Utilizing GQM+Strategies for Business Value Analysis

An Approach for Evaluating Business Goals

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ABSTRACT

Business value analysis (BVA) quantifies the factors that provide value and cost to an organization. It aims at capturing value, controlling risks, and capitalizing on opportunities. GQM$^+$Strategies is an approach designed to aid in the definition and alignment of business goals, strategies, and an integrated measurement program at all levels in the organization. In this paper we describe how to perform business value analysis (BVA) using the GQM$^+$Strategies approach. The integration of these two approaches provides a coupling of cost-benefit and risk analysis (value goals) with operationally measurable business goals and supports the evaluation of business goal success and the effectiveness of the chosen strategies. An application of the combined approach is provided to illustrate the feasibility of the proposed method. It deals with the business goal of modernizing the product for the evolving market.

Categories and Subject Descriptors

D.2.8 [**Software Engineering**]: Metrics—*Performance Measures*; D.2.11 [**Software Engineering**]: Management—*productivity*

Keywords

Software Metrics, Business Value Analysis, Value-Based Software Engineering, GQM$^+$Strategies, Value Goals, Benefits Realization

1. INTRODUCTION

Business managers and business owners are paying considerably more attention to *business value* nowadays than in the past. However, what is the business value? There is no consensus, either in academic circles or among management professionals, as to how to define it. The general understanding is that business value is a concept which extends the traditional bookkeeping-like definition of the value by including different aspects of the business as well. Those different aspects of business (e.g., employees, partner networks, ability to adopt new processes rapidly, etc.) form an endless list that is under continuous amendment. A rich financial apparatus for evaluating business investments (e.g., return on investment (ROI), net present value (NPV), portfolio management, etc.) is powerless if we are not able to define inputs (components of the business value). Therefore, the problem focus should be to provide valid inputs or a working structure that can facilitate further analysis.

Business value analysis (BVA) tries to analyze the factors that shape the future instead of forecasting the future. With BVA, one can clearly define "value" from all stakeholders' perspectives and quantify the value of different options. Furthermore, BVA can provide metrics to capture value, control risks, and capitalize on opportunities during projects [29].

In the software industry, where intangible products are produced by intangible production lines "operated" by creative people, the problem is even more challenging than in the manufacturing industry. The special issue of IEEE Software [19] was dedicated to business value aspects in software engineering and ROI. The majority of the papers report cases with a value analysis performed at the end of the investment cycles for a variety of different aspects: software process improvement [32], software product lines [12], and software development [24]. Sharma et al. [28] conducted a study on the relationship between business value and product line engineering, while Harrison [23] demonstrated the usefulness of the financial apparatus on the example of accounting for the economical value of a software company. All these examples address a certain aspect of the business value; actually, they select one item from the endless list.

Boehm [14] proposed the VBSE (Value-Based Software Engineering) framework in order to integrate all aspects of the software creation process from the perspective of value. Business value cannot be measured in the same way as time or volume, because the value is always context-dependent [10]. Added value is not explicitly addressed in software engineering standards or its body of knowledge. The VBSE approach helps elicit sources of value, reconciling value conflicts and organizing activities in software en-

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gineering according to their value [11]. Determining cost–value tradeoff relationships is crucial, especially for software product lines [20].

At the organizational level, Boehm [13] suggests using a value-based version of the Experience Factory [2] and Goal Question Metric (GQM) [3] approach to align the measures to business goals.

GQM$^+$Strategies[1] [6] is an approach designed 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. Research work with GQM$^+$Strategies is in the early phase. The first version of the method was published in 2007 as a white paper [4]. A series of publications illustrated the method's usefulness on limited examples [7, 5, 8]. An empirical study was investigated with one company. It showed that the method could be applied successfully to improve organizational transparency through tighter alignment of measurement practices and business goals [25].

In this paper we describe how to perform business value analysis (BVA) with the GQM$^+$Strategies approach. Integrating BVA with the grid-derivation process adds value to the GQM$^+$Strategies grids in that it enables the identification of the success-critical business goals. The significance of this approach is that it is not dependent on the certain aspects of the business, it provides mechanisms to define business goals. The business aspect of interest is expressed through the business goals, that are further derived and refined it the context of a particular organization.

The rest of the paper is structured as follows. Section 2 gives an overview of the GQM$^+$Strategies approach and reviews the relevant work on business value analysis. In Section 3 we explain how GQM$^+$Strategies is utilized for the BVA. An example of the application of the approach is given in Section 4. Section 5 highlights contributions of our approach. In Section 6 we explain the future direction of our research.

2. BACKGROUND AND RELATED WORK

GQM$^+$Strategies is the result of a 30-year-long evolution and use of the GQM paradigm. The foundation of the paradigm was laid out in the Software Engineering Laboratory (SEL) at the beginning of the 1980s [1, 9]. Even though the method was originally developed for research purposes, in a relatively short period of time it was recognized by the software industry as a viable solution for establishing measurement programs. The method quickly evolved beyond its initial purpose.

Despite difficulties in defining business value, there are frameworks and approaches available for the analysis of the business value in the software domain. We will mention here the most relevant ones for our approach: value-based software engineering [16] and the Benefits Realization Approach [30]. The concept of the value-based software engineering emerged in the late 1990s in the areas of product line engineering and software economics. The Benefits Realization Approach was developed in the late 1990s at Fujitsu's Consulting Center for Strategic Leadership.

2.1 GQM+Strategies

GQM$^+$Strategies [6] is an extension of the GQM approach [3]. The GQM approach 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 supporting and integrating *different* goals at different levels of the organization, explicitly linking them so we can feed the analysis back up the chain. GQM$^+$Strategies creates mappings between the data related to goals at different levels, so that insights gained relative to a goal at one level can still feed up and contribute to satisfying goals at higher levels.

GQM$^+$Strategies introduced several new concepts: multi-level goals, strategies, context/assumptions, and an enhanced interpretation model. Discernment is made between *goal* and *GQM goal*. At one level, the goal can be a business goal, abstract and difficult to operationalize, while GQM goals are directly measurable. Business goals are further refined by *strategies*. The end result of applying strategies is more concrete goals. Using this mechanism, abstract business goals are brought to the level where operationalization is possible. Business goals are formalized by using the *(business) goal template* (Table 1). The template documents the basic *activity* that should be performed in order to accomplish the goal, the main (quality) *focus* of the goal, the *object* under consideration, the quantification of the goal specified by a *magnitude* and the *timeframe* in which the magnitude has to be achieved, the *scope*, and basic constraints that may limit accomplishing the goal. Furthermore, potential *relationships* with other goals are listed.

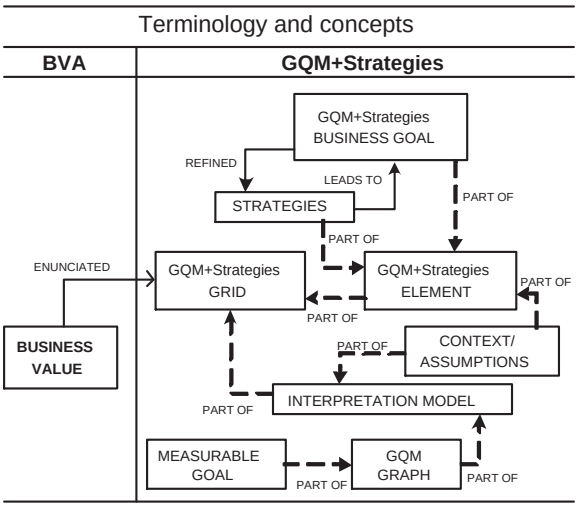

Figure 1: Terminology and GQM$^+$Strategies concepts.

The *Goal+Strategies element* (Figure 1) represents a single goal and its derived strategies, including all context information and assumptions that explain the linkage between 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.

During the entire process of grid derivation, each goal is linked with context/assumption elements. Facts about the business environment are modeled with context factors, while uncertainties about the environment are represented by predictions and are modeled as assumption variables.

GQM$^+$Strategies also introduces the concept of levels. Top-level business goals exist on strategic levels. Further on, the goal derivation process addresses lower levels, for example, the operational level. The number of levels is not predefined, and is determined by an organizational structure. The concept of levels is convenient for

[1] *GQM$^+$Strategies*® is a registered mark of the Fraunhofer Institute for Experimental Software Engineering, Germany and the Fraunhofer USA Center for Experimental Software Engineering, Maryland.

Table 1: GQM⁺Strategies goal formalization template with an example. The template specifies eight goal elements (dimensions).

GOAL TEMPLATE	EXAMPLE
Activity	Increase
Focus	Customer satisfaction
Object	Product X
Magnitude	15% reduction of customer complaints
Timeframe	12 weeks after release
Scope	Web Products Division
Constraints	Product price and functionality
Relations	Can conflict with...

grouping and organizing GQM⁺Strategies elements.

The GQM⁺Strategies grid deviation process [7] is flexible and allows different approaches, starting from top-level business goals down to addressing lower-level goals, or vice versa. During the derivation process, two parallel threads are running: (1) one is related to defining business goals, context/assumption elements, and strategies for addressing goals and, (2) the other is related to defining measurable goals and actually deriving the GQM graph.

In what follows, we give an overview 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 (business) environment is defined by specifying context factors. Uncertainties are documented using assumptions, which represent beliefs or estimates regarding relevant business issues.

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 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 GQM⁺Strategies goal template.

Creating the measurement branch of the grid for each goal and strategy level is not an isolated task; that is, the metrics derived across different levels of the GQM⁺Strategies grid will usually overlap.

Define GQM Graphs. The GQM graph derivation process is well documented in the literature, for example, in [33].

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 realization.

2.2 Business Value Analysis

In IT-enabled businesses, the business value is limited less by hardware capability and more by the ability of managers to invent new processes, procedures, and organizational structures that leverage this capability [17].

The Benefits Realization Approach [30] accentuates the importance of techniques for modeling and value assessment of the investment initiatives (programs). For modeling the Result Chain tool is suggested, while for value assessment a set of four predefined questions is used (Are we doing the right things? Are we doing them the right way? Are we getting them done well? Are we getting the benefits?) [30]. Although the Benefits Realization Approach is mainly used by IT-enabled business, it can be beneficial to business value analysis in general. Thorp [30] identified four so-called *management blind spots*: *linkage* — non existing or vague links between expected results of a business strategy and investments done on different organizational levels, *reach* — an unclear picture of the breath of change required by an investment, *people* — lack of proper motivation and preparation of the people who will be affected by change, and *time* — notoriously hard to estimate realistic time frames. Business value analysis should shed light on those blind spots.

In software engineering, Boehm [13] introduces seven key elements that form the foundation for value-based software engineering. These are: (1) benefits realization analysis, (2) stakeholder value proposition elicitation and reconciliation, (3) business case analysis, (4) continuous risk and opportunity management, (5) concurrent system and software engineering, (6) value-based monitoring and control, and (7) change as opportunity, where the first three are the essential elements for a business value analysis approach.

Benefits realization analysis [13] requires 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 the system development. The analysis also results in visible contributions, outcomes, and assumptions about the system. This key element corresponds to the modeling techniques of Thorp's [30] approach.

Stakeholder value proposition elicitation and reconciliation involves identifying and documenting success-critical stakeholder value propositions. Eliciting stakeholder interest, understanding conflicting positions, and negotiating mutually satisfactory agreements are integral elements of VBSE [21, 11]. Approaches for guiding and structuring group sessions of stakeholders are needed in elicitation and reconciliation process. EasyWinWin [22] is one of such groupware-supported approaches based on the win–win negotiation model. One of the process-related challenges is complexity and identification of goal hierarchies and dependences [21]. The number of goals and the structure of the hierarchy can be large and complex.

Business case analysis [13] involves determining the costs, benefits, and return on investment of a system during its life cycle. Unquantifiable benefits, such as stakeholder good will and uncertainties, e.g., assuming that a product will be the first of its kind in the market, make the business case analysis challenging. Analyzing uncertainties helps in identifying risks related to each development option.

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 [15]. BVA could offer the following benefits to decision-makers [29]:

- Clear definitions of "value" and how those definitions relate to decisions from all stakeholders' perspectives.
- Analysis of the tangible, quantitative outcomes of the project, but with credibility testing to avoid unfounded conclusions.
- Clear, logical analysis of non-quantified and intangible factors.
- A compelling vision that provides the logic and significance for non-quantified and intangible factors

- Quantifying the value of flexibility, options, and choices
- A roadmap that helps firms navigate the transformation from current state to future state
- Metrics and analysis to manage projects during and after deployment to capture value, control risks, and capitalize on opportunities

Properly implemented with supporting information systems, BVA has the potential to lead to better investment decisions and business results [29].

3. BUSINESS VALUE ANALYSIS WITH GQM+STRATEGIES

Our approach promotes the concept of perceiving business value through the GQM⁺Strategies grid (Figure 1). The grid integrates the various aspects of business value expressed and defined by goal owners or stakeholders from different levels (e.g., business owners, managers, developers, etc.). The definition of these goals require the knowledge and experience of the stakeholders to identify what grid elements (context, assumptions, strategies, goals) are valuable and appropriate for the company's success.

Business value should be the most visible at the strategic level of an organization. The constituents of business value permeate through the entire organizational structure, therefore it is difficult to understand the true business value of an organization. The GQM⁺Strategies method provides a structure and process for deriving the goals in a given organizational context, while actual data are used in the GQM graph to interpret the success of realizing business goals and strategies. In order to analyze the value aspect of business goals, it is necessary to implement mechanisms for integrating cost and benefit estimates from different organizational levels, bringing different goals into the same time line, and handling uncertainties (risk). The value goals implement those mechanisms by exploiting the existing GQM⁺Strategies concepts.

We suggest that the business value analysis be a continuous process, based on predictions and assumptions at the beginning, but with the capability of using actual data during the execution phase. Such capability is essential for understanding how real-world situations impact the value of business goals.

The GQM⁺Strategies grid derivation process is flexible as to the starting point for deriving the grid. The value analysis approach presented here does not limit that flexibility. However, to increase our understanding of the approach, we will make the following presuppositions:

Presupposition 1 The GQM⁺Strategies grid derivation process is top-down, starting with the top-level business goals.

Presupposition 2 The value analysis steps are taken in parallel with the grid derivation process.

Presupposition 3 The entire process of the grid derivation and business value analysis is done by a single group with knowledgeable representatives from all organizational levels.

Constricting the inherent flexibility of the grid derivation process has no impact on the methods used; the value analysis could be done after the entire GQM⁺Strategies grid is defined. However, a parallel derivation can increase the quality of the strategic decisions by using goal value information to direct the derivation process.

Table 2: Top-level value goal formalization template.

VALUE GOAL	
Activity	**Evaluate**
Focus	**Value**
Object	**Business**
Magnitude	*Acceptable risk*
Timeframe	*Time-period of analysis*
Scope	*Corporation*
Constraints	*Current obligations*
Relations	**Top-level business goals**

3.1 The Value Goals

We introduced the value goals with the intent of analyzing business goals. The value goal is the GQM⁺Strategies goal applicable to the business goals and strategy elements of the grid. The introduction of the value goals enables procedures for effective analysis of business values represented by the GQM⁺Strategies grid and handling of uncertainties or risk.

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 same time integrating cost and benefits estimates from all levels.

Business goals and value goals share the same structure. The significant difference is that value goals are applicable to business goals, and eventually, to the grid. For example, the *timeframe* of a business goal defines a point in time when goal achievement is expected, while the *timeframe* of a value goal defines the time period which will be the basis for analyzing business goals.

Top-level value goals have some peculiarities that are important for successful business value analysis. The following dimensions of top-level value goals are fixed: activity, focus, object, and relations (Table 2).

Activity: Evaluate. Value goals are always about evaluating or analyzing the value of the business goal at certain points in time. A business improvement goal requires value goals to monitor and control the desired improvements.

Focus: Value. In order to evaluate value, it is necessary to appraise or estimate all costs and benefits. In certain cases, it is acceptable to have an ROI (Return On Investment) instead of the value. In both cases, inputs are the same—costs and benefits—except that for ROI, inputs have to be quantified in order to produce an ROI indicator.

Object: Business. In the light of GQM⁺Strategies, the business is perceived according to business goals. By default, it is expected that all business goals will be evaluated; however, it is possible to limit the scope of evaluation to a certain set of business goals.

Magnitude: Acceptable risk. Assumption elements are the main carriers of the risk for successful realization of the business goals. Risk and handling uncertainties will be addressed in the step involving the interpretation model consolidation.

Timeframe: Time-period of analysis. The main input components, costs and benefits, are time dependent. Without a predefined time period, the evaluation is meaningless. 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. The most common obligations are contractual (external) or obligations defined by organizational policy or other corporate documents (internal).

Relations: Top-level business goals. If the object is to assess the entire business, then all top-level business goals should be evaluated. However, it is possible to limit analysis to certain business goals.

The difference between the top-level value goal and other value goals is that the top-level value goal defines the model of acceptable risk for the available size of investment, and based on context information, specifies the time-period of analysis. Further, value goals are refined by the strategy: *evaluate value (ROI) of level-i business goals*. A value goal estimates cost and benefits of the corresponding business goal for the specified time period, and uses cost–benefit information to assess acceptable risk with the model specified by the top-level value goal.

The rationale for investment-related decisions [26, 27] is based on a minimum of three components: size of the investment, the risk, and the expected ROI. Knowing the level of the financial resources available and the ROI model makes it possible to assess the acceptable risk level.

Acceptable Risk.

Acceptable risk is the amount of risk that business owners (investors) are willing to take in order to materialize perceived benefits in a certain period of time. We defined acceptable risk exposure (ARE) as a measure of that acceptable risk:

$$ARE = ARE(\mathcal{I}, \mathcal{B}(\mathcal{I}), t) \tag{1}$$

where $\mathcal{I}$ is investment size, $\mathcal{B}$ is relative size of benefit from investment $\mathcal{I}$, and t represents the time period in which the investment is supposed to be realized.

The ARE model is defined by the top-level value goal, while other value goals specify the acceptable risk exposure based on cost–benefits estimation.

Cost analysis.

In order to integrate the cost estimates of business goals, we have to understand the recursive structure of the costs (Equations 2 and 3). 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 which 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. Allocation of resources is mainly done at the operational level.

At the moment a business goal is achieved, some resources should be allocated to maintain the desired state (*goal maintenance costs*).

$$\hat{Cost}(A) = \hat{Cost}(A(Strategies)) + \hat{Cost}(Maint(A)) \tag{2}$$

$$\hat{Cost}(A(Strategies)) = \sum_{A_i \in D(A)} \hat{Cost}(A_i) \tag{3}$$

where $\hat{Cost}(A)$ is the cost estimate of goal A, $\hat{Cost}(A(Strategies))$ is the cost estimate of strategies for addressing goal A, $D(A)$ is a set of goals derived from a goal A, $\hat{Cost}(Maint(A))$ is the goal maintenance cost estimate, and $\hat{Cost}(A_i)$ are cost estimates of the derived goals $A_i, A_i \in D(A)$.

The value analysis is performed for a predefined time period, which is determined by the timeframe of the top-level value goal.

$$Cost(A) = Cost(A)|_0^{Timeframe} = Cost(A)|_0^T \tag{4}$$

$$= Cost(A)|_0^{T_A} + Cost(Maint(A))|_{T_A}^T \tag{5}$$

where T is the timeframe defined by the top-level value goal, and T_A is the timeframe defined by business goal A.

A GQM$^+$Strategies grid usually contains business goals with different timeframes; equations 2 and 5 enables cost analysis in such cases.

Taking benefits into account.

Unlike the costs, benefits can be harder to estimate and quantify. It is important to analyze the benefits at all levels (e.g., a benefit at the-top level can be expressed as increased market share, while a benefit at the operational level for the same top-level business goal can be effort savings).

It is not possible to calculate the overall benefit as a simple sum of the benefits because the existence of conflicting value goals can have, as an implication, a mutual cancellation of the benefits. Therefore, a step involving analyzing conflicting value goals to re-estimate benefits is necessary. Let us define for each value goal A a set of conflicting value goals $C(A)$, The re-estimated benefit is calculated as:

$$Bnft^*(A) = Bnft(A) - \sum_{A_i \in C(A)} v_i \cdot Bnft(A_i) \tag{6}$$

where $Bnft^*(A)$ is the re-estimated benefit of the goal A, $Bnft(A)$ is the benefit of goal A before taking conflicting goals into account, and $v_i, v_i \in \mathbb{R}$ are factors for modeling the impact of conflicting goals.

This could occur if the value goals are competing for the same resources in a mutually exclusive way. For example, company ABC is in the consulting business. Their service delivery channel depends on a software product developed in-house. In order to cope with new technologies, the company established a new department responsible for delivering the services via a global network. A new web-based version of the existing software has been developed. Old and new departments can have the same business goal to increase the market share, but in certain market segments they are targeting the same pool of clients. If the targeted market segments are not overlapping, then there is no impact: $v = 0$. However, if they do overlap, then $v > 0$.

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. Therefore, the same set of equations can be written for benefits based on Equations 2 and 3.

Investment decisions are governed by the level of embedded risk, size of the investment, and expected benefits (ROI). Once value goals are defined and information regarding the expected benefits and costs (the investment size) becomes available, the remaining steps involve using the risk-related information and interpreting the risk with the interpretation model.

3.2 Interpreting Risk

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.

Prerequisites for the risk interpretation are:

1. Defined the top-level value goal, with an acceptable risk model
2. Defined value goals and corresponding business goals

3. Determined and estimated cost and benefits through context and assumption variables for each value goal

We can identify the assumption elements of the GQM⁺Strategies grid as carriers of the uncertainties. A properly derived GQM⁺Strategies grid identifies and documents assumptions that are key for the successful realization of business goals. Let us define for a business goal B a set of key assumptions A. The risk of a business goal B can be assessed by analyzing the level of certainty of key assumptions (likelihood), and its impact on the goal contentment:

$$RE(B) = L(A) \times I(A, B) \quad (7)$$

where $RE(B)$ is the risk exposure of a business goal B, $L(A)$ is the likelihood of key assumptions A, and $I(A, B)$ is an impact of A on the realization of goal B.

We differentiate two types of assumptions: positive and negative. Positive assumptions predict a desirable situation, while negative assumptions describe a situation in which actualization has a direct impact on a goal's failure. For proper risk assessment it is necessary to negate positive assumptions.

Our intention is not to define methods and tools for quantifying risk, but to describe a procedure for how to use the risk-related information. Therefore, this approach is not dependent on a risk quantification method. It only requires that all participants are familiar with the risk quantification method used and its relation to the acceptable risk model. Some advanced methods for quantifying risk can be found in [18, 27].

Incorporating risk into the interpretation model.

After deriving all business and value goals, the context and assumptions are documented for all levels. The next step is to incorporate risk level into the interpretation model. During the derivation process, assessment of the level of the acceptable risk of value goals (*ARE*) and the level of the risk of business goals (*RE*) was carried out.

For each pair (v, b) of value goal v and business goal b:

IF $ARE(v) \geq RE(b)$ **THEN** the risk level is acceptable; **ELSE** risk of business goal b exceeds the acceptable risk level for that size of investment and ROI, so we need to re-evaluate the business goal and/or cost and benefit estimations.

It is possible that after re-evaluation the situation remains unchanged. Those cases have to be discussed during the feedback session, and an explicit decision is required in order to retain "risky" goals.

By defining value goals, we can use the GQM⁺Strategies process and tools to determine the context and assumption variables. The cost structure is specified by the context factors, while expected costs and benefits are specified by the assumption variables.

Value goals as elements of a GQM⁺Strategies grid participate in two types of relationship: (1) those between value goals at one level and value goals at the next level, and (2) those between value goals and the corresponding business goals.

The advantage of using GQM⁺Strategies is that it provides an explicit link to the different levels, from the top level to the operational level. This implies that value goals exist on different levels, analyzing benefits and costs at those organizational levels.

4. 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 and not to validate it empirically.

Due to space limitation we will present here a partially defined GQM⁺Strategies grid. The goal tree has only operational level GQM⁺Strategies elements completely defined (made measurable). This restriction of the grid does not affect the illustration of the business value analysis steps. First we will explain the business goals derived in the context of Comp@ny; after that the BVA is described.

The GQM+Strategies grid derivation.

Comp@ny has been present on the market for more than 15 years. In that period it has grown from a small company into a multinational organization, having operations in nine countries worldwide. The main focus of the company is the development of tools for testing specific systems. The development of such tools requires both software and hardware design and development. 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 the business goal template (Table 1),for Comp@ny, the top-level goal (**B1**) is defined as: Activity to *modernize* the *business* (focus) for *testing services domain* (object) for the magnitude of *at least one new market niche*; within a timeframe of *5 years* in the context (scope) of *a European corporate site* with constraints of *current resource availability*. Relations to *the corporate policy*.

There are assumptions: that expanding testing services with IP testing systems is a business valid 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: Activity to *develop* the *marketability* (focus) for *IP testing products* (object) for the magnitude of *50% coverage of customer needs (for the first release)*; within a timeframe of *2 years (to have the first release)* in the context (scope) of *R&D and the marketing department* with constraints of *resources, IP competence, and compete with existing competitors*. Relations are to *competing resources, existing business*.

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 MoSCoW method* [31] is chosen and it further leads to the next level business goal.

The level-3 business goal (**B3**) is: Activity to *develop the software product* (focus) for *IP testing business* (object) for the magnitude of *100% of the MUST features and 30% of the SHOULD features*; within a timeframe of *1 year (to have a beta version)* in the context

(scope) of *R&D* with constraints of *resources, IP competence, compete with existing competitors*. Relations are to *competing resources, existing business*.

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 $MF(x), x \in \{M, S, C, W\}$ percentage of features by category (Must, Should, Could, Would) in 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):

$$\vdots$$
if $MF(M) = 100$ and $MF(S) \geq 30$ **then** B3 is on track **else** re-evaluate level-3 decisions;
$$\vdots$$

The statement *re-evaluate level-i decisions* is often used in the interpretation model, and it means to check context and assumptions (which can be seen as rationales for decisions) if there are any changes or assumptions which proved to be wrong. The new/changed set of assumptions, most probably, will result in new level-i decisions.

We will illustrate business value analysis (BVA) using the exemplar GQM+Strategies grid, derived for the Comp@ny's scenario to modernize the business. The example is simplified with the presupposition that the time period of 5 years is too short to affect the time component of investment decisions.

The Business Value Analysis.

First, general context and assumptions of the BVA characterized 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).

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 matrix, Equation 8)*; 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*.

There is a context factor that quantifies size of investment and benefits as: 1–small, 2–medium, and 3–large. The investment size (I) is categorized in 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 specified an investment of less than €7 million as small, an investment of greater than €7 million and less than €13 million as medium, and greater than €13 million as large. The common understanding is that small benefit is less than 20% of investment, medium is between 21% and 50%, and large benefit is if it is greater than 50% of investment.

In order to produce the acceptable risk matrix (Equation 8), business owners were asked to specify acceptable risk exposure for each pair of investment size and benefit size. Risk exposure is quantified on a five point scale from VH (very high risk), most probable to occur with significant consequences, to VL (very low risk), unlikely to occur with no severe consequences. Therefore, the ARE matrix is:

$$ARE = I \times B(I) = \begin{bmatrix} M & L & VL \\ H & M & L \\ VH & H & M \end{bmatrix} \quad (8)$$

where the columns represent investment size and the rows the benefits size. Risk exposures: VH is very high, H is high, M is medium, L is low, and VL is very low.

The **strategy** to address the level-i value goal is *evaluate value (ROI) of the level-i business goals*. The next level value goal (**V1**) is associated with business goal (B1) and documented as: Activity to *estimate* the *cost and benefits* (focus) of *B1:modernize testing business* (object) for the magnitude of *acceptable risk exposure*; within a timeframe of *5 years* in the context (scope) of *Comp@ny* with constraints of *current resources availability*.

For this goal, V1, context elements and assumptions were used to estimate the level-1 cost and benefits. The significant benefit is estimated from entering a new business domain, which has the potential of several hundreds of millions of Euros. A reasonable estimate is to take over 5% to 10% of the market share, which is worth about €10 million in a 5-year period. The only cost estimated at this level is a probable loss of several customers, which will result in €2.5 million less income for 5 years. The perspective on cost and benefits from the top-level of the organization is incomplete until the same analysis is done on all levels, using the recursive cost (Equation 3) and benefits formulas.

The same procedure is applied to all business goals, in our case it results in value goals **V2** and **V3**. Value goal V3 is associated with business goal (B3) and documented as: Activity to *estimate* the *cost and benefits* (focus) of *B3: developing software product for IP testing* (object) for the magnitude of *acceptable risk exposure*; within a timeframe of *5 years* in the context (scope) of *Comp@ny* with constraints of *current resources availability*.

All cost and benefits are estimated in FTE (Full-Time Employee) units. Tool related costs are converted to the FTE equivalent. Estimated level-3 benefits were savings accomplished by introduction of new technology; total savings of about 36FTEs in a 5-year period. The main level-3 cost carrier is product development, estimated as 120FTEs (team of 10 people for one year) and 72FTEs for maintaining the product for four years (Equations 2 and 5). Also, some additional tools and licenses are needed; the cost equivalent is 8FTEs.

After estimating level-3 cost and benefits, using the acceptable risk exposure (ARE) matrix, it is possible to assess the acceptable level of risk of value goal V3, which is associated with business goal B3. The summary of benefit/investment analysis and acceptable risk exposures is given in Table 3.

In parallel with benefit/investment analysis, business goals owners are asked to identify key assumption(s) for the realization of goals, and for each business goal, to estimate the assumption certainty and the impact of the assumption on goal contentment.

The likelihood of an assumption (or assumption certainty) is quantified using a three-point scale: 1–low, 2–medium, and 3–high. The goal impact is also specified as: 1–low, 2–moderate, 3–significant. Based on that, risk exposure is calculated from the *RE* matrix (Equation 9). Risk exposure is quantified with the same five-point scale as used for acceptable risk exposure.

Table 3: 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*

Table 4: GQM⁺Strategies business goals' risk assessment.

Business Goal	Key Assumptions	Likelihood (certainty)	Goal Impact	Assumpt. Type [+/-]	RE
B1	[A1]: Existing core competences can be adequately extended with IP testing knowledge/skills in relatively short time period.	High	Significant	+	*M*
B2	[A2]: Product manager and marketing department have sufficient understanding of customers' needs in new business domain.	Medium	Significant	+	*H*
B3	[A3]: Stable product requirements will be ready and specified on time.	Low	Moderate	+	*H*

$$RE(x) = L(y) \times I(y,x) = \begin{bmatrix} VL & L & M \\ L & M & H \\ M & H & VH \end{bmatrix} \quad (9)$$

where the columns represent the likelihood of an assumption y, and the rows are the impact of assumption y on contentment of business goal x.

The results of the goals risk assessment are given in Table 4. For example, for successful realization of the business goal B3 (develop IP testing software product) the key assumption is that product requirements will be stable and will be specified on time [A3]. The likelihood of having such requirements ready is assessed as very low. Not having stable requirements on time does not mean certain goal failure. Therefore, the goal impact of the assumption is moderate. The type of assumption is positive, therefore risk exposure is quantified based on consequences of **not** having stable product requirements on time (the opposite of low is high, therefore RE(B3)= High×Moderate= H).

The result of **the interpretation model** identifies goal B3 as a risky due to higher risk than it is acceptable for the business owners (the condition: $ARE(B3) \geq RE(B3) = M \geq H$ is false). Further, for the business goal B2 the risk is exactly on the acceptable limit (the condition: $ARE(B2) \geq RE(B2) = H \geq H$ is true); while for the business goal B1 the acceptable limit is higher than the assessed goal risk level (the condition $ARE(B1) \geq RE(B1) = VH \geq M$ is true).

During the feedback session, business owners acknowledged the situation and approved the business goals as such.

Summary of the business value analysis: The Comp@ny's business goal and strategy to modernize its testing business by extending its existing range of products with IP testing products has a business value due to the large benefits realization potential. The level of overall investment for the period of 5 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.

5. BENEFITS OF THE APPROACH

In previous sections we explained the approach of performing business value analysis with the GQM⁺Strategies method. The advantage of this approach is coupling cost-benefit and risk analysis (value goals) with business goals.

The result of the BVA provides additional insight into the quality of derived GQM⁺Strategies grids. The incorporation of the risk level into the interpretation model identifies a *critical GQM⁺Strategies sub-grid* (Figure 2). The critical sub-grid contains risky goals and goals whose realization is threatened by the risky goals. Thus, the critical GQM⁺Strategies sub-grids provide valuable information to the managers, i.e., which goals require more detailed analysis in planning and which goals require more monitoring when implementing the business goals and strategies.

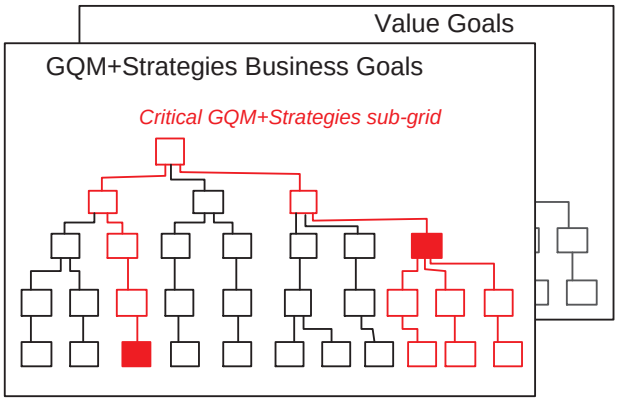

Figure 2: Illustration of a critical GQM⁺Strategies sub-grid.

The approach presented here is fully aligned with the business value analysis key elements of the VBSE. VBSE defines a framework that specifies activities that need to be performed in order to understand and analyze value in a software engineering context. The *benefits realization analysis* is carried out while analyzing the context of the value 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*. GQM⁺Strategies provides a single structure (grid) and the process (grid derivation process) that are able to accommodate those activities; in other words, the grid *enunciates* business value.

Therefore, using GQM+Strategies for a business value analysis is a logical consequence of the fact that business value is enunciated by the grid. Also, our approach complements the modeling and value assessment technique for the *Benefits Realization Approach* in a goal-oriented manner.

The utilization of GQM+Strategies for business value analysis addresses the management blind spots. Linkage — the GQM+Strategies grid explicitly exposes all relations between grid elements within and between different organizational levels. Reach — the grid derivation process permeates the entire organizational structure, from the top-level to the operational levels, and makes visible the breath of change. People — the grid derivation process is transparent and requires involvement of the people from all organizational levels, as those very same people are defining their own goals and strategies to address upper-level goals and strategies. Involving all these people in goals and strategies definition is a preparation and motivation for change. Time — one of the business goal's dimensions is time (*timeframe*), which is explicitly part of the process of defining and analyzing business context dynamics and value while defining goals and strategies.

6. FUTURE WORK

In the early planning phase of business goals and strategies, value goals help us to select the GQM+Strategies grid elements that are needed (inputs) for the business value analysis. BVA evaluates business goals and strategies and provides information regarding cost and benefit estimates, and goal risk to decision-makers. With such ascertainment, the decision-makers are in a position to make valid decisions on further support and commitment to strategic plans. Consequently, when the support and commitment is granted by providing real resources (e.g., financial, human, time, etc.) estimated costs with needed adjustments become budgeted costs, and estimated benefits become planned benefits.

The focus of our future research work will be on tracking actual costs and benefits by incorporating a GQM cost–benefit graph into the grid, and on risk monitoring. Interpreting actual cost–benefit and risk data will enable further alignment of our approach with the key elements of the VBSE.

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