goal level, using the implications of the upper-level strategies to determine the lower-level goals. Again, these goals are selected and formalized using the goal template. And, *Define GQM Graphs*: the GQM graph derivation process is well-documented in the literature, for example, in [20].

The entire process of deriving business goals and measurable goals is consolidated through the interpretation model. During the interpretation process, measured GQM goals and statuses of the context/assumption variables influence assessment of business goal achievement.

Business value analysis (BVA) [16] tries to analyze the factors that influence the business (e.g., employees, partner networks, ability to adopt new processes rapidly, etc.) to shape the future. These factors are under continual change so the challenge is to focus on providing valid inputs or a working structure that can facilitate further analysis. According to [16], business value is enunciated with the GQM$^+$Strategies grid (Figure 2.1). The GQM$^+$Strategies method provides a structure and process for deriving the goals in a given organizational context.

BVA is supported by the derivation of value goals [16]. Value goals form a hierarchy in the same way as business goals. The purpose of the value goals 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 dimensions of value goals are *activity—evaluate* — value goals are always about evaluating or analyzing the value of business goals at certain points in time; *focus—value* — in order to evaluate value, it is necessary to appraise or estimate all costs and benefits; *object—business* — in light of GQM$^+$Strategies, the business is perceived according to business goals; and *magnitude—acceptable risk* — risk and handling uncertainties will be addressed in the step of risk interpretation. The ARE (acceptable risk exposure) model is defined by the top-level value goal, while other value goals specify the acceptable risk exposure based on cost–benefits estimation; *timeframe—time-period of analysis* — the main input components, costs and benefits, are time-dependent. The timeframe defined by a top-level value goal is the same for all value goals in the hierarchy; *scope—corporation units* — the scope determines which parts of the organizational structure will be involved in the evaluation; *constraints—current obligations* — these are the constraints that have to be considered during the analysis; and *relations—top-level business goals* — if the object is to assess the entire business, then all top-level business goals should be evaluated.

Cost analysis In order to integrate the cost estimates of business goals, we have to understand the recursive structure of the costs. The business goal represents a desired future state, while the strategy represents a means for achieving the goal. In that sense, actual cost carriers are actions that will lead to a desired future state. Further on, the cost of the strategy can be analyzed using the costs of derived business goals, and so on. The recursion is stopped when the goal derivation process reaches the operational level. At the moment a business goal is achieved, some resources should be allocated to maintain the desired state (*goal maintenance costs*).

Benefits analysis Unlike costs, benefits can be harder to estimate and quantify. It is important to analyze benefits at all levels (e.g., a benefit at the top level can be expressed as increased market share, while a benefit at the lower level for the same top-level business goal can be effort savings). It is not possible to calculate overall benefit as a simple sum of benefits because the existence of conflicting value goals can have, as an implication, a mutual cancellation of benefits. Therefore, a step involving the analysis of conflicting value goals to re-estimate benefits is necessary. This could occur if goals are competing for the same resources in a mutually exclusive way. However, the number of conflicting goals is expected to be small, so this kind of analysis is feasible. Benefits manifest the same recursive behavior as costs.

Critical GQM$^+$Strategies Sub-grid The risk-handling procedure can be divided into two parts. The first part is related to analyzing assumptions' uncertainties and quantifying them as the risk exposure of business goals. The second part consists of comparing the acceptable risk level of value goals and the risk exposure of the corresponding business goals. This is done during the incorporation of the risk into the interpretation model. The incorporation of the risk level into the interpretation model identifies a *critical GQM$^+$Strategies sub-grid* [16]. The critical sub-grid contains risky goals and goals whose realization is threatened by the risky goals.

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.

The grid derivation process and BVA aim to support decision making in the strategy-planning and business goal definition phase. In the execution of selected strategies, the derived GQM$^+$Strategies grid can be utilized to monitor and control realization of the business goals.

Chapter 3

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, human, time, etc.). Each business goal Bi is supported by budget ($\hat{Cost}(Bi,t)$) and planned benefits realization schedule ($\hat{Bnft}(Bi,t)$). We will assume that all costs and benefits are converted into the monetary units or into any other equivalent.

In the following section, we will explain how to track actual costs and benefits with a cost–benefit GQM graph.

3.1 Tracking Actual Costs and Benefits

In order to measure actual costs and benefits, we have to define a cost–benefit GQM graph and incorporate it into the grid. The process used for defining the cost–benefit graph is a typical GQM process [20], albeit with several differences. First, the assumption and context elements of the value goal and corresponding business goal are at disposal, 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 (Vi) 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 3.1.

A distinguishing characteristic of cost–benefit GQM goals is that dimensions of analyze, purpose, and viewpoint are fixed to costs and benefits, monitoring, and business, respectively. The *with respect to* dimension 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*

Table 3.1: GQM goal template for measuring value goals

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

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):

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

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.

During the business value analysis (Section 2.2), we discussed a situation when conflicting value goals can have, as an implication, a mutual cancellation of the benefits. The analysis of such conflicts is important for defining realistic benefits realization plans for goals. But, in the strategy execution phase, aggregation of the collected actual benefits data is performed as with costs. Therefore, in the same way, the equation $Bnft(Bi,t)$ can be written to address the benefits-related questions.

3.2 Earned Value Metrics

Earned value analysis (EVA) [11] 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 3.2).

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 3.2).

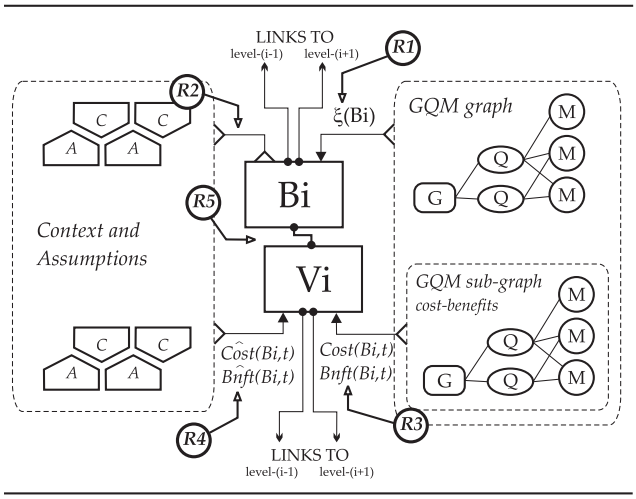

Figure 3.1: Tracking actual costs–benefits and goal realization. $R1$ – tracks goal realization, $R2$ – identifies Bi's success-critical assumptions and context factors, $R3$ – tracks actual costs and benefits, $R4$ – estimates (budgeted) costs and (planned) benefits, and $R5$ – analyzes the level of acceptable risk.

It is expected that the strategy and business goal implementation plan will contain a budget for implementing business goals and plan for benefits realization. The level of detail of the plans can vary depending on the goal level. For example, lower-level goals can have very detailed plans (same level of detail as for a project), while the top-level goals can specify quarterly or half-year plans. Let us define $\hat{Cost}(Bi,t)$ as budgeted costs of a goal Bi; therefore:

$$BCWS_{Vi}(t) = \hat{Cost}(Bi,t) \tag{3.1}$$

where $BCWS_{Vi}(t)$ is the budgeted cost of a value goal Vi up to the moment t collected through $R4$ in Figure 3.1.

Actual costs are collected through cost–benefit graph ($R3$, Figure 3.1):

$$ACWP_{Vi}(t) = Cost(Bi,t) \tag{3.2}$$

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

Table 3.2: 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.

3.1). Once, the goal is achieved ($\xi = 1$) it is maintained. Therefore, we define the budgeted cost of work performed as:

$$BCWP_{Vi}(t) = \begin{cases} \xi(Bi) \cdot \hat{Cost}(Bi, T_{Bi}), & \xi < 1 \quad (3.3) \\ \hat{Cost}(Bi, t), & \xi = 1, t > T_{Bi} \quad (3.4) \\ \xi(Bi) \cdot \hat{Cost}(Bi, T_{Bi}), & \xi = 1, t \leq T_{Bi} : \quad (3.5) \end{cases}$$

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 $PBRM < ABRM$). More detailed explanations of how to perform the analysis can be found in [9, 11].

The most common way of performing analysis is by calculating derived metrics from the basic set of earned value metrics. Here, we will mention one such metric that we find particularly useful. It is the *costs performance index* (CPI) and when used for benefits-related data, we will call it the *benefits performance index* (BPI):

$$CPI = BCWP/ACWP \quad (3.6)$$

$$BPI = PBRM/ABRM \quad (3.7)$$

when $ACWP \neq 0$ and $ABRM \neq 0$. If it is less than 1, you are over budget/plan. If it is greater than 1, you are under budget/plan.

The interpretation of the benefits performance index differs from the costs performance index. A small value of CPI indicate situation when more resources are spent than budgeted, but if BPI has a small value it indicates better materialization of the benefits than it was planned. If the denominators of the performance indices ($ACWP$ and $ABRM$) have values close to the zero, it will result with high values of the performance indices. Therefore, we accept interpretation of performance indices when their values are from the interval $(0, 2)$, meaning that a variation from budget/plan is at most plus/minus 100%. If the value is out of the interval, it is a good indicator that something unplanned is happening and further analysis is required.

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.

If we compare performance indices (CPI, BPI) of two adjacent levels, they should converge toward a value close to 1 in the ideal case. But, if the lower level's goal realization is proceeding according to plan, and if the upper level's goal realization is halted, then performance indices will start to diverge from each other. This situation indicates problems with the strategy that links those adjacent levels. Such situations are easily noticeable when performance indices are plotted on a single graph.

3.3 Risk Monitoring

For all goals belonging to the GQM$^+$Strategies critical sub-grid, it is necessary to reassess the goal's risk exposure and acceptable risk level (Section 2.2), appraised at step $R5$ (Figure 3.1). Situations where goal realization is not going according to plan can reveal changes in context factors and assumptions. Such changes have consequences for the goal's risk assessment ($R2$, Figure 3.1).

After the risk reassessment, new goals can become risky, while known risky goals can cease to be risky. Actually, risk monitoring is continually changing the configuration of the critical sub-grid. It is expected that in an ideal situation when prediction capabilities are good and no unexpected events rise, every new critical

sub-grid is a sub grid of the previous critical sub-grids.

Chapter 4

Exemplar Application of the Approach

Our exemplar application of the approach is inspired by a real-world situation encountered during a GQM$^+$Strategies pilot in an organization, which we will call Comp@ny. The goal of the example is to illustrate the feasibility of the proposed method rather than to validate it empirically.

Due to space limitation, we will present a partially defined GQM$^+$Strategies grid here. The goal tree has only the lowest level GQM$^+$Strategies elements completely defined (made measurable). This restriction of the grid does not affect the illustration of the method's feasibility. First, we will give an overview of Comap@ny's grid and business value analysis; after that, we will define the budgeted and planned benefits realization schedule, and illustrate value-based earned value analysis.

4.1 The GQM$^+$Strategies grid derivation

Comp@ny has been present in the market for more than 15 years. The main focus of the company is the development of software products for testing specific systems. We can summarize Comp@ny's internal environment as human intensive, exploiting human creativity for the purpose of creating the end product. The external environment is dominated by turbulent changes in the market. In light of those conditions, one of the Comp@ny's objectives is to diversify its current market position within the existing market segment (business domain).

General context elements that need to be characterized include: products and services, process, business model, and measurement practices. Comp@ny offers a range of products for embedded software testing. The market for testing products is becoming highly competitive and there is a need to safeguard Comp@ny's market position.

According to Comp@ny's objectives, the top-level business goal **B1** is defined. We can summarize the goal B1 as: *modernize testing services business within a*

Table 4.1: Benefit/investment analysis.

Value Goal	Level	Level-i		Lower levels		Estimated		ARE
(Object)		Cost	Benefit	Cost	Benefit	Investment	Benefit	
V1(B1)	1	300FTE	1200FTE	228.5FTE	54FTE	Small	Large	*VH*
V2(B2)	2	28.5FTE	18FTE	200FTE	36FTE	Small	Medium	*H*
V3(B3)	3	200FTE	36FTE	n/a	n/a	Small	Small	*M*

timeframe of 5 years. There are assumptions: that expanding testing services with IP testing systems is a valid business option, and that existing core competences can be adequately extended with IP testing knowledge/skills in a relatively short time period [A1]. Apparently, IP testing is one of the business "hot-spots". For the business goal B1, a **strategy** *to build an in-house solution* is selected. The assumption is that in the context of existing skills and testing domain knowledge an in-house development will further contribute to Comp@ny's core business competences.

At the next lower level, level-2, a business goal (**B2**) is derived from the strategy that addresses the top-level business goal. The goal B2 is formulated as: *develop marketability for IP testing products within timeframe of 2 years.* There is an assumption [A2] that the product manager and marketing department have sufficient understanding of customers' needs in the new business domain. The marketability of the new product depends on the success of implementing key functionalities (features). Therefore, for business goal B2 a **strategy**: *use the MoSCoW method* [18] is chosen and it further leads to the next level business goal.

The level-3 business goal (**B3**) is: *develop the software product (beta version) for IP testing within timeframe of 1 year.* The B3 is specified according to the goal template as presented in Table 2.1. There is an assumption [A3] that stable product requirements will be ready and specified on time.

The measurement goal associated with business goal B3 would be: Analyze *the IP testing software product* for the purpose of *evaluation* with respect to the *percentage of MUST and SHOULD features implemented in the beta release* from the point of view of *the product manager* in the context of *the Comp@ny*. This goal leads to questions: How many M features are in beta release? How many S features are in beta release? Both questions are measured with $MF(x), x \in \{M, S, C, W\}$ percentages of features by category (Must, Should, Could, Would) in the product release.

Decisions regarding business goal realization are documented in the **interpretation model** as (this is a portion of the interpretation model, related to the goal B3): [...] **if** $MF(M) = 100$ and $MF(S) \geq 30$ **then** B3 is on track **else** re-evaluate level-3 decisions; [...]

For this example, we assume that in the short time period of 5 years, the BVA is unaffected by external factors such as inflation, the cost of capital, etc.

4.2 The Business Value Analysis

First, general context and assumptions of the BVA characterize the current business-financial situation, current and future investment initiatives, and time constraints regarding investments. The business owners (stakeholders) are assessed with respect to the available size of the investment (€10 million) and time period for which the business value analysis is done (5 years).

There is a context factor that quantifies size of investment (I), which is categorized with respect to the absolute number of investment units (money or any equivalent), while the benefits size ($B(I)$) is categorized as the relative quantity of the invested amount. Given the available resources of €10 million, the Comp@ny's business owners were able to provide such quantifications, which made it possible to define the acceptable risk model [16].

The top-level value goal (**V0**) is defined as: Activity to *analyze* the *value* (focus) of *business* (object) for the magnitude of *acceptable risk exposure (ARE model)*; within a timeframe of *5 years* in the context (scope) of *Comp@ny* with constraints of *current resources availability*. Relations are to *the top-level business*

goals.

The **strategy** to address the level-i value goal is *evaluate value (ROI) of the level-i business goals*. Applying the strategy to all business goals, in our case, results in value goals **V1**, **V2** and **V3**. The value goal V3 is associated with business goal (B3) and documented as: *estimate costs and benefits of the business goal B3 for the time frame of 5 years*.

All costs and benefits are estimated in FTE (Full-Time Employee) units. Estimated level-3 benefits were about 36 FTEs in a 5-year period, mainly due to savings accomplished by the introduction of new technology. While, estimated level-3 costs were about 200 FTEs in a 5-year period. The estimates include cost/benefit projections for the goal's realization and later for the goal's maintenance.

In parallel with benefit/investment analysis, business goal owners are asked to identify key assumption(s) about the realization of goals, and to assess the goal's risk exposure (RE). Acceptable risk exposure and risk exposure are assessed on a five-point scale (VH–very high, H–high, M–medium, L–low, and VL–very low) [16]. The summary of business value analysis is given in Table 4.1.

The Comp@ny's business goal and strategy to modernize its testing business by extending its existing range of products with IP testing products have a business value due to the large benefits realization potential. The level of overall investment for the period of five years is relatively small, but there is significant risk, which exceeds the acceptable risk level, associated with the development of the IP testing product (a high likelihood of not having stable product requirements on time). Potential failure of the goal B3 is a threat to the top-level business goal realization. During the feedback session, business owners acknowledged the situation and approved the business goals as such.

Based on results of BVA for the business goal and strategy to modernize the testing business, Comp@ny's management made the decision to proceed with the strategy implementation.

4.3 Organizational Earned Value Analysis

Budget and planned benefits do not just specify the total amount of the financial resources available and overall gains from benefits; they also specify the dynamics of expenditures and of benefits realization materialization.

For the Comp@ny's case, we created the budget and planned benefits according to the estimates assessed during the BVA. In order to demonstrate different potential situations that can occur during the execution phase, we simulated data for four different scenarios.

Ideal case (Scenario 1) In an ideal case, the goals realization proceeds according to plan with minor variations in the budgeted costs and planned benefits realization. Cost-related earned value metrics (Table 3.2) have similar values. In the graph, we can see plots that are close to each other. The cost performance index for all goals

converges toward a value of 1, meaning that all costs are on budget. We can observe the same situation with benefits-related earned value metrics. Both performance indices are converging toward a value of 1, forming a kind of funnel shape.

Total disaster (Scenario 2) In the second scenario, we simulated the worst possible situation. Actual costs exceed budgeted costs, while there is no sign of goal realization. This situation is easily recognizable; $BCWP$ and $PBRM$ values are very small, close to zero, meaning that there is no progress with goals realization. Furthermore, because $BCWP < BCWS < ACWP$ is true for all goals and the gap between them is constantly increasing over time, actual cost is far over budget with uncorrectable delays. Cost performance indices converge toward small values, while the situation with the benefits performance indices is mirrored (larger values are an indication of benefits that are less materialized than planned).

Effective realization (Scenario 3) This scenario illustrates a hypothetical situation where the chosen strategies at all levels are achieving results, with limited but acceptable variations from the plan. Earned value metrics are plotted in Figure 4.1. The top-level business goal B1 was realized in the given timeframe of 5 years ($BCWS = BCWP$ in year 5), with around 20% more costs than budgeted (cost performance indices are converging toward 0.8). At the same time, there was about 50% less planned benefits realized (performance indices converge toward 1.5). If we further analyze the metrics, we can see that significant deviation from the plans occurred after the first year. Earned value metrics for the goal B3 indicate that realization of the goal was lagging behind in the first year ($BCWP < BCWS$). Also, for the same period, the goal B3 was over budget ($ACWP > BCWP$), and after one year and a half the goal B3 was achieved ($BCWS = BCWP$). From the funnel-like shape formed by performance indices we can conclude that in general all chosen strategies were achieving results. In the end, actual expenditures were about 592 FTEs, while realized benefits were about 795 FTEs (calculated as explained in Section 3.1). This situation illustrates the advantage of having information regarding the tracking of not only costs, but also of benefits. The possibility of balancing cost-related information with benefits realization increases the validity of the decision to proceed with goal realization despite over-budgeted costs.

Ineffective strategy (Scenario 4) The last scenario illustrates a situation where realization of the lower-level goal proceeds according to plan, but at the same time, the upper-level goal realization is not achieved. Earned value metrics for this scenario are plotted in Figure 4.2. The plots for the top-level business goal B1 indicate that after the second year, the goal realization was halted (no changes in $BCWP$ and $PBRM$ values). With further analysis, we can conclude that the B3 goal was achieved after 1.5 years with additional costs of about 35% over budget ($CPI = 0.66$). Further, on the next upper level, we can see that the realization of goal B2 was halted after the first year. The unsuccessful realization of B2 has

consequences for the realization of the top-level goal B1. If we compare performance indices for B3 and B2, it is clear that they are diverging from each other. Apparently, the strategy that links B3 and B2 has to be reevaluated.

4.4 Risk Monitoring

Every six months, the key assumptions of the business goals were checked and the risk reassessed. For example, in scenario 3, the earlier identified threat of not having defined product requirements on time (assumption: [A3]) occurred. That was the reason for the delayed realization of the goals, as the product team could not work to full capacity. After the product manager and marketing department specified stable product requirements, the planned team of developers was reinforced with additional members. This situation is visible from Figure 4.1 as the over-resourcing of goal B3 after the first year ($ACWP > BCWP$).

Using earned value metrics, we can identify situations, like in our example, when goal realization is behind schedule, or when the goal is under- or over-resourced. Understanding of the reasons for such situations is provided by risk monitoring. In this example, the reason was not having specified product requirements on time.

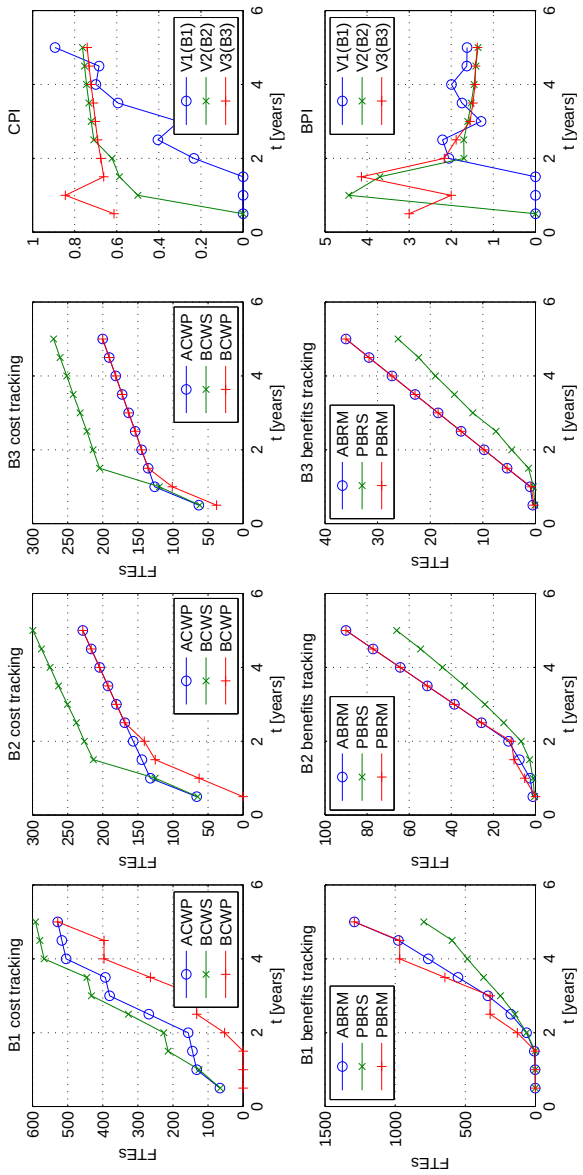

Figure 4.1: Scenario 3: earned value metrics for tracking budgeted cost and planned benefits realization of business goals $B1$, $B2$, and $B3$. Costs-and-benefits performance indices.

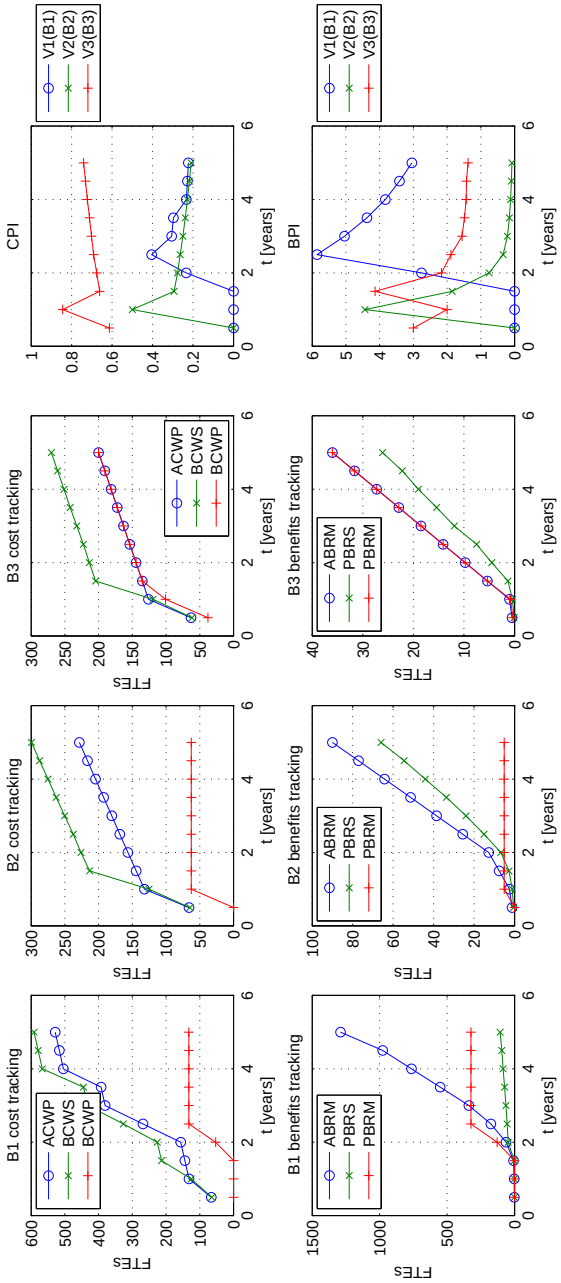

Figure 4.2: Scenario 4: earned value metrics for tracking budgeted cost and planned benefits realization of business goals $B1$, $B2$, and $B3$. Costs-and-benefits performance indices.

Chapter 5

Conclusions

The concepts and ideas introduced by the value-based software engineering framework are attractive to business decision-makers. In light of those ideas, we believe that the goal-driven analysis of the business value equipped with earned value analysis as presented in this paper complements the VBSE framework.

The approach presented here is fully aligned with VBSE concepts defined by key elements. 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 and enables the analysis of earned value at different levels of the goal hierarchy, integrating the cost and benefit analysis throughout the grid by enabling the definition and quantification of the compound phenomenon. The utilization of GQM graph makes measurable not only business goal costs, but allows business goal benefits to be quantified as well by making use of the integrated hierarchy. It allows the calculation of the true earned value of a business goal as the combination of earned value on the cost side and earned value on the materialized benefits side. For example, in section Section 3.2, we explained how the grid structure can be used to help us

measure customer satisfaction in terms of financial value.

We explained how to use earned value analysis for the purpose of monitoring the progress of strategies and business goal implementation. As a part of our future work, we will explore the use of earned value analysis to predict the degree of deviation from the original plans (cost, benefit, and schedule). Such predictions could be used by business owners to decide whether it is worth proceeding with strategy implementation.

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