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A Conceptual Model For Developing KPIs For Early Phases Of The Construction Process

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Abstract
The pre-project stage in construction is where most of the decisions about project investment and development are taken. It is therefore very important to be able to control and influence the process at the very beginning of the project. This paper proposes a model for developing a set of KPIs for controlling the pre-project stage. The KPIs are to be identified based on a proposed framework which describes the model of the construction process. Literature reviews and interviews are used to identify the process main activities that will be used for developing the key indicators. The relevance of key process activities and some of proposed KPIs are verified by experts during a number of pilot studies. The paper describes how KPIs enable control of the processes while a project is in progress.

Keywords
Process, Control , Performance Indicators, Pre-project Stage

1. Introduction

Traditionally performance in construction is measured based on what is so called the "iron-triangle"of time, cost and quality, see Walker (1995), Belassi and Tukel (1996). In recent years indicators have been developed to include the measurements of other aspects of project performance. A major characteristic of these however is that most of them are used primarily for benchmarking purposes but are of little use for controlling the performance during projects.

In early stages of the construction process such as the pre-project stage, the level of influence on the process and hence on the project is substantial compared to other stages. The pre-project stage hasn't always performed well in the construction industry, and as result it has suffered from poor performance due to poor project scope definition, changes that result in cost overruns and time delays see, for example, (Gibson and Hamilton, 1994). It is therefore beneficial to be able to control the process performance in the early stages of the construction process.

This paper describes a research to develop a set of generic Key Performance Indicators (KPIs) that can be used for measuring process performance during pre-project stage. This has been done using a research methodology consisting of three main steps. The first step involves mapping the construction process to provide a theoretical framework of the process using literature review. The second step involved the collection of data to identify the main activities within the process, their inputs and outputs. This has been done using interviews. Based on the results of the second step the third step is concerned with identifying the KPIs. This step is still ongoing and will also involve determining how the various key performance indicators can be modeled to be used for performance control.
The intended KPIs are aimed not only at measuring the process, but also indicating where control action should take place if necessary.

2. Measuring process performance in the construction industry for control purposes

The construction industry is project-based, dynamic in nature and involves many participants with different interests. In many ways, performance measurement is ultimately aimed at improving performance and hence achieving success. In construction, attempts have been made over recent years in several countries to establish and measure construction performance over a range of its activities to meet a set of improvement targets. The results of such attempts have produced a number of measures and indicators; see for examples KPI in the UK (DETR, 2000), the construction performance measures developed by the CII in the United States (CII, 2000) and KPIs developed by the CDT in Chile (CDT, 2002). A performance indicator can be defined as being:

'A measure used to provide information about the performance of a process or a product and the degree to which its objectives are achieved'

The aim of many of the existing indicators has been to assess the overall project performance or to measure the performance of its main activities. There are many indicators that are proposed in previous studies for use in construction. They measure a construction project from different perspectives. For example, the performance indicators can be:

- customer focused or employee focused (Karna, Beatham et al.), (Beatham et al., 2004);
- performance indicators developed for measuring specific aspects such as Design Quality Indicator (DQI) (Gann et al., 2003) or design KPI developed by CIRIA (CIRIA, 2001); PDRI metrics for the pre-project stage described by (Griffith & Gibson, 2003) and project planning indicators (Dvir, D. et al., 2003);
- special KPIs as mechanical and electrical works - contractors KPIs, consultants KPIs and construction products KPIs (Construction Excellence, 2006).

The concept of using indicators to assess performance originates from the theory of benchmarking. Benchmarking has been widely used for establishing targets for comparison and improvement of production or processes. It is also a term that is synonymous with 'best practice', (Bhutta and Hug, 1999).

The concept involves measuring one or more aspects of the business or part of it and comparing it with the best in its specific sector. Benchmarking can be defined as a process of continuous improvement based on the comparison of organisation, processes or products with those identified as best practice. The best practice comparison is used as means of establishing achievable targets aimed at obtaining process or product improvement. Since most of the indicators are based on the comparison of actual performance with targets or desired processes they therefore also provide a basis for process control.

Developed for benchmarking purpose the performance indicators reflect a statement of the "post-event" without any opportunity to change the process while it is in progress. Many of the developed indicators so far are also focused on the product and not on the process. There are few existing indicators that can be

used to inform stakeholders of how well their process is going during the various stages. This major shortcoming of existing performance indicators has created the basis for idea of the research described in this paper.

To illustrate how the process performance indicators are developed for control purposes, descriptions of what the process and control cycle involved are described below.

A process can be defined in many ways but for the purpose of this paper the definition of a process by Oakland (1999) is to be adopted. Oakland defined a process as the "transformation of a set of inputs, which can include actions, methods and operations, into desired outputs which satisfy the customer needs". Therefore, process performance can be defined as the degree to which the processes involved into the project execution are meeting the desired project outputs, in other words, a set of desired targets, while the project is in progress. Hence, to be able to control any process it is necessary to control the variability of the outputs within the process. A representation of a typical process is shown in Figure 1.

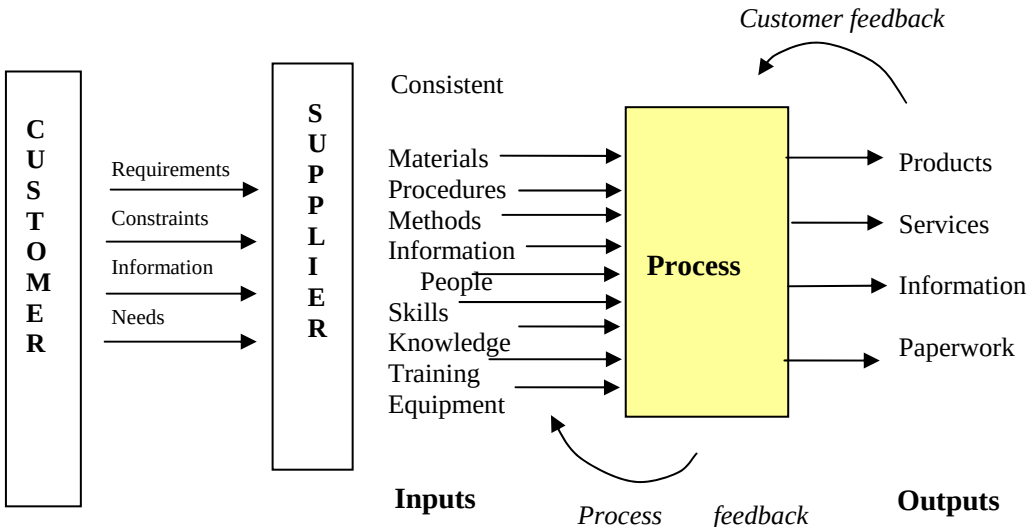

Figure 1: A typical process

A basic control process consists of three main sub-processes namely: establishing standards or desired targets, measuring performance against set desired targets and correcting variations from desired targets by taking action (Koontz, Weihrich, 1990). Establishing desired targets is a process of selecting the degree to which the performance of desired objectives should be achieved so that the project managers can receive signals how the process is going. The actual performance should then be measured against the set desired targets. The corrective action should be taken in case there is an evidence of mistakes, recognising lack of progress or identifying areas of poor quality (Mawdesley et al, 1997). These sub-processes form parts of the control loop as shown in Figure 2 (adapted from Koontz, Weihrich, 1990).

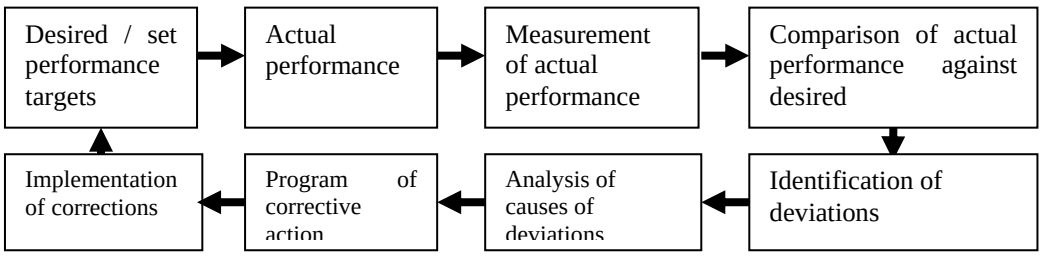

Figure 2: Control loop adapted from (Koontz, Weihrich 1990)

The work described by this paper focuses on measurement and control of main sub-processes within pre-project stage to increase the possibility of achieving project goals.

The pre-project stage is considered to be a stage where the idea of the project is taken from general set of ideas and requirements to a specific well-defined project. The word “main” concerns the most relevant for the process sub-processes such as activities, their inputs and outputs.

3. Proposed conceptual framework

To identify KPIs for control purposes a conceptual framework is proposed to establish where the focus of measurement and control would be. The process KPIs are expected to be developed for project managers because of their overall responsibility of all of the activities within the pre-project stage.

In considering processes, it is necessary to break them down into small parts in order to understand and control them. Therefore, the proposed framework consists of a number of steps that include: dividing the construction process into main stages that are subdivided into phases; identifying the main or relevant activities within these phases, their inputs, expected outputs and; identifying indicators that can be used for process control.
In the case of the pre-project stage, the identified phases and their definitions are describes as follows:

- initiative phase - phase where a list of reasonable alternative options is composed based on the analysis of client requirements;
- feasibility phase - phase where alternatives' options are analysed and the preferred option is chosen;
- project definition phase - phase where the preferred option is developed and the decision to proceed with the project is made.

The proposed conceptual model (see, Figure 3) forms a basis for identifying KPIs. Unlike many other techniques such as IDEF0 (see, for example, Ang et al, 1994) the proposed format is intended to be simple enough for representing and understanding the construction process within the pre-project stage.

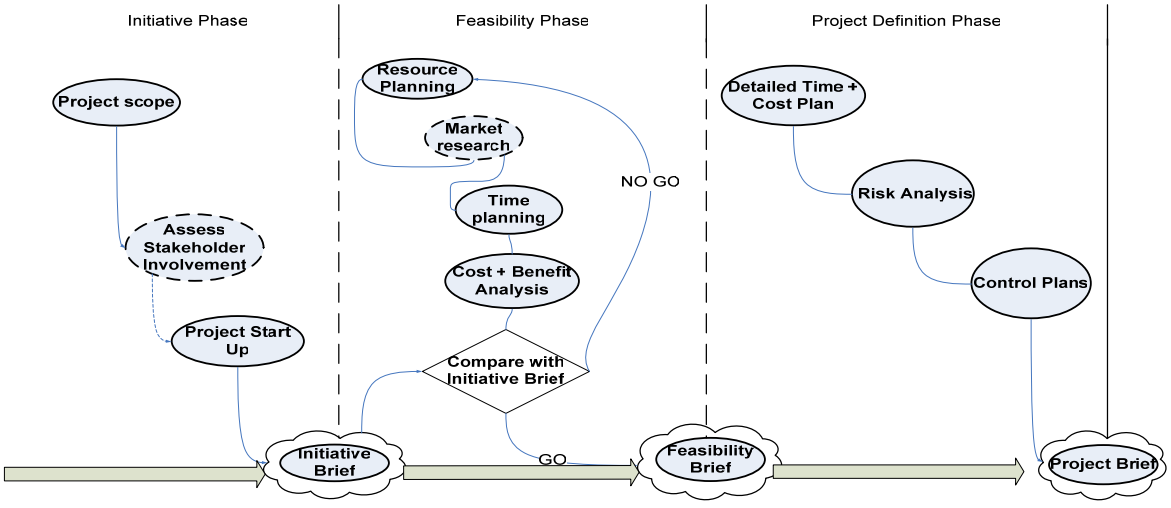

Fig. 3: Conceptual model based on the literature review

The main construction process phases and main activities within these phases are defined to establish the so called control points during the construction process. “Phase/gate” concept is used to establish the so

called control points where the measurement and control of the process at the end of each phase takes place, see (Kagioglou et al., 1999).
In addition to the processes at the phase gates, the activities during each phase of the pre-project stage can also be used for controlling the performance during the phase.

4. Research methodology

The research methodology adopted in this work is based on the understanding that ultimately the purpose of using the key performance indicators is to provide process control. The research methodology consists of two main steps. The first step is related to identifying the main sub-processes (core activities) within the pre-project stage. The second step involves defining KPIs to control these activities within the pre-project stage.

In the first research step the pre-project stage was split into main phases as was described earlier. Within each phase the main activities or sub-processes were identified. According to (Davenport, 1993) a construction process is a "structured set of activities". To establish the order of the identified activities the inputs and outputs need also to be identified. Input to an activity is output of its preceding activity. If the inputs or the information available to an activity are inconsistent, insufficient or wrong then there is a great chance that the process and its outputs will also be deficient. Naturally there is not only sequential connection between the activities. Some of them can be done parallel to each other and others will be iterative.

A comprehensive literature review was conducted to identify the main phases, activities, their inputs and outputs. Process mapping was used to visualize the construction process and to understand the sub-processes of the construction process within the pre-project stage. The main activities identified are the focus of the measurement and control and the outputs of the identified activities are the issues that should be controlled within these activities. Hence, the KPIs that control the outputs of the main activities are the KPIs that provide process control within the pre-project stage.

Ten pilot studies within the Dutch construction industry were carried out to validate whether the mapping of pre-project stage based on the literature review corresponds with practice. The pilot studies were aimed to answer the following questions:
1) whether the proposed model is representative of practice;
2) whether the phases within construction pre-project stage are well identified and can be used as the control points for pre-project stage;
3) whether the activities and their main outputs are relevant for process control and to decide
4) what KPIs to develop for control within the pre-project stage.

The pilot studies were developed in the form of a questionnaire. The first section was an introduction of the research framework about pre-project stage with definitions of the various elements and explanation of them. The second, third and forth sections included the main activities with their outputs for the initiative, feasibility and project definition phases accordingly. Last section was presented in the form of open question about the KPIs that are used to measure and control construction process in the Dutch construction industry. These questionnaires were presented to different experts as a way to validate the conceptual model. The received information was analyzed and the priorities in measuring certain activities and outputs within the phases were determined.

Based on the information obtained from the pilot studies and interviews a slightly modified conceptual model for pre-project stage was proposed as a basis of establishing the control points within the pre-project stage. In addition, a set of KPIs was identified to be developed and used for controlling the construction process within the pre-project stage.

5. Analysis of results and disscussion

The proposed conceptual model of the construction process within the pre-project stage was verified during the pilot studies. The interviewees agreed that the proposed model contains the main sub-processes that occur within the pre-project stage and that it reflects the real process.

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The experts during the pilot studies have suggested adding a “project idea” phase at the very beginning of the project to make the proposed model more complete. This phase is a phase where the idea of a project is taken from general set of ideas to well defined client requirements.

Another suggestion was to combine some of the activities identified through the literature review in order to avoid the overlap between them.

During the study the relevance of the main activities identified was assessed using a 5 point scale, where 5 indicated the activity to be of high importance whilst 1 as of little relevance. The scores from all the experts were then averaged to produce a prioritized list. Table 1 shows a list of the most relevant activities within the pre-project stage based on the result of the scores achieved.

Table 1: The prioritisation of main activities within pre-project stage

Main activities within pre-project stage	**Average score(based on using a 5-point scale)**
Client requirements definition	4.4
Time and cost planning	
Risk assessment and project control	
Project start up	4.1
Project scope definition	4
Stakeholders’ involvement	3.9
Pre-project planning	
Resource planning	3.8
Project goal definition	3.5

The proposed assessment was aimed at identifying the important activities to be controlled within the pre-project stage. Based on this assessment it can be seen that client requirements, project planning, risk assessment and project control were considered to be more important then the other activities.
It is necessary to mention that all respondents agreed on the importance of communication between the stakeholders involved and its role especially at the very beginning of the process.

During the pilot studies the respondents also highlighted that the more accurate the different types of analyses are performed in the pre-project stage, the better the chance that the project will meet the desired goals.

In addition to the main activities within the pre-project stage their outputs were also identified and verified by respondents. As a result, some of the outputs were relocated from one phase to another and some of them were not included because of their little relevance for control.

The last section of the questionnaire was related to determining the KPIs to be used for control of the construction processes. The respondents pointed out the importance of measuring and control the soft aspects of the process in addition to measuring and control the normal hard aspects of time, cost and quality. Subjective aspects related to communication and stakeholders’ alignment are considered to be very important especially during the pre-project stage.

The overall view of the results of the pilot studies shows agreement that process-based performance indicators are needed to be developed for the control purposes in addition to those, used to measure the project performance of the completed projects.

During the study several process-based KPIs were identified as being relevant for control of the pre-project stage. The identified KPIs are phase based and cover all the phases of the pre-project stage. The identified KPIs will be developed further based on the outputs of each phase. Both qualitative and quantitative information will be used in developing the measures.

The control of the process can be effective only in case when changes are made to correct poor performance. Failure to initiate change is a significant reason why any type of performance measurement fails. Hence, to be effective control tools, the proposed KPIs should not only indicate to the project managers where the problems are, but also indicate where corrective actions are needed. The results of process control can be used to implement changes to future activities with a view of still achieving the set desired targets.

6. Conclusions

The paper described a proposed theoretical framework for providing control during the pre-project stage using process-based KPIs.

Control of construction processes is considered to be an important factor in achieving desired project targets. It is therefore important to have a better understanding of the construction processes to effectively control the projects.

Control of the construction processes requires knowledge about the main sub-processes and therefore the main phases, activities, their outputs and sequence. This paper assumes that controlling the various relevant activities sub processes within the pre-project stage will enable control of the whole process and hence achieving project goals.

Using the proposed methodology the main sub-processes were identified and mapped. The relevant activities are also proposed by experts. KPIs that are based on those activities are suggested but the process is still in progress.

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