

Assessment of Line of Balance Planning Technique for Construction Project Planning and Control in Nigeria

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Abstract- *Project planning requires proper planning in which risk are minimized, resources are effectively utilized, and project monitoring is made easy. However, project planning tools and technique are important component of actualizing a project. It is evident that Line of balance as a project method is not commonly used by professionals in the field, hence a need to conduct this study. This paper analysed line of balance, its method, description, diagrams, and questionnaire findings as well as recommendation. The study employed quantitative data; a total of 55 questionnaires were administered via e-platform to randomly selected personnel in different disciplines, there are three sections in the questionnaire; the first section is bio data; the second section is the level of efficiency in planning project and the third section is the most effective in terms of speed of delivery. The findings revealed that the Line of Balance method remains unused. Finally, the research suggested strategies in addressing the findings which include to use all project planning methods, both employees and employers, enlightenment line of balance method on e-media and materials and line of balance should be given more recognition and put into practice.*

Indexed Terms- *project, project planning, management process, line of balance, linear scheduling method,*

I. INTRODUCTION

In general, a project is a new endeavor with a specific goal that varies so widely that it is difficult to precisely define. The following are some commonly used definitions. A project is a short-term endeavor undertaken to create a one-of-a-kind product, service, or result. (ANSI/PMI99-001-2004 AMERICAN NATIONAL STANDARD). A project is a one-of-a-kind process that consists of a series of coordinated

and controlled activities with start and finish dates that are undertaken to achieve a specific goal while adhering to time, cost, and resource constraints. (Open Learn, 2021).

According to (Islam, 2021), A project is temporary because it has a defined beginning and an end in time, and therefore defined scope and resources while project management is the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements. The planning and organization of an organization's resources in order to move a specific task, event, or duty toward completion.

The Line of Balance technique was developed by the Goodyear Company in the early 1940s before being adopted and used by the United States Navy in the early 1950s. It was later adapted for industrial manufacturing and production control, as well as the fundamental concepts underlying construction planning and scheduling. (Acqnotes, 2021).

The line of balance, on the other hand, is a graphical device that allows a manager to see at a glance which activities of an operation are in balance. The line of balance chart depicts the exact situation of the operations, implying that the resources required will remain constant, and a chart is progressed by plotting the work accomplished and the planned rate of completion of the various trades, which can then be compared to the actual. The likely completion date can be predicted based on the rate at which the work has been completed. (Jadhav et al, 2018).

As a result, the purpose of this article is to explore line of balance as a project management measuring tool, its technique, applications, description, and explanation of the examples that are used when applying this

method in a project with repeated activities, as well as recommendations.

II. LINE OF BALANCE METHOD

For projects with recurring operations, LOB is a resource-driven scheduling solution. The main purpose is to find the resources needed for each assignment. The project is progressing according to plan, with activity flowing in a steady stream. The LOB approach is based on the number of needed units to be supplied at the end of the project, which determines the entire project's production rate. Crew synchronization, calculating resource demands, and creating the LOB schedule are all part of the line of balance formulation process. (Elyamany, 2021).

the project schedule in comparison to CPM schedules. It could only be divided geographically.

III. DESCRIPTION OF LINE OF BALANCE

The LOB approach is taught in this section utilizing (Astigarraga, 2019) An example of a project with a lot of repeatable tasks. Company ABC has been tasked with delivering 60 units to a customer at a weekly pace of three units. A normal work week is made up of five days of eight-hour shifts.

Activity	Worker (hrs /units)	Workers per crew	Activity buffer (days)
A	100	3	2
B	200	8	2
C	350	9	1
D	50	2	2
E	210	5	-

Table 1: Activities in the project

The first step is to create a network diagram of one of the units that will be manufactured. Figure 1 illustrates the network diagram:



Figure 1: A network diagram of a manufactured device.

The next step is to figure out how long each action will take. So that a schedule can be created afterwards. This is accomplished by creating a table containing all of the available data.

Several equations must be utilized to complete the table.

Crew size (theoretical) at the objective production rate:
 $G = \frac{\text{Worker hours per unit}}{\text{No hours per worker/week (40 hours)}}$

The number of workers that should potentially be required to meet the objective production rate ($r=3$ units/week) is calculated using this equation.

Size of the actual crew:

$G_a = \text{multiple of } G$

The result must be rounded to the nearest number of teams because Company ABC's employees are organized in teams, and the theoretical gang size is probably certainly not an integer. In this equation, G represents the number of workers on each team. Actual production rate $R_a = r * G_a$

The equation computes the activity's real rate of production, which will be used to draw the LOB graph later. G is the theoretical gang size in this case.

Duration of one unit's activity in days:

$D = \frac{\text{Worker hours per unit}}{\text{Workers per gang} * \text{N}^\circ \text{ hours per worker/day (8 hours)}}$

This equation computes the time required to complete one unit.

Time elapsed between the start of the first and the start of the last unit: $T = (Q-1) * \text{N}^\circ \text{ working days/week}$

R_a This is carried out for each and every project activity. The scheduler will be able to draw the LOB diagram afterwards.

IV. LINE OF BALANCE DIAGRAM

It should be noted that the buffer period between activities must be placed after the first unit when the subsequent action has a lower rate of production than the present one. The Line of Balance employs three (3) diagrams: a production diagram, an objective diagram, and a progress diagram. The LOB diagram is predicated on the assumption that production rates in each activity are uniform, but that rates between activities can vary. By objectively illustrating the cumulative completions of tasks associated with a

level of predicted number at a given point, the LOB diagram delivers a visual snapshot of the project's overall development. The rate of production for each activity should be larger than the rate of delivery to ensure that the project is completed on time.

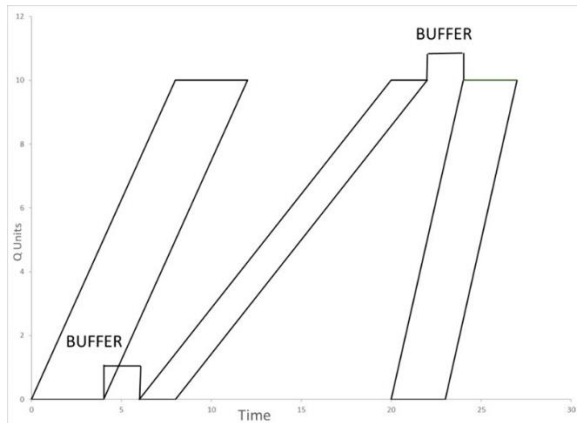


Figure 2: Buffer time disposition between activities

Each activity is performed by more than one team, as shown in Table 2. At any one moment, each crew can only work in one unit. If more than one crew is working on an activity at the same time, the crew that finishes working on one unit will go to the next available unit.

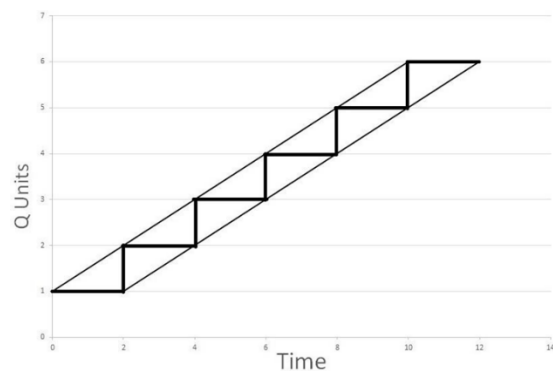


Figure 3: Movement of a crew's units during an activity.

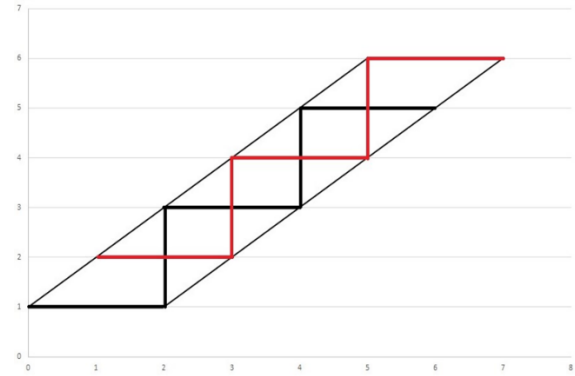


Figure 4: In an activity, movement between units of two crews.

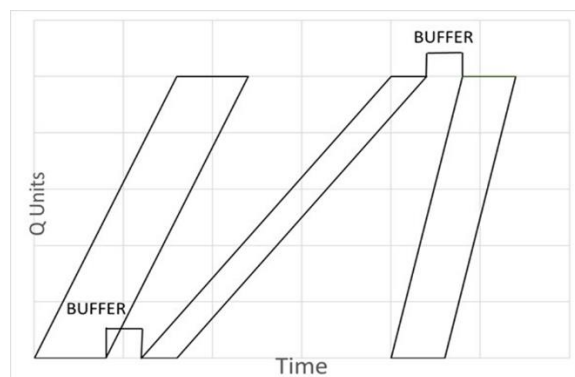


Figure 5: Depending on production rates, the order of time activities changes.

The LOB diagram is used to keep track of the project in an easy-to-understand format. It enables you to keep track of finished units while also determining where personnel should be and where resources are required at any given time. The use of distinct colors for each activity simplifies and speeds up the understanding of the LOB.

Sample 2: The LOB approach is demonstrated in this section with a simple example of a project with repetitive tasks. Company ABC has been tasked with completing four units of complete substructure works for a client in 45 days. A typical working day consists of 10 hours of work shift.

Team	Activity	Process time (Hr)	Ideal time
1	O	40	72.5
	M	30	42.5
	L	30	12.5

	C	10	2.5
2	I	30	82.5
	A	20	62.5
	D	20	42.5
	E	20	22.5
	G	20	2.5
3	N	20	92.5
	P	20	72.5
	Q	20	52.5
	J	20	32.5
	K	20	12.5
	F	10	2.5
4	U	20	92.5
	B	10	82.5
	H	10	72.5
	R	10	62.5
	S	10	52.5
	T	10	42.5

Table 4: Line of Balance table for example of activity allocation to 4 team with cycle time of 112.5 hours

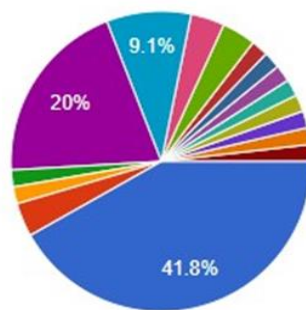
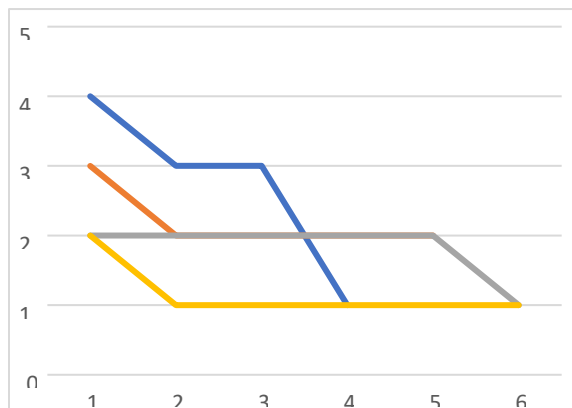


Figure 7: Line of Balance Diagram of the example for the time allocation

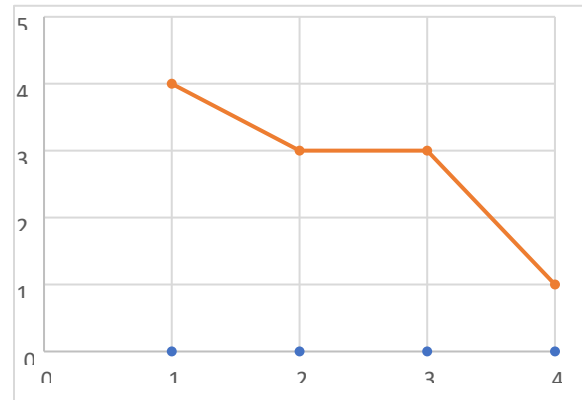


Figure 8: Line of Balance Diagram of the example for the time allocation.

V. QUESTIONNAIRE ANALYSIS

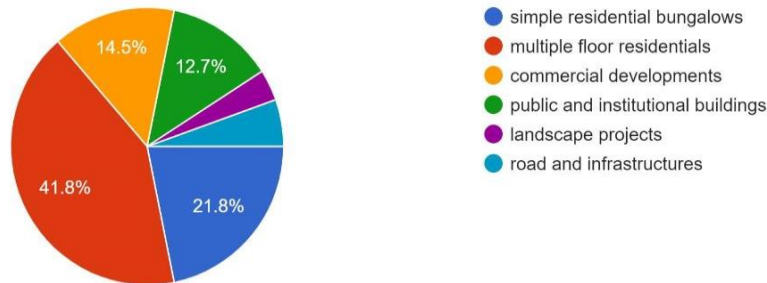
A total of fifty-five (55) questionnaire was distributed on e-platform to randomly selected individuals on assessment of project planning methods in Nigeria construction industry. There are three sections in the questionnaire; the first section is bio data; the second section is the level of efficiency in planning project and the third section is the most effective in terms of speed of delivery. However, the questionnaire will be analyzed using charts and summary in detail.

QUESTIONNAIRE: SECTION 1

I. DISCIPLINE OF THE INDIVIDUAL

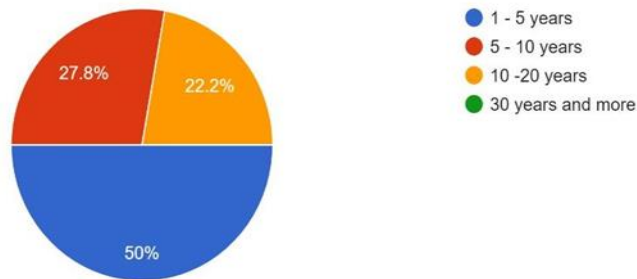
II. EXPERIENCE BASED ON BUILDING SCALE AND TYPE

State experience based on building scale and type
55 responses



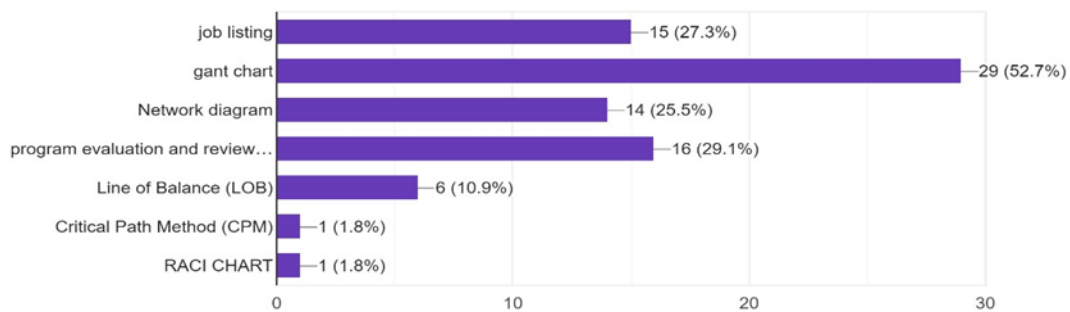
III. YEARS OF EXPERIENCE

years of experience
54 responses



IV. PROJECT PLANNING METHODS KNOWN

known project planning methods
55 responses



This clearly shows responses gotten from individuals in the construction and environmental industry which

indicates they are professionals and well sought. Out of the 55 responses, 48 individuals responded on the

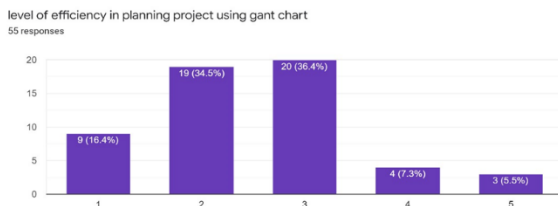
name of the firm and/or construction company employed. In this section, there are professionals who identified that they have over 30years of experience and below and have worked on different building scales and type, other than construction and they employ the seven different project planning methods as shown above. This section gives an insight on the respondent to inquire if they are familiar with project planning and the charts clearly shows the analysis. 10.9% of respondent are familiar with Line of Balance while the remaining 99.1% are familiar with other methods. The effect of this on the construction industry is that some of the non- construction professionals will be willing to take on projects using the knowledge of other project planning methods.

QUESTIONNAIRE: SECTION 2

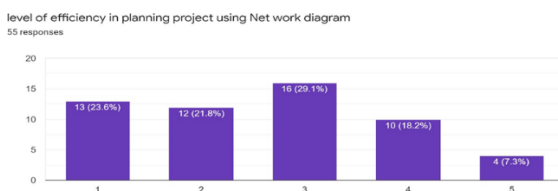
V. LEVEL OF EFFICIENCY USING JOB LISTING



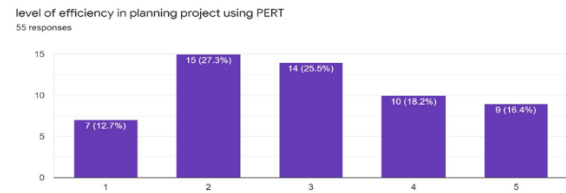
VI. LEVEL OF EFFICIENCY USING GANT CHART



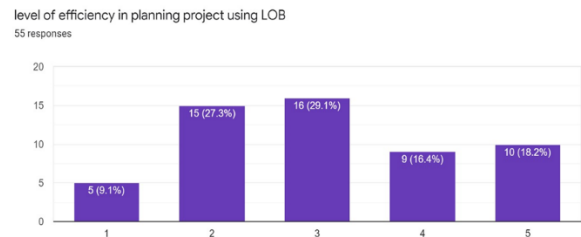
VII. LEVEL OF EFFICIENCY USING NETWORK DIAGRAM



VIII. LEVEL OF EFFICIENCY USING PERT



IX. LEVEL OF EFFICIENCY USING LINE OF BALANCE



The second part of the questionnaire analyzed the level of efficiency using project planning methods. It is obvious with the results, that methods of project planning are being used. In these responses, 40% and below was the highest percentage on efficiency level using project planning methods, which is not up to average of the total respondents especially on Line of Balance. The effect of this on projects is that projects to be delivered will not be timely, effective, and balanced.

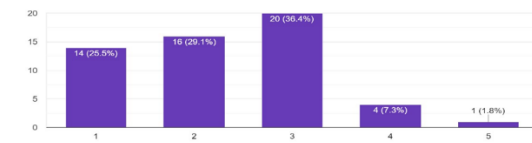
QUESTIONNAIRE: SECTION 3

X. SPEED OF DELIVERY USING JOB LISTING



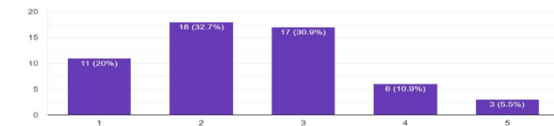
XI. SPEED OF DELIVERY USING GANT CHART

SPEED OF DELIVERY USING GANT CHART
55 responses



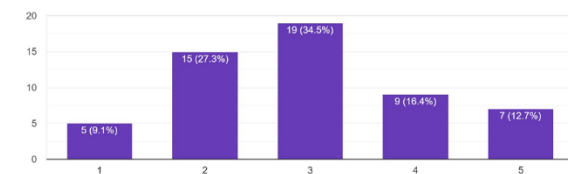
XII. SPEED OF DELIVERY USING NETWORK DIAGRAM

NET WORK DIAGRAM
55 responses



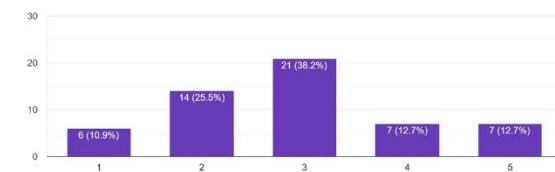
XIII. SPEED OF DELIVERY USING PERT

SPEED OF DELIVERY USING PERT
55 responses



XIV. SPEED OF DELIVERY USING LINE OF BALANCE

SPEED OF DELIVERY USING LOB
55 responses



This final section analyses speed of delivery using project planning methods. Using Job listing 43.6% has the highest speed of delivery, 36.4% using Gant chart, 32.7% using Network diagram,

34.5% using PERT and 38.2% using Line of Balance.

CONCLUSION AND RECOMMENDATION

The LOB scheduling method has been repeatedly shown to be the most effective method for scheduling recurring projects such as pipeline construction or high-rise building construction. It simplifies keeping track of how the project is progressing. Planners can

use a LOB diagram to identify any schedule imbalances and take corrective action at the source of the problem.

Understanding the mathematics involved in the LOB technique's construction, as well as how to construct the LOB diagram, is essential for realizing the LOB method's full potential. One of the primary benefits of LOB diagrams is their ease of use and comprehension. The acceleration procedure assists the planner in optimizing the distribution of available crews in the project, reducing total project length while maintaining total worker hours. The correct application of the LOB approach relies on the usage of multiples of the natural rhythm. Only in this manner can the project be completed efficiently and with the fewest possible worker hours. Because idle time exists between units, if a different crew size than the optimal one is utilized, the overall worker hours' increase. The LOB approach has never been employed. One possible cause is that LOB is not typically taught in academic programs, and there is currently no computer software accessible for enterprises to employ. The creation of relevant curriculum and software. Because the Line of Balance is a good way to utilize, the study demonstrates how to use it to simplify and clarify resource management and resource optimization activities, as well as to visualize productivity and crew location. As a result, non-construction and construction companies must use LOB as a project planning tool. It is also advised that both employees and employers use all project planning methodologies. On e-media and materials, project managers should inform and teach these ways. As a result, Line of Balance should be given more attention and practiced.

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