Application of Benefit-Cost-Risk Formula and Key Change Indicators to Meet Project Objectives

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Abstract

An approach to facilitating the definition, selection and achievement of the quantitative objectives (e.g. cost, benefit, time, quality, functionality) and qualitative objectives of a software project is proposed. It is designed to be flexible, easy to understand and implement, and cost effective. It is based on:
Identifying, analysing, evaluating changes effecting the objectives and emanating from its internal and external context/environment. A change is defined as a change in circumstance including events that can effect objectives, and the project is considered in terms of culmination of changes and their relationships.
Implementing a plan to implement measures to respond to changes and requirements for Key Change Indicators (KCI).

KCI is proposed to indicate deviation of change from expected, and whether a change has or has not occurred.
A benefit-cost-risk formula is proposed for analysing quantitative objectives: To represent financially objectives or aspect of objectives, for financial cost and benefit to be multiplied by their respective probability with a rage from ($0 < p \leq 1$), and for the accumulated benefit to be divided by accumulated cost to provide a ratio.
A diagrammatic convention is proposed to visualise changes and their relationships.

The approach is intended to be used with any type of project size and complexity, type of software, and software development, project management, risk management and change management approaches.

Keywords: Project, Risk, Cost, Benefit, Objective

1.0 Introduction

The software industry is a large, growing and evolving industry which has encountered numerous problems with delivering projects to meet their original quantitative and qualitative objectives for software development and maintenance and the expected benefit to the organisation/user.

The aim of the proposed approach is to facilitate the definition, selection and achievement of software objectives given various levels (e.g. phase, project), timespans and types (e.g. quantitative, qualitative) through:

- Better identifying, analysing, evaluating changes effecting the objectives emanating from its internal and external context/environment (context)
- Implementing a plan that implements measures to respond to changes and requirements for Key Change Indicators (KCI). KCI is proposed to indicate deviation of change from expected, and whether a change has or has not occurred, and is relevant to prior and/or post change state

The strategic and software project objectives should be consistent with each other. A change is defined as a change in circumstances including events that can effect one or more objectives, and the project is considered in terms of culmination of changes and their relationships. The level of changes at its highest level is overall project level and the lowest level is the activity/process.

The approach incorporates and takes into consideration the correlation between the following software project objectives which can be estimated or evaluated:

- Financial objectives (e.g. financial cost, financial benefit)
- Nonfinancial objectives (e.g. time, quality, functionality). If possible the deviation from expected should be represented financially
- Nonfinancial objectives that cannot wholly or partly be represented financially (e.g. reputational, human factors, protecting personally identifiable information, social benefit from software related service)

The post-implementation financial cost and benefit can result from software (e.g. internal service/support improvements, value of source code and reuse, provision of software externally, cost of downtime, maintainability and support) in addition to other sources.

A quantitative benefit-cost-risk formula is proposed:

- To represent financially objectives or aspect of objectives
- Financial cost and benefit are multiplied by their respective probability with a range from ($0 < p \leq 1$)
- The accumulated benefit is divided by accumulated cost to provide a ratio

- The ratio based on division can indicate the following projection or progression: less than 1 not feasible, 1 breakeven, and the greater than 1 the better

A diagrammatic convention is proposed to visualise changes and their relationships.

This approach provides a formal, effective, efficient, and adequate means of managing change including risks. In the context of this paper a risk is the effect (i.e. positive and/or negative) of uncertainty on objectives [1]. The benefits of integrated risk management include lack of duplication of effort, gaining an overall perspective, involvement of all relevant stakeholders in decision making, and improved risk management.

2.0 Managing Change Process

Changes are the necessary part of accomplishing the objectives of a software project. Given change can or will create, enhance, prevent, degrade, accelerate or delay the achievement of objectives, this approach recommends best practice in dealing with current and future change. Best practice should be supported by communicated principles.

2.1 Table for Identifying Changes

Table 1 can be used for identifying changes. The organisation should add, delete or modify the objectives, internal and external context categories provided to match the requirements of their organisation or project. For brevity the table of columns and rows are not drawn in a matrix.

Table 1: Identifying changes

Columns: objectives include, but is not limited to	Cost	Benefit	Time	Quality	Functionality	etc

Rows: internal context that can give rise to changes in objectives include, but is not limited to	Decision making / stakeholder expectation	Action / Activities	Relationships and interaction	Information / data
	Communication / reporting	Service / Product	Resource (e.g. financial, physical,	Process / procedure

				human)		
	Organisational policy / direction		Methods / methodology / techniques / standard	Governance / organizational structure	etc	
Columns: objectives include, but is not limited to	Cost	Benefit	Time	Quality	Functionality	etc

Rows: external context that can give rise to changes in objectives include, but is not limited to	Decision making / stakeholder expectation	Action / Activities	Relationships and interaction	Information / data
	Communication / reporting	Service / Product	key drivers / trends / factors	Legal / regulatory
	Market positon / share	etc		

2.2 The Process Steps in Managing Change

2.2.1 General

The organisation should adapt/design and plan the process steps in managing change (Figure 1) to their specific requirements and if required combine it with their existing processes. These steps do not need to be followed in a rigid and sequential manner. Information such as objectives, scope, stakeholders and relations, coordination, communication/reporting/control lines, roles, accountability/responsibly/authority, and requirements including resources should be defined and endorsed (e.g. policy, mandate) by management.

The outcome of this process should be appropriately recorded (e.g. Spreadsheet, database, word processor document) and used for communication, future projects, organisational learning and continual improvement, and adequately reported to relevant stakeholders in a timely manner.

During the process monitoring is likely to be continual and review is likely to be periodic or ad hoc.

This process is dynamic, can iterate and should be responsive to relevant changes in internal and/or external context of project, requirements, assumptions, and quantity and quality of information.

The maturity of this process can result in:

- Improved performance, effectiveness, and efficiency of measures to respond to changes
- More accurate estimates based on benefit-cost-risk formula (point 4)

The supporting approaches that can be used include interviews with experts, workshops, historical information investigation, research, modelling, scenario analysis and prototyping that can be performed in combination. If there is more than one stakeholder they should be involved. Factors such as divergence between opinions of experts, inadequacy of information and inherent problems with the modelling technique used should be considered.

The level of detail performed for each step and the type of supporting approach used can depend on criteria such as requirements, resource availability, capability and nature of change.

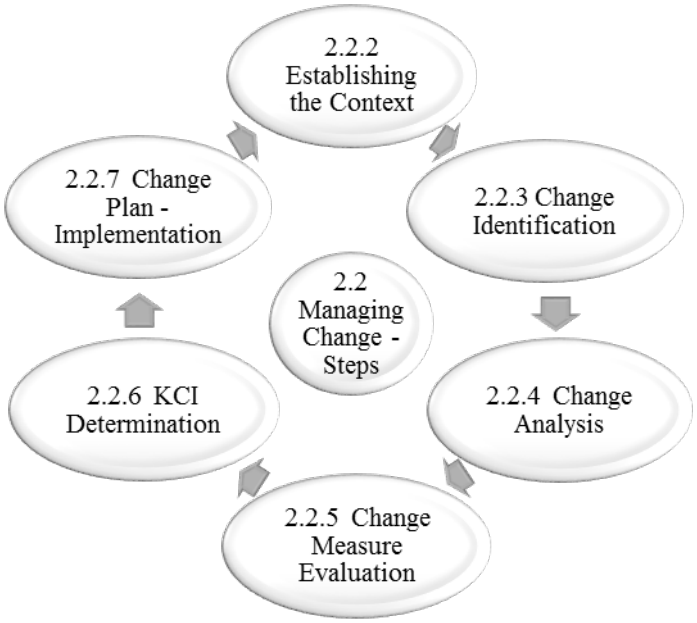

Figure 1: Managing change steps

2.2.2 Establishing the Context

The internal and external context of the organisation or project should be adequately known. Where possible or feasible actions can be undertaken to ascertain unknown information.

2.2.3 Change Identification

The purpose of this step is to reveal what, where, when, why, how and who related to a change.

The following are the recommended steps for identification:

- Identify the changes in each cell of Table 1 (2.1)
- Identify the known characteristics (e.g. source, destination, cause, negative/positive effect, timing, purpose, scope, frequency, probability/qualitative-likelihood) and related factors (e.g. stakeholders, existing response measures, resource allocation) for each change
- Identify the relationships between changes where relevant

The lack of identification of changes does not preclude the occurrence of that change.

2.2.4 Change Analysis

The purpose of this step is to develop a more detailed understanding of the change under consideration.

The following are the recommended steps for quantitative analysis of the change:

- To calculate the direct financial cost and/or benefit for a change
- If possible:
    - The improvements in quality and functionality and reduced time should be converted in to a financial benefit
    - The diminishment in quality and functionality, and increased time should be converted into a financial cost
- For each change with unknown characteristics:
    - Estimate/evaluate an unknown probability from factors such as qualitative-likelihood, cause, frequency, and timing where $0 <$ probability < 1
    - Estimate/evaluate an unknown financial cost and/or benefit from effect and timing.
    - A probability distribution graph (point 3) can be used
- If there is one cause and effect, the probability should be multiplied by financial cost and/or benefit

- If there is more than one cause and/or effect, the multiplication can be considered on a case by case basis. A simple approach is to use the highest probability and for financial cost and/or benefit to be accumulated

The total financial cost and/or benefit for a change portfolio of an option (e.g. phase, project) is the accumulated cost and/or benefit of individual changes, multiplied by their respective probabilities, and taking into account relationships (e.g. combination, effect) between changes.

Provided the benefit can be represented financially the benefit-cost-risk formula (point 4) can be used to facilitate evaluation of one or more options. Where benefit is partially or wholly nonfinancial approaches such as cost-effectiveness analysis can be used. The financial benefit and/or cost may be adjusted for present value based on nominal or real interest rate.

A diagrammatic convention (point 5) is used to visualise the change portfolio and make reference to its content. The change portfolio that can be dynamically updated and diagrammatic convention will be used in subsequent steps.

2.2.5 Change Measure Evaluation

The purpose of this step is to make decisions about which measures to use for which changes.

To establish the measures that need to be taken in isolation or combination to address current and future changes. This can entail additional measures, and removing or adjusting existing measures. A change may not require any measure and there may be occasions where no measure or viable measure are available. The effect of the measures can be to avoid or enable a future change, or increase and/or decrease one or more characteristics of change (e.g. probability, cost, benefit, time, rate of change).

The adequacy, effectiveness and efficiency of measures is an important consideration.

Factors other than probability, cost and benefit can be considered in prioritisation of changes. Where relevant these include rate of change, relationships between changes (e.g. knock-on effects), and time to occurrence.

Selecting the most appropriate measures involves balancing:

- The financial cost of measure against financial benefit gained from its effect on change(s). These benefits include:
    - Enabling benefit
    - Avoiding cost
    - Increasing benefit
    - Decreasing cost

The results can be incorporated in the benefit-cost-risk formula (point 4) to facilitate selecting the most appropriate measures.

- The financial cost of measure against nonfinancial benefit gained from its effect on change(s). Approaches such as cost-effectiveness analysis can be used

Human and cultural factors should be considered. For example some measures can be equally relevant however one may be more acceptable.

2.2.6 Key Change Indicators Determination

The purpose of this step is to make decision about which KCI to use for which Changes.

An applied KCI provides a better understanding of the change in a proactive, dynamic, timely, accurate, transparent, and responsive manner.

The following are the recommended steps:

- Determine which change will have a KCI based on prioritising of changes
- Determine whether this will be a pre-change and/or post-change KCI
- Determine one or more characteristics for pre-change KCI (e.g. probability, cost, benefit, rate of change, timing) and post-change KCI (e.g. cost, benefit, rate of change, timing)
- Determine how KCI will be measured, compared and reported/escalated

KCI will indicate:

- A deviation of change characteristic(s) from expectation
    - A pre-change KCI will indicate estimated/probable deviation
    - A post-change KCI will indicate evaluated/actual deviation
- A change is happening
- A change is not happening

2.2.7 Change Plan – Preparation, Implementation, Monitoring and Review

The purpose of this step is implementation of measures for changes and requirements for KCI.

The information in the plan should include:

- Characteristics of changes
- Relationships between changes where relevant
- Measures to respond to changes
- KCI
- Timing and schedule

The information in the plan can include:

- Objective/strategy
- Resource requirements (e.g. human, information, financial)
- Those having accountability/responsibility/authority for the plan
- Reporting and communication requirements
- Milestones
- Other factors (e.g. performance criteria, constraints, expected difficulties)

Plan should be defined, documented, communicated with relevant stakeholders, implemented, and if relevant combined with other project plans.

Monitoring and review needs to be an integral part of the plan to:

- Indicate progress against the plan
- Give assurance that the measures remain effective, efficient and adequate

A diagrammatic convention (point 5) is used to visualise the plan in terms of changes and their relationships (e.g. combination, effect, dependency) and make reference to its content.

3.0 Probability Distribution Graphs

There may be occasions where there is relatively too much uncertainty attached to financial cost and/or benefit estimation however the requirement is for more accurate estimation. In this case probability distribution graph (PDG) can be used. The probability ($0 \leq$ probability ≤ 1) is on the Y-Axis and financial benefit and/or cost is on the X-Axis.

If cost and/or benefit values are a finite number then a discrete PDG should be used. The probability for all cost or benefit values must equal to 1.
If cost and/or benefit values are an infinite number then a continuous PDG should be used. The probability for the total area of cost or benefit values must equal to 1. However for simplicity a discrete PDG can be used instead of continuous PDG where probability density function is unknown or difficult to calculate.

If the cost and/or benefit values are closely distributed then the mean can be used. If cost and/or benefit values entail outliers (i.e. extremes) compared to majority of values then the median can be used. With regard to continuous PDG the probability density function for the graph needs to be defined in order to calculate the mean or median.

An approach to sampling values other than the mean or median will be to use an error adjustment table (Table 2) for the organisation or a particular project. A value will be compared with the mean or median based on ratio. Any value within the

ratio bracket will be increased or decreased using the respective percentage. The aim is to adjust the value with respect to tolerance around mean or median. These values can be used as part of approaches such as what-if analysis or used instead of mean or median.

Table 2: Tolerance around mean or median

Ratios:	A: C	A : B	A (Mean / Median)	D : A	E : A
Percentages**:**	Increase	Increase	Not Applicable	Decrease	Decrease

The following calculations can contribute to composition of the Table 2:

- The standard deviation around mean or the median absolute deviation.
- The measure of skewness (i.e. asymmetry) and kurtosis (i.e. flatness/pointedness) about the mean.

There are software tools that visualise and automate the calculations of mentioned values.

Provided the benefit can be represented financially the selected values can be used in benefit-cost-risk formula (point 4) to facilitate decision making. Where benefit is partially or wholly nonfinancial approaches such as cost-effectiveness analysis can be used.

4.0 The Benefit-Cost-Risk formula

4.1 Benefits for Having the Benefit-Cost-Risk Formula

The benefits of benefit-cost-risk formula include:

- To select alternative options at various levels of project or between projects
- To measure the progress of project with regard to its objectives
- To measure the cost effectiveness of measures
- To be used as part of communication and reporting to relevant stakeholders
- To be recorded and used for comparison with previous or future projects

In decision making the formula should be used in conjunction with objectives that are partially or wholly nonfinancial.

4.2 Descriptive Definition of Benefit-Cost-Risk Formula

The values for the following formula are based on a given point in time or over a period of time.

$$\text{Ratio} = \frac{A + B + C}{D + E}$$

A: Accumulated value for the actual financial benefit. Each financial benefit is multiplied by probability where probability = 1.

B: Accumulated value for the probable financial benefit. Each financial benefit is multiplied by probability where 0 < Probability < 1.

C: Option saving with relation to the difference between the highest financial cost for an option and the financial cost of option under consideration. This is not relevant if no alternative options are available.

D: Accumulated value for the actual financial cost. Each financial cost is multiplied by probability where probability = 1.

E: Accumulated value for the probable financial cost. Each financial cost is multiplied by probability where 0 < Probability < 1.

Ratio can indicate the following projection or progression: less than 1 not feasible, 1 breakeven, and the greater than 1 the better. A ratio greater than 1 is not indicative that is desirable or acceptable (e.g. low financial return, too much risk exposure). For this purpose the ratio for full or subset of values can be compared to a predetermined single or range of ratios with respect to a given point in time or over a period of time.

4.3 Mathematical Definition of Benefit-Cost-Risk Formula

The following equation has been provided to illustrate the mathematical foundation of the proposed approach.

$$\Delta R = \frac{D + E[B] \sum_{i=1}^{n} Bi\ Pi}{E[C] \sum_{i=1}^{n} Ci\ Pi}$$

R: Ratio.

Δ (uppercase delta): To examine a change in ratio over time. This aspect of the formula is optional.

D: Option saving.

E[B]: Expected benefit.

E[C]: Expected cost.

i: counts the number of items.

Bi Pi: Each financial benefit item multiplied by respective probability.

Ci Pi: Each financial cost item multiplied by respective probability.

∑ (summation):

- Addition of all Bi Pi items
- Addition of all Ci Pi items

5.0 Change Implementation Diagram

The aim of this diagram is to visualise changes and their relationships. The relationships between changes is represented in terms of combination, effect, dependency.

The convention is as follows:

- The time horizon for the plan moves from left to right
- A change is represented as a line in timeline given its start and finish time
- The combination of one or more changes is represented by merger of lines
- A dotted line with an arrow from change-1 to another change-2 means dependency:
    - Change-1 needs to finish before change-2 can start
    - Change-1 needs to start before change-2 can start
    - Change-1 needs to finish before change-2 can finish
- A full line with one arrow from change-1 to change 2 means change-1 effects change-2
- A full line with two arrows between change-1 and change 2 means change-1 and change-2 effect each other

6.0 Summary

Global expenditure on software production and maintenance is significant with relatively large number of software projects failing to meet their original quantitative and qualitative objectives.

Given change has been described as any change in circumstance including events that can or do invariably effect the objectives, the proposed approach describes a managing change process including key change indicators, benefit-cost-risk formula, diagrammatic convention, and two tables to address changes and their relationships in a formal, effective, efficient, and adequate manner.

This approach can be used in defining, selecting and achieving software objectives given various levels (e.g. phase, project), timespans and types (e.g. quantitative, qualitative).

The main benefits in no order of priority include:

- More accurate and specific estimates/evaluations for quantitative objectives (e.g. cost, benefit and time) prior to and after initiation of project
- Improved allocation of resources (e.g. human, financial)
- Improved response to changes that can facilitate successful achievement of objectives

The approach has been devised with consideration of the following factors:

- Managing change and their relationships is a key driver for achieving project objectives
- Importance of explicitly addressing uncertainty effecting objectives. For example uncertainty with regard to a change that may or may not be a risk
- To Incorporate risk management with other aspects of project management. In international standardisation arena this requirement is considered to be very important
- To have aspects such as ease of understanding and implementation, flexibility, scaling, customisation and cost effectiveness
- To be used with any type of project size and complexity, type of software, and software development, project management, risk management and change management approaches

This approach entailing change and objectives can be used in functions and levels of an organisation other than software projects.

7.0 References

1 ISO 31000, Risk management — Principles and guidelines, 2009