An Alternative Framework for Managing Engineering Change

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Abstract – **Effective engineering change management (ECM) procedures are very important over the whole life cycle of every engineering change (EC), from EC proposal to implementation and documentation. However, the success of an EC procedure depends on the amount of focus on the critical areas of the EC project. The purpose of this research to develop an alternative ECM framework based on critical success factors of ECM. The study follows through three steps: (i) identify the common focus areas of ECM, (ii) identify, from past empirical studies, the critical success factors for ECM, and (iii) develop a proposed framework that incorporates the identified critical success factors for ECM. The proposed ECM framework provides practitioners with a change management process that incorporate ECM critical success factors, to guide in implementation of ECM projects.. This is anticipated to increase the chance of success for the ECM projects.**

Keywords - **Engineering change management, engineering change projects, change management framework, critical success factors**

I. INTRODUCTION

Engineering changes, such as new product development, always need to be planned for and managed through a formal process commonly known as Engineering Change Management (ECM) [1]. Every Engineering change (EC) is aimed at making a product or process better, through product redesign, process redesign, technology upgrade, or product performance improvement. According to Reddi and Moon [1], a typical EC process goes through four basic sub-processes: proposal, approval, plan and implementation, and documentation. At the proposal stage, EC proposals are scrutinized by the EC committee for its worth. The approval phase is focused on analyzing the impact of the proposal, both from stakeholders' perspective and from the organization's view point. Once approved by the engineering change committee and stakeholders, a detailed plan of the proposal is prepared, implemented and reviewed. Upon successful implementation of the project, relevant findings, problems and other experiences are documented, which marks the end of the entire EC life cycle. The documentation is reviewed and stored for any future references when similar engineering change projects arise.

The ECM process is crucial because it influences the productivity or success of the change to be implemented [1] [2]. It enables an organization to respond to changing business environment, work environment, and to market opportunities and threats. However, in practice, there are several factors that need to be taken into account and be incorporated into the ECM procedure. The criticality of different factors dictates the amount of focus needed for specific factors [3] [5]. This will drive the success of an EC.

The success or failure of ECM projects is often influenced by a number of factors, such as the complexity of the ECM process, and the entities involved. When several companies are involved, the complexity of the ECM process increase considerably [2] [5]. In practice, influential factors range from the depth of the conceptual understanding of the EC itself, and the EC implementation and evaluation processes.

From a review of existing articles on engineering change management, EC projects fail or succeed due to various reasons. However, there seems to be no consensus on the specific set of reasons behind failure or success of the engineering change projects. The major research

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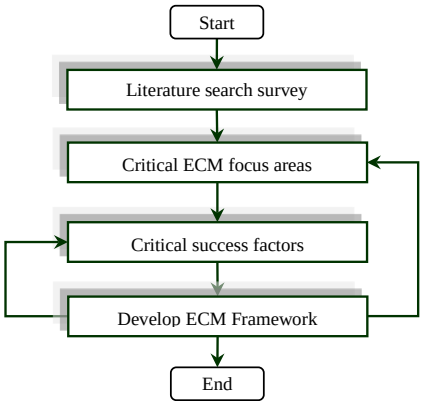

Fig. 1. Research Methodology

questions arising from this research are summarized as follows:

(1) What are the typical critical success factors for the ECM process;
(2) Can these critical success factors be incorporated into the ECM process?
(3) Can a general, improved ECM framework be developed?

The purpose of this study, therefore, is to come up with an alternative ECM framework based on identified critical success factors of engineering change management.

The rest of the paper is structured thus: The next section outline the research methodology. Section III presents the critical success factors for ECM. Section IV discusses the proposed ECM framework based on the identified critical success factors. Conclusions and further research directions are presented in Section V.

II. RESEARCH METHODOLOGY

Research was carried out in two phases (see Fig. 1): First, a literature search was done to obtain useful background information on factors influencing success and failure of ECM projects (as summarized in Table I) as well as frameworks for the ECM process. Second, a literature search survey was done, in connection with existing empirical studies, to identify the major contributors to the success and failure of ECM projects. Information from past empirical studies will go a long way to assist in elucidating the exact critical success factors for ECM, from a practical point of view. The identified ECM critical success factors are then used to inform the development the proposed ECM Framework.

III. ECM CRITICAL SUCCESS FACTORS

To guarantee successful engineering change management projects, it is crucial to understand the critical factors behind successful projects and the failure factors or obstacles that contribute to project failures. In this section, based on the summary of ECM critical success factors in Table 1, the major ECM success and failure factors are identified and discussed.

A. Major Contributors to Project Success

There are five major contributors to a successful implementation of engineering change projects. These are outlined as follows:

1) Top Management Support

The greatest contributor to project success is strong and effective top management sponsorship [3]-[5]. In particular, effective sponsors are focused on the

TABLE I
CRITICAL SUCCESS FACTORS FOR ECM

Category	Factors	Failure Reasons	Success Reasons
Definition	Concepts [2] [3] [5] [11]	Unclear terms and definitions	Clarify the terms and concepts Build awareness
	Methods [5] [8] [14]	No standard methodology	Develop proper approach Select a well-planned methodology
	Goals [1] [2]	Unclear goals	Clear goal setting, realistic expectations
Human	Resistance to change [4] [5] [10] [18]	Resistance to change	Well established effective communication channels
		Inertia against culture shift	Well informed and enlightened workers Care for those who cannot adapt
	Top management commitment [3] [4] [5	]Lack of top management commitment	Top management included in the steering committee Setting appropriate, clear strategic plans
	Workers engagement [4] [5] [9] [10]	Neglect line workers	Involve line workers in the ECM steering committee
		Reliant on outsourcing	Establish a balanced team of local and outside experts
Skills	Scope and objective [3] [5] [8] [16]	Inappropriate scope	Establish realistic business context and scope
		Wrong objective	Prioritize objectives
	Project duration [3] [6]	Delay of delivery of result	Well planned project management Project divided into workable phases
	Understand benefits [3] [6] [7]	Not able to recognize ECM benefits	Use of simulation methods Use of dynamic simulation methods Use proper evaluation methods
	ECM team expertise [3] [6] [7]	Little experience and exposure	Highly committed team with experience and exposure
		Inadequate or inappropriate skills	Appropriate training, skills, expertise, and experience

following:

- they show active and visible support, privately and professionally;
- communicate a clear understanding of the goals and objectives of the change;
- demonstrate their commitment as a role model for change, providing compelling justification for the change;
- provide sufficient resources for the team and project to be successful; and,
- they ensure that every approved engineering change remains a priority.

2) Worker Involvement

In practice, adequate support from the impacted employees and front-line managers are crucial [4] [5]. Early involvement of workers in the process increase support from these levels [9], [10].

3) Skilled Change Management Team

The expertise, skills, experience and commitment of the ECM team are critical [3] [6] [7]. In particular, the team should be led by effective leadership and motivators that can consistently keep the team highly motivated, highly focused, highly inquisitive and resourceful [5] [16].

4) Effective and Targeted Communication

Communication is crucial right from the onset of the project till the end [5] [8]. Effective communication is expected to be consistent, honest, targeted at specific recipients and delivered through appropriate media [3] [11] [12] [14]. The objective should always be: right communication to the right stakeholder at the right time [2]. The use of dynamic simulation tools and graphical tools comes in handy for effective demonstration to relevant departments with different backgrounds [1] [2] [7] [13] [17].

5) Well Planned Approach

Well-organized plans contribute to the success of engineering change projects, including the use of a methodology or specific plan, initiation of change management activities early in the project [5] [15]. An organized approach to change management is expected to be holistic and systematic, while anticipating possibilities of resistances [2] [13].

B. Major Contributors to Project Failure

In this study, five major obstacles behind failure of most change management projects are identified. These are outlined as follows:

1) Worker or Employee Resistance

The top most condition for failure is worker resistance at all levels. Oftentimes, there is natural human resistance to change that hinders project success [4] [10]. In addition, changing the culture at a work place in any

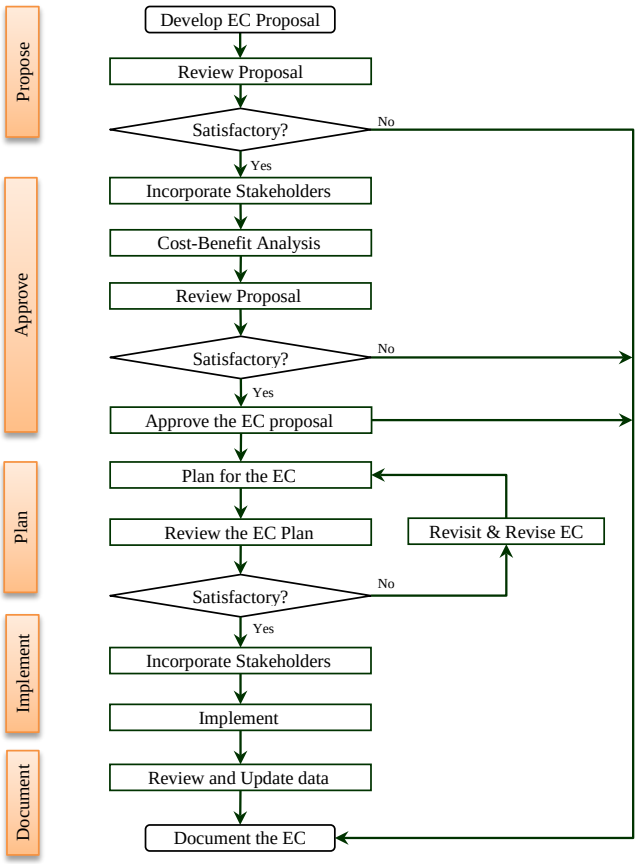

Fig. 2. Proposed ECM Framework

organization is a non-trivial task. Workers fear the unknown and are opposed to moving out of their comfort zone [5] [18].

2) Middle-Management Resistance

Resistance by middle managers is a major obstacle because they directly interact with and influence front-line workers [5] [6]. In most cases, triggers to resistance are due to a perceived loss of power, limited room for input in the project, and poor communication channels [10] [18].

3) Poor Executive Sponsorship

Top management or executive sponsors may not play an active and consistent role in supporting the project. It is also possible that management shifts its support soon after the commencement of the project [5] [6]. A visible reinforcement and an active leadership are essential in steering the change throughout the project life cycle.

4) Limited Resources

An EC project usually causes a strain on existing resources. In other words, the current resources may be stretched beyond capacity, which may lead to unanticipated unwanted delays. In addition, change projects are over-shadowed by daily activities and responsibilities. As a result, the project team will not have adequate project time.

5) Corporate Inertia

Sometimes, organizational culture may push back against the change initiative. Some organizations are too resistant to culture shift. A strong commitment to training, communication and deliberation on the concepts of engineering change and its goals are crucial at all levels in the organization.

IV. PROPOSED ECM FRAMEWORK

An effective ECM framework should incorporate the critical success factors (see Fig. 2). The ECM process commences by building an EC Committee who should oversee the entire EC life cycle. It is essential from the onset of the process to incorporate stakeholders, top management, and representatives from the rest of the departments. This will ensure top management support and stakeholder satisfaction. The proposed ECM framework is a five-stage model with the following stages: (1) Proposal stage, (2) Approval stage, (3) Planning stage, (4) Implementation stage, and (5) Documentation stage. Rigorous testing of the EC proposal is carried out in the first two stages to ensure that the EC project is in alignment with organizational needs and that it is indeed the right solution to the identified problem or that it addresses the identified opportunity, before planning for the EC project commences. The EC proposal can be terminated at any of the first two stages if it doesn't pass the requirements for either of the two stages. The rest of this section discusses the stages of the proposed ECM framework.

A. The Proposal Stage

At the proposal stage, the committee reviews the proposal, to ensure that it satisfies the stakeholder, the organization, and the customer. The concepts, the methods, and the goals of the project must be communicated and taught clearly across all parties. The use of the experience and knowledge of experts from different departments and stakeholders comes in handy at this stage.

B. The Approval Stage

During the approval stage, the interested parties in the committee use their expertise to analyze the benefits of the proposal. Oftentimes, ECs fail to gain the necessary support due to lack of understanding of the potential benefit of the project. An effective framework should incorporate tools that can help elucidate the essence of the EC project. Systems analysis tools, such as system dynamics and discrete-event systems simulation, can be applied, using suitable cost-benefit performance evaluation approaches. Holistic approaches, such as balanced score-card, should be used to evaluate the future benefits of the project. The final decision to approve the proposal should be based on a holistic evaluation.

C. The Planning Stage

Following the approval of the proposal, a detailed implementation plan is developed. All measures and metrics that ensure success of the project should be set in place so as to satisfy stakeholder expectations, the organizational objectives, as well as customer expectations. All the stakeholders should be involved in the drafting and finalization of the plan. Noteworthy, it is essential at this stage to engage and involve workers on the ground, who will be involved in the actual implementation of the EC. The implementation plan includes planning for an enabling environment for the success of the EC project, as discussed under ECM critical success factors. The planning stage is repeated iteratively until a satisfactory plan that provides for the necessary conditions for the successful implementation of the EC project is produced.

D. The Implementation Stage

With a well-defined scope and objectives of the plan, a well-trained and committed team of experts, the implementation of the project is assured to be a success. Adequate top management support guarantees adequate resources and support for the project. In addition, worker engagement and involvement safeguards against inertia and resistance to change. The overall life cycle of the engineering change project is assured to be a success.

E. The Documentation Stage

For future reference, every EC project must be documented. The experiences, findings and knowledge gained throughout the project should be documented. Problems, barriers and enablers encountered during the process should all be reviewed and documented for future use.

V. CONCLUSIONS

The success of an engineering change management project is influenced by the amount of focus on key areas in the engineering change process. Different factors have varying impact on the success or failure of a project. This study identified, from past empirical and hypothetical investigations, the common critical success factors driving an engineering change project. These factors were identified in order to incorporate them in a generalized framework for engineering change management.

Five major factors that play a key role in driving the success of engineering change management were identified: top management support, worker involvement, skills, effective communication, and well planned approach. In addition, five major contributors to engineering change failure were identified: worker resistance to change, middle management resistance to change, poor executive sponsorship, limited resources, and corporate inertia. An alternative framework for engineering change management was proposed, incorporating the identified critical success and failure factors.

It is anticipated that the proposed ECM framework will be useful for organizations intending to implement engineering change projects, such as new product development, process redesign, technology upgrade, and product performance improvement. The proposed ECM framework can assist in selection of EC projects that meet the needs of the organization as well as providing a rigorous process for identifying and building in the structures and conditions necessary for ECM projects success.

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