

Challenges in the Implementation of the Critical Path Method-A Review

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Abstract

Critical Path Method (CPM) is prevalent in Construction Management. Professionals (upper management) of the above discipline use this method to plan a construction project. The field team discarded the plan formulated using CPM because it is a paradox. The paradox is caused by the inability of the field team to adhere to the construction plan made by the upper management using the CPM. It is also the formal plan in the field of construction management and many government agencies perquisite CPM application for completing the project to disburse the first payment to the company. The CPM is cut short by on-site /work management plans which are short-term in nature to complete the project at hand. Investigation for the potential drawbacks and their reasons should be done to increase the reliability and thus the efficiency of CPM. The investigation involves the study of Action Theory which helps in finding out the reasons behind the failure of CPM in completing the project on time parallely reducing the project cost. Deliberative Action Theory, a type of action theory, is typically used in the development of a project plan which requires planning each project activity by the project manager which is a drawback as proved by the Situated Action Theory. The investigation is supported by visualizing a hypothetical scenario that showcases that the application of the Critical Path Method to complete the project on time is ineffective. It takes an example of a Construction Company which uses CPM to develop a project plan such that the project is completed on time. Based on the investigation hypothesis, some potential improvements for the effective and efficient application of CPM are suggested. The suggestion is supported by a case study that takes an example of a furniture manufacturing company that utilizes CPM and PERT to develop a project plan to complete the project on time and at the same time reduce the project costs.

Keywords

Project Management, Critical Path Method, Program Evaluation Review Technique, Critical Activities, Project Planning, Critical Route, Project Activities, Field Activity, Network Diagram.

1. Introduction

Project Management involves planning, scheduling, monitoring, and controlling the different project activities in such a way that the project is completed on time and within the assigned budget. The critical factor in the project completion is completing the project by utilizing an optimal cost-time trade-off. Cost and time required for completing a projected increase by an increase in the complexity of the project. This causes the company to shed more money and other resources such as labor to complete the project. A cost overrun in form of lost resources may cause a huge loss to the company.

Project Management offers some useful techniques to determine the optimal cost-time balance so that the project is completed within the stipulated time and budget (Agyei, 2015; Atin & Lubis, 2019; Göksu, 2017). This makes the work easy and efficient for the Project Managers assigned to the project thereby reducing the foreseeable losses (if any) that the company could have borne if the project had gone awry. These techniques are namely,

- a) Critical Path Method (CPM)
- b) Project Evaluation and Review Technique (PERT)

In this context, the focus would be on the implementation of the CPM. Both CPM and PERT are network models used to link different project activities directly or indirectly by employing logic or relevant technology required to link the activities. These methods thus help monitor and control the project activities. They also help determine a slack time for different activities involved in the project so that the project gets completed on time within the assigned budget. They do so by identifying the critical activities of the project through the network diagram which links the project activities logically. The identification becomes important because if the critical activities are

delayed beyond a certain time, then it may drastically affect the project completion time. This is fatal for the company because it causes cost overrun. CPM and PERT also help the company to assign resources to different project activities efficiently since it evaluates the optimal trade-off between the costs and time involved in the project (Agyei, 2015; Atin & Lubis, 2019; Göksu, 2017; Kikelomo & Olalekan, n.d.)

The underlying theory which governs the implementation of the Critical Path Method is that the amount of time required to complete a particular activity of a project is directly proportional to the number of resources allocated to that activity. This relationship is determined by analyzing the past data of resources required for project activities and the time required to complete that particular set of activities. Resource allocation is a critical component of the project because the company has to ensure that it doesn't assign any more resources to a particular activity which may increase the cost of completing the project. Many Project Managers tend to assign resources to project activities based on experience or gut approximation. This is not an efficient method to allocate resources to a particular project activity. This may cause the activity to be delayed if the resources allocated are not enough to complete that activity according to set requirements. This causes the company to bear the losses associated with the sub-standard completion of that particular activity (Agyei, 2015; Atin & Lubis, 2019; Göksu, 2017).

Sometimes, such completion is near to irreversibility that is, the process cannot be undone unless the company bears a huge cost involved to do so. The Project Managers can use software such as Arena Simulation software to allocate resources efficiently by simulating the project activities by inputting the time requires to complete the respective activities. This serves well for the company to strike an optimal cost-time balance so that the losses involved in the project completion are reduced and the project is completed with the budget decided for it. Software usage also helps in identifying activities that consume a high number of resources.

This helps to iterate the conduction of such activities optimally so that the resource consumption of the respective activities is reduced and the project is profitable to the company. (Agyei, 2015)The network diagram is also optimized by using the simulation software so that the sequencing of the activities is such that the project is in the execution phase with an optimal cost-time balance. A simulation done on the Arena Simulation Software of filling tanks is shown below in the figure. Each activity of the network is allocated time and resources objectively by the software based on the data. This helps in the successful completion of the project and at the same time minimizes losses (Agyei, 2015).

The benefits of CPM are as follows:

1. Identification of critical activities (activities that delay project completion) and interdependence of the tasks can be found.
2. It roughly estimates the expected project completion date and also helps in coordinating between departments and functions
3. Calculates slack so that the date on which tasks must be started to avoid project delay can be known in advance.
4. Tasks that can run parallel to meet completion time can be known. (Göksu, 2017; Senior, n.d.)

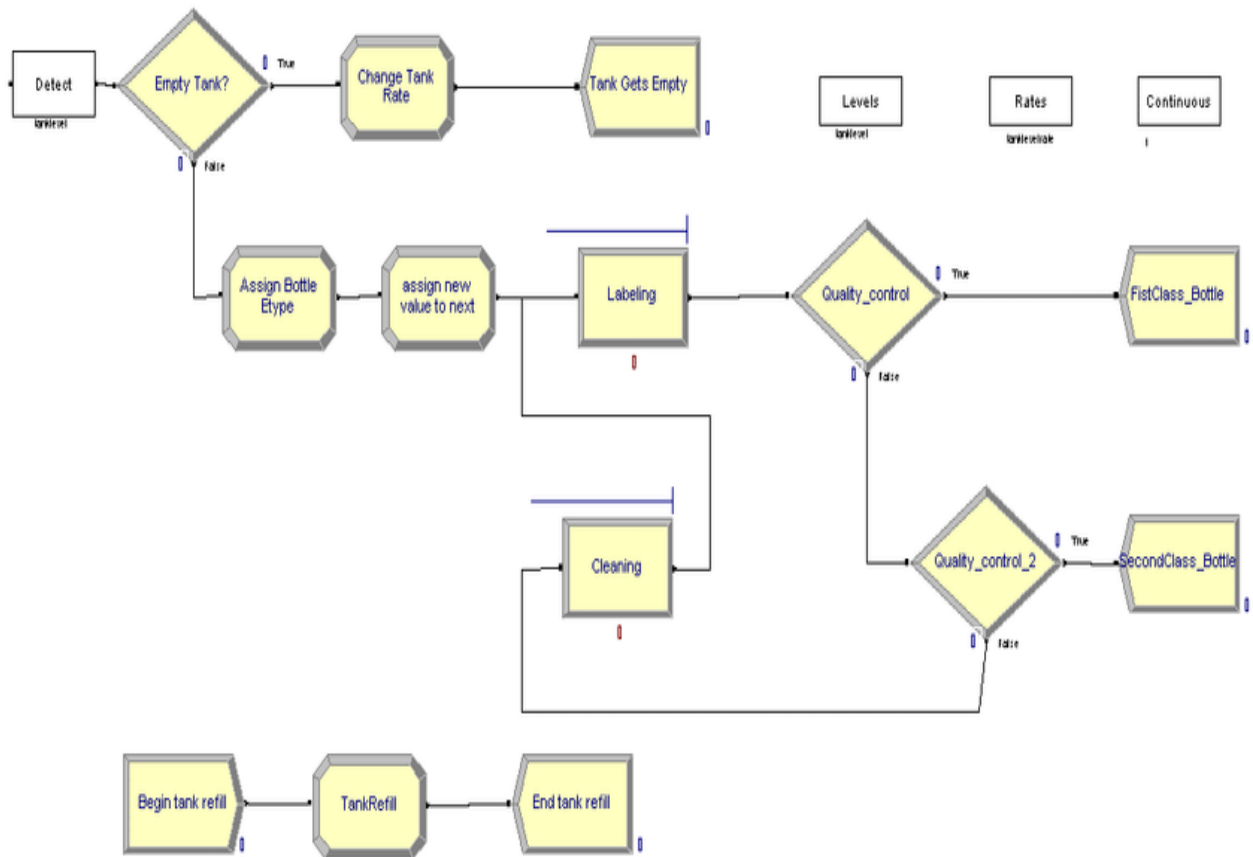


Figure 1. Network Simulation in Arena Simulation Software (Agyei, 2015)

2. Drawbacks of the Critical Path Method

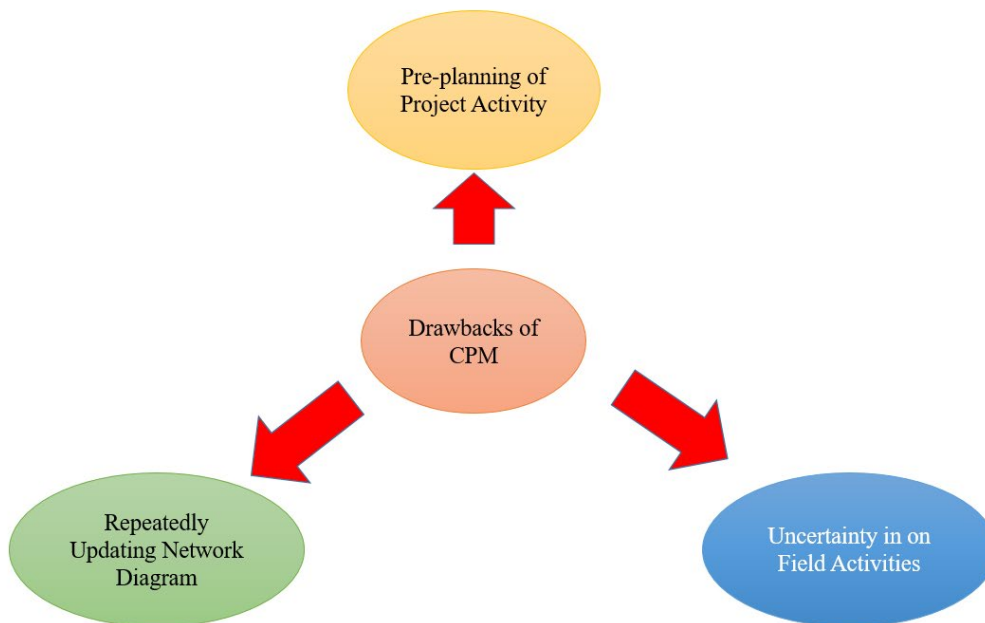


Figure 2. Drawbacks of CPM (Senior, n.d.)

The major difficulty faced by the CPM is that the agents (Project Managers) find it difficult to update the plan formed with the help of the CPM according to the on-field reality of the activities to be carried out to complete

the project. Updating the plan indicate, redrawing the network diagram to factor in the change in the logical sequence of the activities pre-determined by the project manager. (Senior, n.d.)

An example to illustrate the problem is as follows, A construction project costing 20 million dollars took approximately 3 months of pre-planning by using CPM (that's just the tip of the iceberg!) and when the project was started on the field by the construction company it took almost 15 odd months to factor in the filling of the gap between the planned network diagram and the actual network diagram based on the situation on the field. Thus, rendering CPM, the least favorable project management method. Therefore, the cost of planning for 15 man-months with reduced project completion speed adds more money to the project cost and thereby making it less profitable. Updating the plan is viewed as a backward-moving exercise instead of forward-looking action(Senior, n.d.)

2.1 Reasoning behind the CPM drawback hypothesis:

Different lines of reasoning tend to explain the CPM drawbacks. Paradox! There is a misalignment between the line of thinking between the upper management and the on-field construction team. On paper, CPM is the best-known planning method, which allows the project to get completed within the pre-determined time constraints. (Senior, n.d.)

In particular, there are two opposing lines of thinking over the CPM problem. Below is the opposing school of thought,

a) Some people blame the reception ability of the learners of the CPM and conclude that there is no fundamental fault in the method but, in particular the managers that apply the method in carrying out the project. An example is as follows,

Nowadays, computers help schedule specialists to put together the plan but the specialist doesn't know the underlying thought process for the logical build-up of the schedule.

b) There is another group of people that posit that there is no control available for the user over the issues relating to the method and there are some external factors that cause problems in the implementation of the method.

An example to depict it is as follows,

Today, an attitude that focuses on 'what?' instead of 'how?' is deeply embedded in the mind of the project manager and his/her team which is beyond the control of the project manager. (Senior, n.d.)

Both lines of thinking are disconnected from each other, these explanations require an additional premise to prove the underlying point that highlights the CPM problem as discussed above. (Senior, n.d.)

An additional premise is the Action Theory. It helps to find out if the above two hypotheses regarding CPM are consistent with the behavior demanded from the user or if it is just practically inconsistent.

2.2 Action Theory

In the context of project management, action theory helps to assess the behavior of any project manager as a function of the interaction with the project environment. (Senior, n.d.)

There are two types of action theories. They are namely,

2.2.1 Deliberative Action Theory

It explains that a project is always executed after formulating an action plan. The plan is made by discussion and there should be no deviation from the planned course of action. (Senior, n.d.)

The plan is a prerequisite and it controls the path of the project activities and takes it to the execution phase successfully. (Senior, n.d.)

2.2.2 Situated Action Theory:

It states that each step (activity in the network diagram of the project plan) should not be planned. Planning is exceptional activity and is to be done only when there is a deviation from the routine work of the project manager. (Senior, n.d.)

It is so because many steps taken by the project manager in the project execution phase are inherently routine for the project manager. The functionality of the project is void if every step of the project is planned and thus reducing the efficiency of the process. (Senior, n.d.)

3. Case Study on CPM implementation failure for ABC Construction Company. (Hypothetical Company)

CPM is a widely used method by project planners in the construction industry. It is an important process in the construction management program. Despite its popularity, most project plans made using CPM become

insignificant in the fieldwork. Because there are far too many variables attached to the real-world applications than on-paper estimations. One can understand challenges in CPM by studying the following case study of a construction company (Figure 1-4 and table 1).
(Atin & Lubis, 2019; Kikelomo & Olalekan, n.d.; *The Disadvantages of CPM Estimation*, n.d.)

Work plan for ABC Construction Company.

Table 1. Activity Description of ABC Construction Company

Activity	Activity description	Immediate predecessors	Estimated duration (DAYS)
A	Bringing equipment to the site	-	3
B	Site office construction	A	7
C	Foundation work	A	36
D	Position frame	B, C	87
E	Roofing	D	13
F	Erect walls	C	53
G	Walls finishes	F	63
H	Floor finishes	E, G	24
I	Ceiling finishes	E	12
J	Electrical installation	E, I	6
K	Painting & decoration	J	12
L	External works	H	14
M	Cleaning up & final inspection	K, L	14

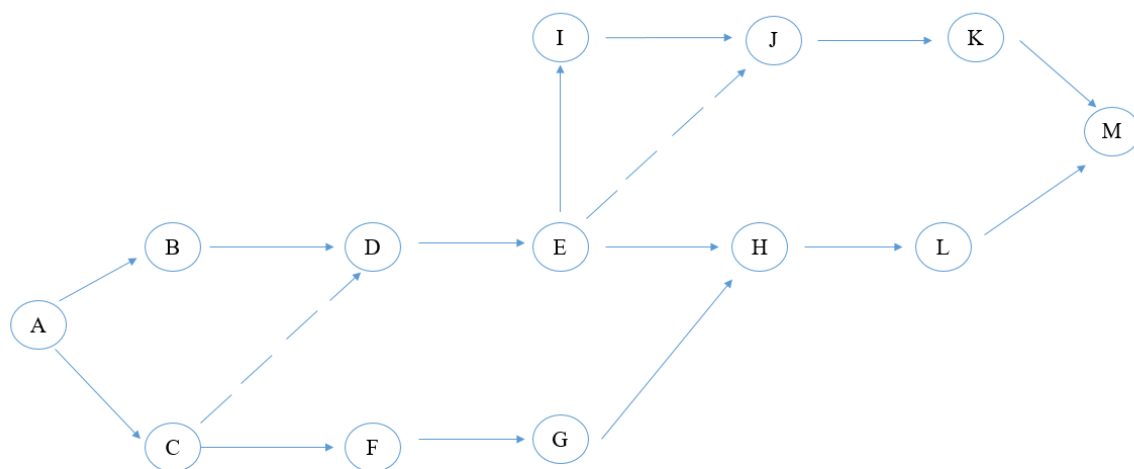


Figure 3. Network Diagram of ABC Construction Company
(Kikelomo & Olalekan, n.d.)

The above work plan is for a 2-story residential house construction project which is going to be developed by ABC Construction Company. The construction manager of the company has estimated the durations & dependencies of all important activities for this project & then developed this work plan. The project plan is then presented before the customer for the approval regarding total duration & cost for the completion of the project. After the approval from the customer, the company initiates the project and is expected to complete the project around the time that is agreed upon.

(Atin & Lubis, 2019; Kikelomo & Olalekan, n.d.; *The Disadvantages of CPM Estimation*, n.d.)

The manager now initiates the project by bringing equipment to the site. Everything goes well for a few days and then a problem arises regarding the foundation of the house. The engineers did a mistake by underestimating the softness of the land upon which the house was being built. Now, for solving this problem engineers decided to dig deeper which will solve the problem regarding the foundation but will increase the time & cost required to complete the whole project.

(Agyei, 2015; Atin & Lubis, 2019; *The Disadvantages of CPM Estimation*, n.d.)

It will result in a longer duration (10-15 more days) to complete the foundation work & all the following activities which will create a bad image of the company for the customer as the project will not be completed as per the agreed time.

(Agyei, 2015; Atin & Lubis, 2019; *The Disadvantages of CPM Estimation*, n.d.)

Now, the manager has to convince the customer of the requirement for a longer time duration & more funds. Because it was a mistake on the company's side the customer argues that he wants the project to be completed as per the agreed terms & conditions. The customer asked the company to provide a discount or pay for the loss that occurred to him due to the company's failure. After a lot of discussions, the company finally agreed to pay for the loss to the customer (which occurred due to them). The company had to face a bad impact because it resulted in financial loss, time wastage, customer loss & bad reputation of it in the market.

(Agyei, 2015; Atin & Lubis, 2019; *The Disadvantages of CPM Estimation*, n.d.)

Because CPM was used as a planning method, here only one-time estimation is taken into consideration & there is no space provided for any unwanted situations which might require more time. If any such situation occurs the project manager faces the following problems:

- Has to make the project network diagram again with updated time durations.
- Has to convince the customer for allowing more time.
- Has to convince the customer to more funds. Has to save the company's image as the customer will not be happy because the project is not undergoing as per the discussed terms.

(Agyei, 2015; Atin & Lubis, 2019; *The Disadvantages of CPM Estimation*, n.d.)

PERT can be used in such cases where there are uncertainties regarding the completion of particular activities in the project. In PERT that are three-time estimations for each activity taken into consideration for making a project plan. It is a very useful method because even if there are any unwanted situations taking place which require more time to complete a particular activity it will have very less probability of affecting the total duration for project completion as the uncertain time for each activity is already considered in starting while calculating the total duration.

Thus, planning through PERT can provide the managers the space where if any unavoidable situation occurs, it still can be resolved without affecting the completion time for the project.

(Agyei, 2015; Atin & Lubis, 2019; *The Disadvantages of CPM Estimation*, n.d.)

4. Potential Improvements to the Critical Path Method (CPM)

The improvements that are possible by Action Theory and Situated Action Theory can be realized by CPM techniques (Figure 4).

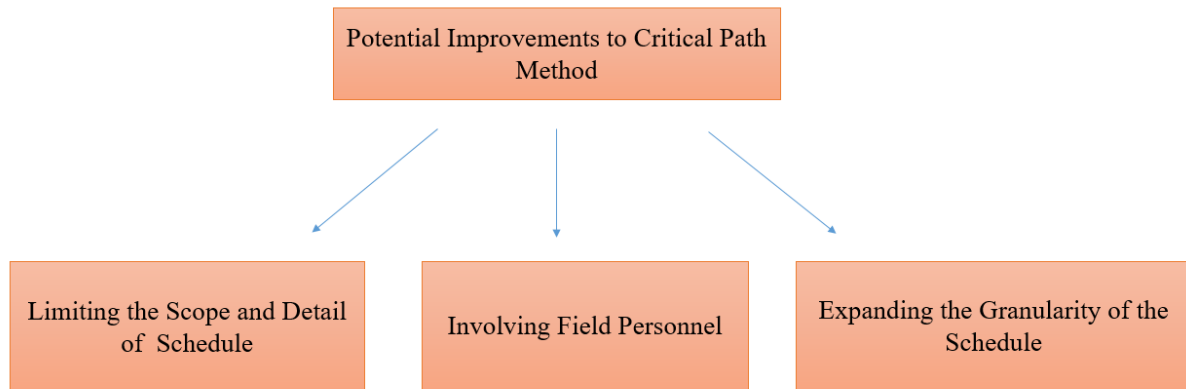


Figure 4. Potential Improvements to Critical Path Method (Senior, n.d.)

4.1 Limiting the scope and detail of the schedule

According to Situated Action Theory, a detailed plan for the entire project is ineffective if it is made from the start of the project. The detailing of the plan is proportional to the information in hand. A CPM becomes more effective if the detailing of activities is increased as their start time is approached. (Senior, n.d.)

4.2 Involving Field Personnel

CPM schedules are implemented in field management. The process of project plan development and execution is considered an independent issue in Deliberative Action Theory. A weekly meeting between the manager and field personnel should be organized to get a better update on the schedule. The involvement of an on-field supervisor in the planning of the project improves the success ratio for the project. A weekly meeting between the manager and field personnel should be organized to get a better update on the schedule. (Senior, n.d.)

4.3 Expanding the granularity of the schedule

Sometimes, a CPM schedule is very elaborate for activities in long run and is compact for upcoming management needs in the short run. A CPM schedule should also specify a detailed plan of immediate tasks. (For example, rooms to be finished next week, part of the construction of a bridge to be completed next week). The execution of the plan should run according to CPM Scheduled. (Senior, n.d.)

5 Case Study: Implementation of Critical Path Method on Dallas Furniture Company's Operation

The furniture-making industry is mainly an assembly industry, which makes use of various raw materials like panels made from wood, plastics, metals, textiles, glass, and leather. The furniture sector of European country alone consists of 150000 companies which have a turnover of 126 Billion EURO. (Göksu, 2017)

The Manufacturing process of any furniture product includes-

1. Selection of Design
2. Cutting/ slicing of Blocks(wooden)
3. Moulding to desired shaped
4. Carving
5. Assembly
6. Grinding to make the surface smooth.
7. Application of paint/polish. (Göksu, 2017)

5.1 Dallas Company

Dallas is a family-run business with more than 1000 employees and a 20-year history of making upholstery. The business operates in the Federation of Bosnia, Serbia, and Herzegovina. In all of the large towns in Bosnia, Serbia and Hercegovina, and Montenegro, the Company has established its retail network with a department-store chain due to its rapid growth. The long-term goal of Dallas' expansion into European and other international markets is to win them over with its high standards of quality, design, and pricing. The management of the company is looking to the future since Dallas is a name that evokes security and confidence and whose corporate history is founded on client satisfaction. (Göksu, 2017)

5.2 Collection and Processing Data

In the research study, the data is directly collected from an interview with an expert team of a Furniture Company. In processing, the data quantitative as well as qualitative data have been applied and the quantitative study used findings from the qualitative study to explain/interpret quantitative data. (Göksu, 2017)

5.3 Research Question

How will the implementation of CPM and PERT influence the effectiveness and efficiency of the furniture company "Dallas"? Is the question to which the research paper is seeking an answer? (Göksu, 2017)

5.4 Problem Defining

Six items from various product lines have been chosen to address the research issue. The time and cost of every activity in the production process must be presented in a table to identify the "critical route," project length, and cumulative project expenses for all of these items. The results should demonstrate how these methods significantly shorten the project's completion time. All findings will be compared to the company's historical data. (Göksu, 2017)

5.5 Results

The project completion time of Dallas's furniture company is significantly shortened by CPM and PERT. The study's final findings are anticipated to aid everyone—individuals and businesses alike—in better comprehending how CPM and PERT methodologies can cut down on project completion costs and time. As anticipated, the quantitative findings highlight the significance of using those techniques while planning, scheduling, and managing a project to maximize the efficacy and efficiency of a furniture company. The same procedure was carried out on six chosen items, and the results revealed that these strategies significantly shorten the project's completion time. (Göksu, 2017)

6. Conclusion

CPM follows the Deliberative Action Theory because the project is simulated beforehand by the project manager. The problems on the way while using CPM are mentioned above in the overview of the CPM. The main problem is the repeated updating of the network diagram by the on-field management team to factor in the real changes in the network diagram. This is explained by the usage of the above-mentioned action theory in carrying out project planning. (Göksu, 2017; Senior, n.d.)

The gap between planning and the ground reality is filled by updating the inputs (activities) to the plan. It comes to notice that updating is not a simple task. It involves a huge opportunity cost in terms of time (man-months) and money to carry out the updating and also finishing the project on time. This cannot be afforded by the client as well as the project manager. (Göksu, 2017; Senior, n.d.)

The role of plans and instruction are both pre-decided by the project manager and is proven by the deliberative action theory. A good manager always set out eccentric to the plan and completes the project within the established time limits because he/she knows that perfectly follow of the plan and instructions is not possible because of a difference between the planned project environment and the ground reality. The project manager has also the burden of going awry and not finishing the project, in such cases, the manager has to introspect on his planning and change it accordingly so that future managers don't make such mistakes again. (Göksu, 2017; Senior, n.d.)

Also, the nature of the world is hostile that is dynamic in nature preplanning is judged and is often termed as an absurd thing to do at the expense of resources and time. (Göksu, 2017; Senior, n.d.)

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Biographies

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Dr. M.B. Kiran is an Associate Professor in the Department of Mechanical Engineering, School of Technology, Pandit Deendayal Petroleum University, Gandhinagar, and Gujarat, INDIA. He earned his graduation (B.E.) from the University of Mysore in 1987. He did his post-graduation (M.E.) in Production Engineering from P.S.G. College of Technology (1991) and Doctoral degree (Ph.D.), in Surface Metrology from the Indian Institute of Technology (I.I.T.), Madras in 1997. He has Industry/Research/Teaching experience of 25 years. He has published technical papers in many reputed national/international journals and conferences. He is a certified project manager (P.M.P.) from P.M.I. He has completed many mission-critical projects. He has conducted many training programs for working executives.