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CONSTRUCTION ENGINEERING: ROLE OF SIX SIGMA APPROACH

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ABSTRACT

Construction projects are a set of unique activities that are performed to achieve a particular goal. It can be very well said that these projects need very accurate monitoring to achieve the results or desired parameters for the customer. Project needs are to be managed for deriving such results.

The continuous tracking of these projects are possible only when there is a structured mechanism to be followed for monitoring. In the present study, existing technique of control like 'lean Six Sigma' is contemplated for monitoring such processes in a project. Further, special attention has been given to the problem of inaccurate monitoring of project parameters.

The study is based on designing and analyzing a methodology that improves the project risk management process by having efficient monitoring system for these projects. The monitoring should be based on the risk sensitivity of the various parameters of the project. These parameters, derived through exhaustive literature survey and expert advice, are given special references whilemonitoring the project for risk analysis. Six Sigma level of accuracy is conceptualized in this study for the execution of the projects.

On analyzing the possibility of risk occurrence on Sigma levels for each pre-decided parameter, it is found that technical parameters have gotthe maximum number of risks associated with them. The methodology proposed in the paper provides a guideline for risk monitoring for Power transmission construction projects.

This study bridges the gap between uncertainty and well-planned project management which will help to enhance the project performance.

KEYWORDS: Project Risks, Six Sigma, Risk Management, Construction Projects

INTRODUCTION

Construction projects are a set of unique activities that are performed to achieve a particular goal. The project needs to be managed. It can be very well said that certain projects need very accurate monitoring to achieve the results or desired parameters for the customer. Project needs are to be managed for deriving such results. The term project management actually implies the set of whole activities starting from the initializing phase of a project to the final post project evaluation and it has been studied by various authors like Marques *et al.* (2013), Lindkvist*et al.* (2013), Nahod*et al.* (2013), Stare (2014), and Smitha (2014).

Project management is very essential for churning out the desired outcomes from a project within the applied constraints. This is possible only when project managers have a strict continuous control over the project-related activities. The continuous tracking of any project is possible only when there is a structured mechanism to be followed for

monitoring. In this study, the case of a power transmission line construction project is taken in order to analyze the need for monitoring of a project on a continuous basis and in a professional order.

The projects are unique in characteristics, so a tailor-made system is needed for developing this monitoring procedure for each type of project. In the present study, existing technique of control like 'lean Six Sigma' is contemplated for monitoring such processes in a project. Further, special attention has been given to the problem of inaccurate monitoring of project parameters.

The power transmission line is one such division of power sector which is sure to grow by leaps and bounds in the coming time, and hence it becomes a necessity to monitor the efficiency of electrical transmission line construction projects. In the next Five-Year Plan, India is aiming to develop a power sector to cater to the need of about 1 lakh mega watts, and hence a rapid increase in the electrical transmission line construction projects is to be seen in the near future in India. The story for the rest of the world is also the same. In order to pump up the production schedule for energy, a rapid increase in the transmission lines is needed, and the existing lines are already at the brim of capacity; so a huge number of such projects are going to be undertaken by the various government and private agencies. Although Power Grid Corporation of India Limited, National Thermal Power Corporation, State Power Transmission Boards along with global private players are professionally managing this need and comingup with electrical transmission line construction projects, still on site contractors are needed to be upgraded for scientific (which are not necessarily state-of-the-art, costly or complex) monitoring techniques to be used in electrical transmission lineconstructionprojects.

This study presents an approach for development of such a project monitoring methodology, especially for power transmission lineconstruction projects. Authors like Abdullah and Rahman (2012), Alias *et al.* (2012), López and Salmeron (2012) and Christoph and Konrad (2014) have specifically stressed that risk management and performance of any project depends on the better project monitoring techniques used in the project. Hence, efficient monitoring decreases the risk and increases the performance of power transmission line construction projects.

This study bridges the gap between uncertainty and well-planned project management, that is present in the projects, most of which are being handled by contractors at various levels. So, we have devised this methodology by applying the simple techniques of monitoring which are very accurate in nature, like the lean Six Sigma. Hence, this study is a novel step in the direction of accurate project monitoring for performance increase in power transmission line construction projects.

LITERATURE REVIEW

An exhaustive literature survey is done in order to find out the viewpoint of different researchers on this particular aspect of project management. We have inculcated the viewpoints on general project management and the risk management process involved in power transmission line construction projects. In order to give a monitoring methodology for performance enhancement in theconstructionprojects, each of these aspects has been studied to finally reach the methodology that can be employed for accurate project monitoring.

PROJECT MANAGEMENT

Several researchers like Favari (2012), Ismail *et al*. (2012), Dawei and Xuefeng (2012), Rolfe (2013), Boura*set al*. (2013), Kähkönen*et al*. (2013), Shariff*et al.* (2013), Alketbiand Gardiner (2014), and Singh (2014) have studied project

management with special reference to project risk and the general project management process. These studies provide an insight into the various processes generally involved in project management and most of them stress on dividing the project into various activities or work breakdownbasedstructuring. The studies also opine that for successful attainment of the objectives of a project, project management is very much necessary.

PROJECT RISK

Project risk has been studied by many researchers in the context of various sectors and industries. Studies like Abdullah and Rahman (2012), Alias *et al.* (2012), Pinto and Dominguez (2012), Purnus and Bodea (2013), Maravas and Pantouvakis (2013), Pinheiro*et al*. (2013), Sheykh*et al.* (2013), Binder *et al.* (2014), Hussein and Klakegg(2014), Tenera and Pinto (2014), Papadaki*et al.* (2014) have given insights into the risk management process of some of the common projects of the industry. Some of the factors or parameters suggested by the various studies can be used in fulfilling the most common characteristics of project risk management, and the interrelationship between performance and project management level has been decided on the basis of the findings of such studies only. On the other hand, studies like Favari (2012), Tohidiand Jabbari (2012), Yanwen (2012), Lindkvist*et al.* (2013), Marques *et al.* (2013), Kuchta (2014), Sato (2014), Singh (2014) and Sidawi and Al-Sudairi (2014) have explained the complex project management process but with the help of a particular sector or type of industry. So, the results derived from such studies are applicable only to that particular type of project which stresses on the need for executive risk plan for accurate project monitoring system.

PROJECT RISK MONITORING PARAMETERS

The techniques for measurement of risk parameters for power transmission line projects are found in studies like Dey (2001), Dey (2010), Iyer and Sagheer (2010), Fang and Marle (2012) and Johansen *et al.* (2014). But these studies stressed on the risks present during the running or operation of the project, while the present study isbased on the construction phase parameters. Further, various parameters for evaluating the dispersion of project are found in studies like Baccarini and Archer (2001), Menchesand Hanna (2006), Brown *et al.* (2007), and Wu *et al*. (2008). They stress on technical risks like blueprints, site complexities, machines operation, etc., environmental risks that are ‘Acts of God’ like earthquake, lightning, flood, etc., financial risks that are economy-related parameters, marketing risks that are basically related to the demandsupply, supplier transaction-related parameters, and human safety risk, another important parameter in projects like electrical transmission line construction where high voltage equipments and other human life-related risks are present. The risk parameters as stressed by different studies are presented in Table 1.

Table 1: Risk Parameters Referred to by Different Studies

Risk factors & Referances	Types of Parameters			
	Technical	Environmental	Financial and Market related	Human Risk
Baccarini and Archer (2001)	RF	RF	RF	RF
Dey (2001)	RF	RF	RF	RF
Hillson (2001)	RF	RF	RF	NTR
Thevendran and Mawdeseseley (2004)	RF	RF	RF	RF
Erickson and Evaristo (2006)	RF	RF	RF	RF
Fan et al. (2007)	RF	RF	NTR	NTR
Wyk et al. (2007)	RF	NTR	NTR	NTR

Table 1 – Cond.,

Dikmen et al. (2008)	RF	RF	RF	RF
Chen et al. (2011)	RF	RF	RF	NTR
Fang and Marle (2012)	RF	NTR	RF	RF
Regos (2012)	RF	RF	NTR	NTR
Vidal and Marle (2012)	RF	NTR	NTR	NTR
Aloini et al. (2012)	RF	NTR	NTR	NTR
Olaru et al. (2014)	RF	NTR	NTR	NTR
Note: RF = Referred by the study; and NTR = Not Referred by the study.				

DATA AND METHODOLOGY

The monitoring for any process is done for many industries across the manufacturing sector using Six Sigma (the same methodology was suggested by Tenera and Pinto, 2014). In this study, we have categorized the project management process with certain common parameters (given in Table 1) which are solely responsible for most of the deviations in the project. In the present analysis, simple implementation of Six Sigma is done since it is one such method which is reliable for not only quality testing, but also to measure the slight deviations from the standard procedures. This particular ability is used along with the simple lean ideology to test a particular powertransmission line construction project.

The construction project for an 11 KV state electricity transmission line is considered for the study. Observations are taken for every non-conformity and they are classified into four types of parameters—technical, environmental, financial and market-related and human risk parameters. Five samples are taken in a duration of three months from different stages of the project across the transmission line. A total of 1000 readings are taken over the five samples and the disturbances or risks in these predefined parameters are noted down. The main aim is to create a project monitoring on the level of Six Sigma, that means a defect of just 3.4 per million for non-centralized data.

RESULTS AND DISCUSSIONS

By employing Six Sigma on these guidelines, the data is analyzed and the results arepresented in Table 2. The results show the ambiguities found in the project in variousaspects. The mean of all the samples ranges from 48 to 60, which implies that all theseprocesses have a tendency to deviate from the planned specifications throughout the project tenure.

Table 2: Frequency of Risk Occurrences of the Four Parameters

	Freequency of Occurances					Sum	Mean
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5		
Technical Parameters	27	36	41	35	39	178	35.6
Environmental Parameters	15	17	9	14	7	62	12.4
Financial Parameters	5	4	3	8	11	31	6.2
Human Risk Parameters	1	2	2	0	3	8	1.6
Total	48	59	55	57	60		
Mean of Samples	55.8						

On calculating the Six Sigma level for each of these parameters, it is observed that the projects are nowhere near to the levels of accuracy (Table 3). There can be numerous reasons for this and the solutions also vary with different approaches. The analysis helps in compartmentalizing the parameters on the basis of their importance and the monitoring to be decided for a particular level or compartment only. The whole project needs to be monitored; but since the level of resources that are needed to be filled in for comparing the different parameters along the transmission line are different, in order to decide upon the distribution of resources for achieving Six Sigma, the importance of each parameter in creating a risk is needed to be known in advance.Table 3 shows the risk level of each parameter and its percentage of contribution to the overall fault occurrence at Six Sigma level.

Table 3: Risk Level and Contribution of Each Parameter to the Overall Fault

Occurrence at Six Sigma Level			
Parameter	**Mean of Occurances**	**Defects at Sigma Level**	**%of Defects in Complete Project Sigma**
Technical Parameters	35.6	35600	63.8
Environmental Parameters	12.4	12400	22.2
Financial Parameters	6.2	6200	11.1
Human Risk Parameters	1.6	1600	2.9
Mean of Samples	55.8	55800	100

It is observed from Table 3 that the technical parameters are the most important parameters which are required to be dealt with while designing the Six Sigma levels for power transmission line construction projects. The analysis proves that while monitoring these phases, if technical parameters alone are taken into consideration, then about 60% of the risks can be mitigated.

Environmental risks are second most important, since about 22% of the faults can be mitigated by dealing with this cadre of parameters only. Experts opine that preparation for environmental faults or risks needs extreme level of resources and historical data related to geographical details of transmission line area can be of great help.

Hence, it is inferred that different risk parameters have different effects on thelevel of risks for achieving the Six Sigma level in projects and the monitoring needs tobe centered according to the guidelines provided for these different parameters.

CONCLUSIONS

In this study, it is shown how a project can be divided on the basis of risk parameters,and the power transmission line construction project is thus divided into four parameters of risk and the Six Sigma level analysis is then performed. The values derived by project's deviations from the planned specifications show that such projects are always prone to risks, which can lead to delay and losses. This is forecasted forabout the entire duration of the project because of the high mean values of risk occurrence observed in all the samples taken for the study. However, the percentage share of the parameters in the total risk occurrence is not the same.

The technical parameters are observed to be the most important ones since most of the risks (63%) arise out of these parameters. The study proves that a huge number of such potential risks are present which are needed to be continuously monitored forachieving Six Sigma in power transmission line construction projects. Environmental risks are,

however, hard to discover and mitigate, but since they also account for about 22% of the total risk occurring in the project, it is mandatory to study the details of such risks before starting a project at a particular venue with the help of data already present.

Hence in order to achieve the Six Sigma level in power transmission line construction projects, a wide range of risks are required to be monitored, and since a majority of them are technical in nature, it is possible to mitigate most of them through vigilant monitoring.

In future studies, such a system can be attached to a network system acting as the backbone of data transfers, i.e., in other words, we are suggesting an automated network control system through which the data from the different project sites can be derived automatically with the help of networking, and this will lead to better self-operated project risk-related data collection. This automated self-collected data will be used for analysis in Six Sigma. In these power transmission line construction projects, this self data collection module can be automated and will be able to collect the Sigma level for each part of the transmission line and feed this data to the central monitoring system. Such a system can be updated for each part of the project along the different parts of transmission line. This will help in real-time monitoring of the projects very efficiently.

Hence, the study successfully stresses on the novel concept of introduction of Six Sigma in the power transmission line construction project and successfully develops the guidelines on the basis of various parameters that are needed to be monitored. If the monitoring is done on the basis of this methodology, risk management and achieving of Sigma levels in the project management of power transmission line constructionprojects is possible. Further, similar continuous and accurate monitoring methodologies can be derived in future.

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