APPLICATION OF PROJECT EVALUATION AND REVIEW TECHNIQUE (PERT) IN ROAD CONSTRUCTION PROJECTS IN NIGERIA

Onifade Morakinyo Kehinde, Oluwaseyi Joseph Afolabi, Ajuwon Babawale
Department of Management Technology, Bells University of Technology, Ota, Nigeria

Abstract: Due to the growing effects of the globalization in various business environments, the construction industry is expected to be effective and more efficient. For planning, scheduling and controlling a construction project, Project Evaluation and Review Techniques (PERT) need to be used by the project management team. The survey research design was adopted and copies of questionnaire were administered on one hundred (100) staff of Ministry of Works and Transports in Ogun State. The target groups of respondents are Project Director, Project Manager, Senior Pavement and Highway Engineer, Material Engineer, Quantity surveyor, Health, Environment and Safety Engineer. The data collected were analyzed using descriptive statistics and chi-square statistical analysis. The study revealed that the application of Project Evaluation and Review Technique (PERT) in road construction is an essential management approach that tends to achieve specified objectives within specific time and budget limits through optimum use of resources.

Key words: construction, road, projects, abandonment

1. INTRODUCTION

Construction Management is the art of directing and coordinating human and material resources throughout the life of a construction project by using modern construction management techniques to achieve predetermined objectives of scope, cost, time, quality and participation satisfaction. Project management in construction encompasses a set of objectives which may be accomplished by implementing a series of operations subject to resource constraints. There are potential conflicts between the stated objectives with regard to scope, cost, time and quality, and the constraints imposed on human material and financial resources. These conflicts should be resolved at the onset of a project by making the necessary tradeoffs or creating new alternatives. The construction management techniques are useful to professionals in the construction field in their day to day construction endeavours.

The PERT, is a statistical tool, used in project management, which was designed to analyze and represent the tasks involved in completing a given project. Project Evaluation and Review Technique is a method used to analyze the tasks involved in completing a given project, especially the time needed to complete each task, and to identify the minimum time needed to complete the total project. It can be considered as a road map for a particular program or project in which all of the major elements (events) have been completely identified, together with their corresponding interrelations.

PERT charts are often constructed from back to front because, for many projects, the end date is fixed and the contractor has front-end flexibility." A basic element of PERT-style planning is to identify critical activities on which others depend. The technique is often referred to as PERT/CPM, the CPM standing for "critical path method."

Corresponding author. Email: afolabiseyo@yahoo.com

ISSN 2560-4961(online)

www.epmj.org

2. STATEMENT OF THE PROBLEM

Today's road construction projects are more complicated than those of the past. Projects are often constructed in close proximity to traffic and the public, increasing the importance of time for constructing a project. In many building projects, cost is the main driver behind the execution of the project. In contrast, road construction projects typically emphasize time over cost in order to mitigate the risks associated with this public danger type of construction. The factors that motivated this schedule compression study and the selection of the method can be summarized under two major headings: generic factors and project-specific factors. Generic factors and project-specific factors in the use of the Project Evaluation and Review Technique (PERT) have been recommended to road construction contractors for greater management and control of the work and to prove or disprove delay claims and extension requests. It allows for a better understanding of the linear project than any other scheduling technique, primarily because the scheduler has access to activities' rates of production as well as the location.

The following hypothesis was put forward as tested in the course of this study:
Ho: Project Evaluation and Review Technique (PERT) is not an effective and efficient tool for time and work scheduling in road construction
H1: Project Evaluation and Review Technique (PERT) is an effective and efficient tools for time and work scheduling in road construction

3. LITERATURE REVIEW

Project Evaluation and Review Technique (PERT) is a scheduling method originally designed to plan a manufacturing project by employing a network of interrelated activities, coordinating optimum cost and time criteria. PERT emphasizes the relationship between the time each activity takes, the costs associated with each phase, and the resulting time and cost for the anticipated completion of the entire project (Harry, 2004).

PERT is an integrated project management system. These systems were designed to manage the complexities of major manufacturing projects, the extensive data necessary for such industrial efforts, and the time deadlines created by defense industry projects. Most of these management systems developed following World War II, and each has its advantages.

PERT was first developed in 1958 by the U.S. Navy Special Projects Office on the Polaris missile system. Existing integrated planning on such a large scale was deemed inadequate, so the Navy pulled in the Lockheed Aircraft Corporation and the management consulting firm of Booz, Allen, and Hamilton. Traditional techniques such as line of balance, Gantt charts, and other systems were eliminated, and PERT evolved as a means to deal with the varied time periods it takes to finish the critical activities of an overall project. PERT proved to be an ideal technique for one-of-a-kind projects, using a time network analysis to manage personnel, material resources, and financial requirements. The growth of PERT paralleled the rapid expansion in the defense industry and meteoric developments in the space race. After 1960, all defense contractors adopted PERT to manage the massive one-time projects associated with the industry. Smaller businesses, awarded defense related government contracts, found it necessary to use PERT.

PERT centers on the concept of time and allows flexible scheduling due to variations in the amount of time it takes to complete one specific part of the project. A typical PERT network consists of activities and events. An event is the completion of one program component at a particular time. An activity is defined as the time and resources required to move from one event to another. Therefore, when events and activities are clearly defined, progress of a program is easily monitored, and the path of the project proceeds toward termination. PERT mandates that each preceding event be completed before succeeding events, and thus the final project, can be considered complete.

The critical path is a combination of events and activities that will necessitate the greatest expected completion time. Slack time is defined as the difference between the total

expected activity time for the project and the actual time for the entire project. Slack time is the spare time experienced in the PERT (Ghaleb, 2001) A vital aspect of PERT is the formula used for the calculation of expected project time. The project reads:

Where *T* = expected completion time,
A = optimistic estimate,
M = most likely estimate,
B = pessimistic estimate.

Applying real numbers to the PERT formula, the result is as follows, where *A* (optimistic time) = 7 weeks; *M* (most likely time) = 11 weeks; *B* (pessimistic time) = 15 weeks: (or T, expected completion time)

Once the expected time is computed, the critical path is established. The PERT network considers all potential variables, thus quantifying the scheduling and planning of the project. In a comprehensive view of PERT, it becomes clear that despite the fact that some steps of the process are independent, the next step will depend on the successful completion of prior steps.

PERT has advantages as well as disadvantages, but time has seemingly not diminished its applicability. Planning a major network reveals potential problem areas and interdependent events that are not so obvious in conventional project development methods. One advantage is the three time estimate process, again useful in identifying difficulties as well as more effective interrelated processes. When utilizing the latest computer applications to PERT networks, managers have additional benefits with which to plan. A final advantage is the use of what is termed the management-by-exception principle, whereby data accumulated and analyzed by various means can be applied to the planning and execution of a major project.

When managers have used PERT in integrated project management, experience gained is reapplied to future projects, especially in developing bids for project estimates. When appropriate costing techniques are implemented with PERT networking, the project sponsors realize significant financial benefits. The PERT/cost system was developed to gain tighter control over actual costs of any project. PERT\cost relates actual costs to project costs. Job cost estimates are established from an activity or a group of activities on the basis of a time network. Labor and non-labor estimates are developed for the network targeting the control of time and costs and identifying potential areas where time and cost can be traded off—all aimed at more effective, efficient project management.

As with all aspects of business, the internet has become a powerful tool with respect to the implementation of PERT. Managers can now locate PERT applications on the World Wide Web and apply them directly to the appropriate manufacturing project. In most instances, PERT diagrams are available that eliminate the estimating process and make PERT a more useful and convenient tool (Zhong, 2003).

4. RESEARCH METHODOLOGY

4.1 Research Design

The research design used in this study is the descriptive survey method. The descriptive survey research design was used because it gives greater room to study the subject matter and ensures that inferences can be made about some characteristics, attitude, or behavior of the population examined in the study.

4.2 Sampling Technique

This study was carried out, using accidental sampling method (Accidental sampling sometimes known as grab, convenience sampling or opportunity sampling is a type of non-probability sampling that involves the sample being drawn from that part of the population that is close to hand). The expression need to determine the adequate sample size for a given population is

$$n=\frac{N}{1+N(e)^2}$$

Where n= sample size
N= sample population
e= level of error

4.3 Data Collection Instrument

Data collected for this research basically centered on the Application of Project Evaluation and Review Technique (PERT) In Road Construction.

The data collected in the research work are made up of both primary and secondary though a high percentage of data falls into the primary data.

4.3.1 Primary data

Primary data is the data collected by the researcher for the purpose of statistical analysis. It includes interview, personal discussion and distribution of questionnaire. Therefore, personal discussion and distribution of questionnaire are the major source of data accumulation in the research work.

4.3.2 Secondary data

Secondary data refer to materials or information collected previously by researchers or through existing body of knowledge such as books, newspapers, journals magazines, text books, etc. The researcher used this method because data collected are subjective and qualitative in nature.

4.4 Method of Data Analysis

The analysis of data involves more of statistical tools in the presentation of information. Simple percentages were used in qualifying the relationship in one datum to another.

Method of Analysis for Project Evaluation and Review Technique (PERT)

The same percentage frequency method is:

$$\frac{(FX100)}{Tr}$$

F= Frequency, TR= Total Number of Respondents. The research hypothesis will be tested using Chi Square Data Analysis Method.

$$\frac{\sum(Fo - Fe)^{2}}{Fe}$$

Where ∑= summation;
Fo= observed;
Fe= expected

The degree of freedom can be calculated using the formula DF= (r-1) (c-1) Where r = number of rows; c = number of column.

5. DATA ANALYIS AND PRESENTATION OF RESULTS

This discusses the results of data analysis. In reporting the results of data analysis, it starts with reporting the results of demographic data of the respondents and the figure of the respondents based on the subject matter.

The main purpose of the present study was to investigate the application of project evaluation and review technique in road construction. Data for the present study were collected from one hundred (100) staff of the Ministry of Works and Transports in Ogun State. The instrument that was used for data collection was a questionnaire. 100 copies of the questionnaire were delivered by hand to the respondents, 92 copies were returned (percentage of 92%); these 92 copies were accepted and used in the data analysis of the original distributed copies.

Table 1: Percentage Analysis of Respondents Score

S/N	STATEMENT	SA	SA %	A	A %	UN	UN%	DA	DA %	SD	SD %
1	PERT model is a suitable method for analysis and evaluation of mechanized road construction project because project activities are deterministic and times of activities are probabilistic.	32	35%	56	61%	0	0%	1	1%	3	3%
2	PERT models are increasingly powerful tool for modeling, scheduling, planning, controlling, and analyzing of road construction projects.	58	63%	33	36%	1	1%	0	0%	0	0%
3	PERT model Determine the deliverable products of the project	22	24%	60	65%	1	1%	7	8%	2	2%
4	PERT model Assign the boundaries of the project	17	18%	62	67%	0	0%	5	5%	8	9%
5	PERT model Determine budget of resources or cost and weight of the project activities.	16	17%	56	61%	2	2%	13	14%	5	5%
6	PERT model attracts the management attention to those activities which may face problems or seems to be associated with them.	8	9%	46	50%	0	0%	31	34%	7	8%
7	PERT model specifies the optimum start and finish points of each activity in the operation.	40	43%	48	52%	0	0%	3	3%	1	1%
8	PERT model facilitates the possibility of readjusting of the project for new conditions.	9	10%	67	73%	3	3%	5	5%	8	9%

9	PERT model facilitates the reporting and instructing procedures	9	10%	67	73%	0	0%	5	5%	11	12%
10	PERT model is a very useful device for educating employees in different fields of operation.	23	25%	58	63%	3	3%	4	4%	4	4%
11	PERT model is the most suitable tool for presenting the organizational chart and their relation.	6	7%	41	45%	3	3%	23	25%	19	21%
12	PERT model shows the relation between activities.	57	62%	34	37%	0	0%	1	1%	0	0%
13	PERT model is adjustable and also updatable.	34	37%	56	61%	0	0%	2	2%	0	0%
14	PERT model increases the harmony and coordination.	11	12%	76	83%	0	0%	3	3%	2	2%
15	PERT model specifies and segregates the responsibilities.	21	23%	64	70%	0	0%	6	7%	1	1%
16	PERT model refines the thoughts and increases the knowledge of user about related subjects and their relative importance in whole operation.	18	20%	64	70%	0	0%	3	3%	7	8%

Table 2: Chi Square Row and Column Summation for Number 1-8

STATEMENT	SA	A	UN	DA	SD	Column Summation
PERT model is a suitable method for analysis and evaluation of mechanized road construction project because project activities are deterministic and times of activities are probabilistic.	32	56	0	1	3	**92**
PERT models are increasingly powerful tool for modeling, scheduling, planning, controlling, and analyzing of road construction projects.	58	33	1	0	0	**92**
PERT model Determine the deliverable products of the project	22	60	1	7	2	**92**
PERT model Assign the boundaries of the project	17	62	0	5	8	**92**
PERT model Determine budget of resources or cost and weight of the project activities.	16	56	2	13	5	**92**
PERT model attracts the management attention to those activities which may face problems or seems to be associated with them.	8	46	0	31	7	**92**
PERT model specifies the optimum start and finish points of each activity in the operation.	40	48	0	3	1	**92**
PERT model facilitates the possibility of readjusting of the project for new conditions.	9	67	3	5	8	**92**
Row Summation	202	428	7	65	34	**736**

Table 3: Chi Square Calculation for Number 1-8

Fo	Fe	Fo-Fe	(Fo-Fe)2	(Fo-Fe)2/Fe
32	25.25	6.75	45.56	1.80
58	25.25	32.75	1072.56	42.48
22	25.25	-3.25	10.56	0.42
17	25.25	-8.25	68.06	2.70
16	25.25	-9.25	85.56	3.39
8	25.25	-17.25	297.56	11.78
40	25.25	14.75	217.56	8.62
9	25.25	-16.25	264.06	10.46
56	53.50	2.50	6.25	0.12
33	53.50	-20.50	420.25	7.86
60	53.50	6.50	42.25	0.79
62	53.50	8.50	72.25	1.35
56	53.50	2.50	6.25	0.12
46	53.50	-7.50	56.25	1.05
48	53.50	-5.50	30.25	0.57
67	53.50	13.50	182.25	3.41
1	0.88	0.13	0.02	0.02
1	0.88	0.13	0.02	0.02
2	0.88	1.13	1.27	1.45
3	0.88	2.13	4.52	5.16

1	8.13	-7.13	50.77	6.25
7	8.13	-1.13	1.27	0.16
5	8.13	-3.13	9.77	1.20
13	8.13	4.88	23.77	2.93
31	8.13	22.88	523.27	64.40
3	8.13	-5.13	26.27	3.23
5	8.13	-3.13	9.77	1.20
3	4.25	-1.25	1.56	0.37
2	4.25	-2.25	5.06	1.19
8	4.25	3.75	14.06	3.31
5	4.25	0.75	0.56	0.13
7	4.25	2.75	7.56	1.78
1	4.25	-3.25	10.56	2.49
8	4.25	3.75	14.06	3.31
				195.48

$\frac{\sum(Fo-Fe)^2}{Fe}$ = **195.48**

DF = (8-1) (5-1)
= (7) (4)
= 28

χ^2 = **195.48**, *DF* = 28, *p* <0.001. The result is significant at *p* <0.001.

Table 4: Chi Square Row and Column Summation for Number 9-16

STATEMENT	**SA**	**A**	**UN**	**DA**	**SD**	**Column Summation**
PERT model facilitates the reporting and instructing procedures	9	67	0	5	11	**92**
PERT model is a very useful device for educating employees in different fields of operation.	23	58	3	4	4	**92**
PERT model is the most suitable tool for presenting the organizational chart and their relation.	6	41	3	23	19	**92**
PERT model shows the relation between activities.	57	34	0	1	0	**92**
PERT model is adjustable and also updatable.	34	56	0	2	0	**92**
PERT model increases the harmony and coordination.	11	76	0	3	2	**92**
PERT model specifies and segregates the responsibilities.	21	64	0	6	1	**92**
PERT model refines the thoughts and increases the knowledge of user about related subjects and their relative importance in whole operation.	18	64	0	3	7	**92**
Row Summation	179	460	6	47	44	**736**

Table 5: Chi Square Calculation for Number 9-16

Fo	Fe	Fo-Fe	(Fo-Fe)2	(Fo-Fe)2/Fe
9	22.38	-13.38	178.89	8.00
23	22.38	0.63	0.39	0.02
6	22.38	-16.38	268.14	11.98
57	22.38	34.63	1198.89	53.58
34	22.38	11.63	135.14	6.04
11	22.38	-11.38	129.39	5.78
21	22.38	-1.38	1.89	0.08
18	22.38	-4.38	19.14	0.86
67	57.50	9.50	90.25	1.57
58	57.50	0.50	0.25	0.00
41	57.50	-16.50	272.25	4.73
34	57.50	-23.50	552.25	9.60
56	57.50	-1.50	2.25	0.04
76	57.50	18.50	342.25	5.95
64	57.50	6.50	42.25	0.73
64	57.50	6.50	42.25	0.73
3	0.75	2.25	5.06	6.75
3	0.75	2.25	5.06	6.75
5	5.88	-0.88	0.77	0.13
4	5.88	-1.88	3.52	0.60
23	5.88	17.13	293.27	49.92
1	5.88	-4.88	23.77	4.05
2	5.88	-3.88	15.02	2.56
3	5.88	-2.88	8.27	1.41
6	5.88	0.13	0.02	0.00
3	5.88	-2.88	8.27	1.41
11	5.50	5.50	30.25	5.50
4	5.50	-1.50	2.25	0.41
19	5.50	13.50	182.25	33.14
2	5.50	-3.50	12.25	2.23
1	5.50	-4.50	20.25	3.68
7	5.50	1.50	2.25	0.41
				228.64

$\frac{\sum(Fo-Fe)^2}{Fe} = \mathbf{228.64}$

DF = (8-1) (5-1)
= (7) (4)
= 28

$\chi^2 = \mathbf{228.64}$, $DF = 28$ $p < 0.001$. The result is significant at $p < 0.001$.

5.2 Discussion of results

Based on the Hypothesis testing, The Null Hypothesis (*Project Evaluation and Review Technique (PERT) is not an effective and efficient tool for time and work scheduling in road construction*) is rejected while the Alternate Hypothesis (*Project Evaluation and Review Technique (PERT) is an effective and efficient tool for time and work scheduling in road construction*) is accepted.

Table 6: Decision table for the hypothesis tested

Hypothesis Sample size (n)	Degree of freedom	Significance Level (α)	Chi-square values Decision (X2 tabulated)	Decision
92	28	0.001	**195.48**	The Null Hypothesis (*Project Evaluation and Review Technique (PERT) is not an effective and efficient tool for time and work scheduling in road construction*) is rejected while the Alternate Hypothesis (*Project Evaluation and Review Technique (PERT) is an effective and efficient tool for time and work scheduling in road construction*) is accepted.
92	28	0.001	**228.64**	

6. RECOMMENDATION

Keeping the project within schedule and as well keeping the customer satisfied are the key qualities of a successful project.

Successful project management involves the use of a good project management tool. The project management tool can help a project manager spot the early warning trends that could spell the downfall of a project. It also allows the project manager to monitor a project, keeping abreast with trends and possible problems whether it is deviating from the schedule and planned completion time in order to keep it on track.

The study recommended among others that project evaluation and review technique (PERT) should be applied gradually especially in government institutions where resistance to change is perceived to be high and adoption of an appropriate project management tool by any organization to save cost and time. Otherwise the project may be too expensive and be delayed unnecessarily because the more time spent on a project the higher the cost incurred.

REFERENCES

Evarts Harry (1994). Introduction to PERT. Allyn and Bacon.

Fair, Martin L. "A Comparative Study of Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), and Graphic Evaluation and Review Technique (GERT)." Master's thesis, Indiana University of Pennsylvania, 1994.

Horsley, F. William (1991). Means Scheduling Manual: On-Time, On Budget Construction, Up-to-Date Computerized Scheduling. 3rd ed. Kingston, MA: R.S. Means Co.

Kelley, James. Walker, Morga (2004). Critical-Path Planning and Scheduling.*Proceedings of the Eastern Joint Computer Conference*.

Moder, Joseph J. (1983)Project Management with CPM, PERT, and Precedence Diagramming. 3rd Ed. New York: Van Nostrand Reinhold.

PERT, CPM, and Gantt. SanRamon, CA (1990): Center for Project Management.

Soroush H. M (1999). The Most Critical Path in a PERT Network. *Journal of the Operational Research Society*, 89-99.

Spinner, M. Peter (1992). Elements of Project Management. 2nd ed. Englewood Cliffs, NJ: Prentice-Hall.

The Definitive Guide to Project Management (2007). Nokes, Sebastian. 2nd Ed. London (Financial Times / Prentice Hall): ISBN 978-0-273-71097-4

Wiest, Jerome D., and Ferdinand K. Levy (1997). A Management Guide to PERT/CPM. 2nd ed. Englewood Cliffs, NJ: Prentice-Hall.