

# MODELLING AND SIMULATION IN THE MANAGEMENT OF ENGINEERING PROJECTS: A REVIEW

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## Abstract

This study is focusing on using modelling and simulation in the management of engineering projects. As project management is an important area to be explored but unfortunately has been highly ignored and misunderstood in many areas. Delays and cost overrun are quite common in many projects such as power generation, construction, product development, defence, and software. Changings in design creates costly effects which results in delay and disruption in entire organisation. Committing errors in engineering projects at early stage results costly rework, overtime, expediting, scheduled slippage or decrease in project quality and scope. Low profit and loss in market share increases the revenue of management and workforce. Low productivity and higher the costs are the results of these types of errors. This paper describes the relevance of modelling and simulation model in the management of engineering projects.

## Model

The model is a replica system; it can be physical or mathematical. These types of models can enjoy all the properties and functions of the system. Singh (2009) has mentioned that models can be classified as mathematical, physical, and computer models. The physical model represents the actual system having all the properties. The mathematical model reflects a system with mathematical equations, there can be two types of models, formal and mental. The mental model is much more beneficial with multiple advantages as it is flexible, covering multiple ranges of information and presented in a variety of forms. Moreover, Sterman (1992) supported the idea by saying that, the mental model is adaptable in a new situation and modified information can be available. On contrary, mental models have some ambiguities and contradictions, which are highly recommended to be solved. Sterman (1992) has addressed the limitations of the mental model by stating the formal model. Formal models are explicit with unambiguous assumptions. The interrelated factors can be simulated in

controlled circumstances that enable the analysts to conduct nonfeasible experiments in real situations. Moreover, formal models help in computing the logical consequences of modeler assumptions. Sterman (1992) argues that formal models possess characteristics of quality and validity for easy assessment in comparison with the mental model.

## **Project and project management**

The project has been considered as a group of activities that are designed to produce a specific product, results, or services according to the guide to the Project management Body of Knowledge (PMBOK, 2013). A project is temporary with a defined beginning and end time, so, its scope and resources can be defined. A project is unique in the sense that it has not a routine operation but accomplishes different sets of operations for a single goal. So, the people included in the team project may come from different organizations and belong to multiple skills. On the other hand, project management is the application of knowledge, techniques, and skills which are used to execute projects effectively and efficiently. Sterman (1992) has presented five types of projects with the lifecycle stages.

### **Project conception and initiation**

At this stage, a team is formed for decision making that can identify the benefits of the project to the organization.

### **Project definition and planning**

A project plan, project charter, and/or project scope may be put in writing, outlining the work to be performed. During this phase, a team should arrange the project, calculate a budget and agenda, and control the resources that are required.

### **Project launch or execution**

This is a time to convey up important project related information while tasks are allocated to the members of the project team.

### **Project performance and control**

At this stage, project managers regulate schedules and fulfill the requirement to keep the project in line. Project status and progress in the definite plan are compared by project managers, as resources to perform the scheduled work are made available.

## Project

## Close

The project close is related to the evaluation of the project's success and completion of all the tasks in response to the approval of project sponsors. The process of project and project management vary from department to department and industry to industry. The intervening goal is naturally to offer a product, modification is a procedure or resolves a problem to help the organization. The Guide to PMBOK (2013) categorizes the project management procedures into nine knowledge zones which bring the processes together by their unity, namely: management of project integration, time, scope, cost, human resource, quality, communication, risk, and procurement. Project management has a delusion of assuming arrangement as the only major action in a project. Scheduling is confidently important in project management, but it was not the detriment of developing a shared understanding of what the project is supposed to accomplish or constructing a good work breakdown structure (WBS) to identify all the work to be done. there are various reasons for project failure, sometimes project sponsors request that the project manager should finish the task in due time, in a given budget, with having a proper scope. Moreover, it must achieve specific performance levels. It reveals that there are four main constraints such as performance, cost, scope, and time. The sponsor controls these constraints and leaves out the contractor in the scheme of things.



Figure 1. Standard project management constraints.  
Source: Project Management Body of Knowledge (PMBOK® Guide, 2013).

In other words, "cost is a function of performance, time and scope". Figure 1 presents these functions in a triangle, here it is visible that C, P, and T are the sides only but S is the area of these functions.



**Figure 2.** Project Management Constraints  
Source: Project Management Body of Knowledge (PMBOK® Guide, 2013).

Figure 2 shows that two more constraints- resources and risk- have been included to bring into line with the standard published in the PMBOK® Guide.

Here this point should be considered that quality is equivalent to performance. It's a great challenge to work with these five constraints of project management. For example, if the scope of the project and schedule is not changed, then costs can be adjusted. Next, if the cost and schedule remain constant then the performance will be at risk. But if the risks are not acknowledged, it will be a serious threat to project completion. Moreover, the lack of resources can compromise the schedule. Lastly, if the scope and changes are not defined, then project cost and schedule cannot be established and organized.

In a predefined system, change in one constrain will change the others. However, the primary constraints like scope, schedule, or cost cannot be restricted, managing a project is not like problems because problems can be solved by doing changes to the restricted constrains (Juran and Godfrey, 2009)

With these constraints in place within a predefined system, changing one condition will necessarily affect the others. However, if one or more of the primary constraints of scope, schedule, or cost are not restricted, managing the project would likely not present many challenges or problems because any problem could be resolved simply by making changes to

the unrestricted constraints (Juran and Godfrey, 2009).

The Standish Group explored the real targets of performance, cost, scope, and time. These constraints were achieved in The United States, 17% of software projects, 50% of targets were changed due to lateness or cost overruns. Moreover, 33% were canceled outright. Though 83% of software projects were successful. The United States spent more than 250\$ billion dollars on software development, experienced the same rate of waste, failure, and cancellation. 30% of the resources needed to rework. The main causes of the failure were inappropriate planning and wrong application of the tools. Mizell and Linda (2007), added that these types of dismal failures are notwithstanding, placement of modeling and simulation tools has presented great development in the management of projects normally and engineering projects in terms of cost and time.

### **Simulation Management and Models in Engineering Projects**

The cost and schedule estimation have been widely recommended. Ferens and Christensen (1998) suggest that cost and scheduled estimation are historically accurate for large engineering development projects. The most famous models have reflected that only 25% of the actual cost for 50% of the time. The use of the simulation model is to communicate the complexity of the progress. It can also provide a check on other estimating methods that can be utilized in the same conditions. Obtaining an accurate estimation, in anticipation is quite unrealistic.

However, this is the task of management to commit resources to raise funds for projects, bid for a job, cost, and scheduled estimation. Simulation projects are normally developed to explore the effects of process changing. Still, it's not necessary to develop initial cost and scheduled estimation. Cooper (1980) mentioned that in project management, modeling and simulations are widely used. Moreover, it also includes large-scale projects such as in shipping, defense aerospace, oil and gas production, construction, and power plants. Streman (1992) added that using models is widely accepted in project management, as it effectively assesses the degree and sources of cost and schedule overrun in the context of litigation. However, system models are well reputed and used in business strategy.

## Conclusion

Modeling and simulation tools are widely accepted and used globally such as in transportation, accounting, medical, academic, manufacturing, oil and gas, and trading, etc. All these modeling and simulating tools are developed daily while the existing ones are updated regularly. As modeling and simulating tools are enjoying a great relevance to engineering projects at multiple stages.

The simulation models are used to assess the magnitude and basis of cost and schedule overrun in the relevance of litigation. The models are also used in business strategy and policy assessment. In many studies, modeling and simulation tool helped in the completion of the targeted project within the time zone without cost overrun. It is also appreciable that the savings were also recorded in many cases in terms of cost and project period that enchanted commendation for the project team. So, it is observed that modeling and simulation tools are used successfully in project management that helped in the compression of space and time of the targeted projects. Indeed, modeling and simulation are very helpful and relevant in managing engineering projects.

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