CHAPTER TWENTY FIVE

PROJECT PLANNING AND CONTROL

25.1 OVERALL PROJECT CONTROL

The planning process is all- important as the basis for subsequent control. Establishing baselines and measuring progress against these plans is the key to effective control (Cleland 1990). The planning techniques that provides the WBS, cost estimate and network plan are therefore of paramount importance through the life of the project. Although time and cost are the primary targets for control, the principles apply to material, documentation and any set of major project deliverables. If planning is about establishing the when and how much of the project, then monitoring is about the 'where and the action that should be taken if there is any deviation from the plan. Control is achieved by monitoring progress, comparing the actual situation with the project plan and objectives, and finally, if necessary, making adjustments with the help of a control mechanism. The control mechanisms are part of the guidelines set up in the project management procedures. Control cannot happen without prior planning and monitoring processes, this process of progress assessment; its

analysis and comparison with the plan, paves the ways for subsequent control. Figure 25.1 shows a typical control cycle. The Plans and budgets are developed from the project's goals, objectives and scope; detailed schedules of time, cost and materials are derived from the plans and budgets. As part of the regular review cycle, comparisons are made between planned and actual performance. If the variance is acceptable (for example; within the float for activities) then only a minor revision to the schedule is needed. If, however, the variance is greater than can be accommodated by these revision then the plan and / or budget has to be revised. This must bring the change control procedure into play and a formal request to change the budget or plan, or indeed the scope has to be raised. Its effect should be estimated, before agreement and its funding from either client or contractor account should be obtained, especially if the project is a formal contract. On rare occasions, the variance is so great that a change in project objectives is required. This is usually due to external circumstances such as legislation or strategy changes.

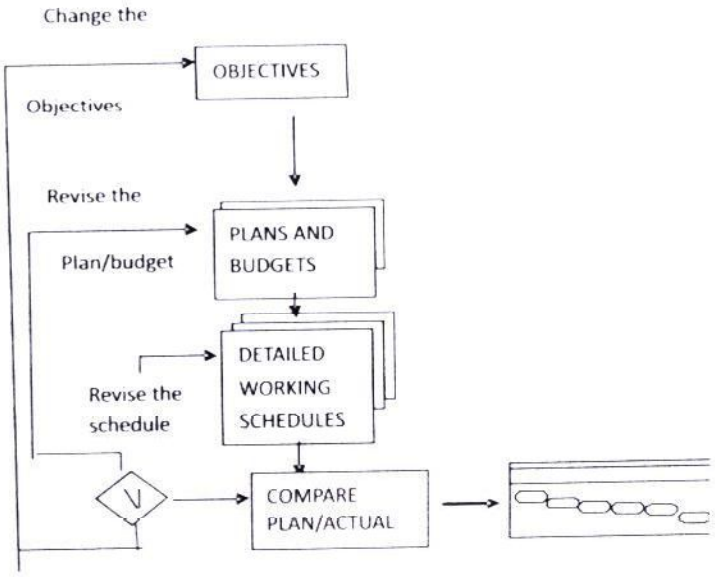


***Figure 25.1** A Typical Control Cycle*
***Source:** Shahani and Stainton (1989)*

The objectives of monitoring are to accumulate performance data, analyze significant deviations and forecast the impact on the project. In other words, it

aims to assess what is happening and where the project is going. The first step in monitoring is to gather information from all the relevant project participants. Some of the data collected will need to be consolidated into graphs and further reports, and finally all the information will need to be analyzed and conclusions drawn. The success of all planning previously done and the ability to control these plans will depend on the effective monitoring of a project's progress. The frequency of monitoring will depend on the project and the stage the project has reached. If a project is nearing completion and is under pressure to be completed, monitoring will become more crucial.

Finally, a meeting of representatives of all departments involved needs to be held to discuss the situation, make decisions and approve them. Any changes and progress will need to be amended and distributed. Control can only be exercised by making decisions and taking corrective action where necessary. It will always be relative to the agreed scope and the defined balance between time, cost and quality.

Project planning and control is the bedrock and engine of a successful project. It is a common saying that one either plans to succeed or plans to fail by not planning or controlling planned work during the implementation process. The inability to control project plans is a major critical factor to project failure and abandonment especially in developing economies. This work is very significant as it produced a road map to project professionals and project stakeholders on a step to step guide in project planning and control procedures. It provided solution to easy understanding of planning tools like the use of network analysis, tracking and smoothing of project time and cost, the use of network floats, Gantt charts, earned value analysis, managing the probabilistic nature of PERT network, calculation of scheduled performance index and crashing of network activity time and cost without compromising quality.

Planning is deciding in advance what to do, how to do it, when to do it, and who is to do it. Planning bridges the gap between, where we are and to where

we want to go. It makes it possible for things to occur, which would not otherwise happen.

Project planning is a more complex function of project management, which requires careful thought and effort. This is because of the magnitude of time, budget and technical performance that surrounds both public and private projects. Project planning consists of identifying all project activities and determining their inter-relationships. It also involves estimating and allocating time and recourses to all activities while striking a balance in the use of available time and resources, to ensure effective implementation of the project. Project planning requires creativity and initiative in other to establish the objectives, goals and strategies within the project life cycle.

This also helps in the development of a plan in sufficient detail, identification of relevant milestones and the application of available techniques to prepare, monitor and control the project.

Planning is closely interrelated with control and feedback to ensure that the project conforms to time, budget and specification.

It is your plan that tells you where you are supposed to be if you have no plan, you have nothing to compare progress against, so without a plan, control is impossible to achieve. None goes without the other.

The basic steps in project planning are:

i. Define the problem to be solved by the project;
ii. Develop a mission statement, followed by the project;
iii. Develop a project strategy (methodology) that will meet all project objectives or target;
iv. Write a scope statement to define project boundaries of all task/works and milestones (what will and will not be done);
v. Develop a work breakdown structure (WBS). By listing all the activities that are needed to be done in the project document plan;

vi. Estimate activity durations, resources requirements and costs (activity costs and project cost);

vii. Prepare the project master schedule and budget. This involves scheduling time and cost for each activity or milestone from WBS based on the resource requirement;

viii. Decide on the project organization structure you intend to use if you are free to choose;

ix. Set up the project notebook;

x. Get the plan signed by all project stakeholders

xi. Budget and Budgeting

CHAPTER TWENTY SIX

NETWORK AND TIME ANALYSIS

26.1 NETWORK ANALYSIS

Network planning is one of the most significant project management techniques used in planning scheduling and controlling a project. Planning technique is vital at all the stages of a project life cycle. It is a continuous process because of the prevailing need to keep track of progress changes delays or changes in technical conditions. Delays and changes in project implementation are controlled by the application of critical path methods. They enable management to cope with the complexities, masses of data and tight deadlines characteristic of many industries and their highly competitive environments.

It is important at this stage to know that in Network analysis, the terms "planning" and "scheduling" are not synonymous. To this end planning involves the establishment of objectives, definition of the content of the project and the determination of the relationships between the jobs or activities. Planning indicates what activities are to be accomplished which may not be time dependant.

Scheduling is the development of a time-table in consideration of the duration of activities, which means putting time estimates alongside the developed plan. At this point, time estimates, timing calculations and job scheduling are involved.

Project control is regarded as the third major element of project management, it is a follow-up, updating and reporting, in a process of making events confirm to schedules by co-ordinating the action of all parts of the organization accordingly for the attainment of set or originally established objectives.

26.2 SOME TECHNICAL TERMS ASOCIATED WITH NETWORK ANALYSIS

1. BAR CHARTS OR GANTT CHARTS.

Gantt charts were introduced in Net work planning by Henry Gantt. The method was most widely used before the formal development of network planning. It is for examining project progress, determination of specific work required to accomplishing an objective. It includes:

(a) The listing of activities

(b) Activity duration.

(c) Schedule dates.

(d) Project status.

Network analysis is advantageous over Gantt chat for reasons which include the following: it enhanced inter-departmental communications; the project activities are properly evaluated before another project activity begins; it permits the use of alternative methods for completing the project by concentrating on the critical tasks; it permits clear definition of responsibilities and minimizes the incidence of crisis. This is achieved by identifying critical part activities that are behind schedule for special attention.

The two network methods popularly in use are: the Critical Path Method (CPM), and the Program Evaluation and Review Technique (PERT). The fundamental departure of the two is that CPM is cost conscious while PERT is time conscious. PERT uses probabilistic activity time estimate (3-time estimate) in determining probability that a project could be completed by a given date. CPM on the other hand uses deterministic activity estimates (single time estimate) and is designed to control both the time and cost aspect of a project; in particular time/cost tradeoffs. The network principle involved in both CPM and PERT are alike, little differences exist

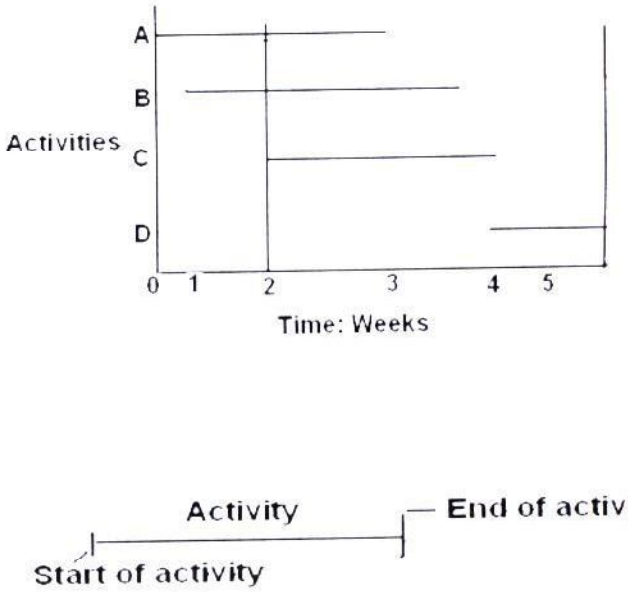


***Figure 26.1** Simple Gantt Chart*

Each line represents a single activity. We have four activities with five weeks duration. In week Two, activities A and B are still behind schedules. Activity C is on schedule the same with D.

Example of some activities on a project site.

A - Clearing of site.
B - Excavation of taproots and other obstacles.
C - Clearing of obstacles and leveling off the ground.
D - Pegging and Rope administration foundation work.

26.3 STEPS TAKING IN BAR CHART PREPARATION.

1. Analyze the project and determine the approach that may be more applicable to the execution of the project.
2. Streamline reasonable activities to be scheduled.
3. Determine possible time limit for each activity.
4. Place activities on a time sequence knowing that certain activities must be performed sequentially while others can be performed simultaneously.

5. If a completion date is specified, the diagram is adjusted until this constraint is satisfied.

26.4 PERT AND CPM

The program Evaluation and Review Technique (PERT) and critical Path Method (CPM) for performing time – cost tradeoffs is one of the best tools for project planning and control.

The technique helps to determine cost – effectiveness as a way to expedite a project knowing that certain projects can be rushed for a price.

This method has been successfully and advantageously used while planning and managing large scale and complex projects. PERT was first used in the 1950's to manage the Polaris missile program. Since then the scheduling techniques to be described have been successfully used by private industries in such areas as;

(a) Construction of complex structures, shopping centers and subways.
(b) Major maintenance efforts.
(c) Pilot production runs.
(d) Introduction of new products.

These tools should be used when starting new educational programs designing experiments, publishing books, or planning vacations.
Whenever faced with complex situations, a manager should use these techniques.
There are two major types of PERT.

1. STERMINISTIC PERT (DETERMINISTIC).
2. STOCHASTIC PERT.

26.5 STERMINISTIC (DETERMINISTIC) PERT

This assumes that all the tasks that make up a project are sufficiently routine in the sense that the time needed to complete each task is known with reasonable certainty. For example, construction industry project, tasks associated with

normal repair and maintenance. Even though the individual tasks are fairly routine, the project as a whole may comprise a large numbers of such tasks. This method estimate the optimistic project completion time.

26.6 STOCHASTIC PERT

This is often used to plan either research or one-of-a- kind development projects because of the valuable insights gained by the very act of identifying intermediate miles tones and establishing logical processes among them. Due to the inherent novelty of the component task of such project however, it is usually not possible to estimate task duration precisely. Nevertheless, it is possible to obtain a range of estimates of duration for tasks. In more difficult cases advice must come from a panel of experts. The Delphi method and the nominal group method are the most frequently used techniques for obtaining and assimilating the expert advice.

26.7 PERT TIME ESTIMATE

In PERT activity time estimates are in the form of three time estimate, **a,m,b,** where a denotes the most optimistic time which assumes that everything will go according to plan. It is the shortest possible time required for completing an activity; **m** is the most likely or normal time. This is the most likely time if the activity was repeated over and over: **b denotes** the pessimistic time which is the maximum time required to accomplish the activity. This assumes that everything goes wrong.

In assuming that the standard deviation ♪ is one-sixth of the time requirement range, and the expected time (te) is given

$$\text{by } t_o = \frac{a + 4m + b}{6}$$

Where t_o = expected time, a = most optimistic time, b = most pessimistic time and m = most likely time.

26.8 HOW TO DRAW A NETWORK

O = Event, ⟶ = activity, --------- = Dummy arrow.

Dummy arrows (dashed lines) may be used to express relationships between jobs that are not indicated by solid arrows. Dummy arrows do not represent a job or activity. They do not consume resources and they have no duration.

Table 26.2 NETWORK CHART PLAN

ACTIVITY	TITLE	PREDECESSOR IM	AT
A 1 2	A	-	5
B 1 3	B	-	3
C 2 4	C	A	2
D 2 5	D	A	3
E 3 5	E	B	3
F 4 6	F	C	3
G 5 6	G	E	6
H 6 7	H	F	4
I 6 7	I	E	3

IM = Immediate predecessors.

AT = Activity time.

Figure 26.1 Network chart (plan)

The network can be drawn once the sequences of the job are known. The above is a network plan with time estimate.

26.9 CPM NETWORK WITH TIME ESTIMATE.

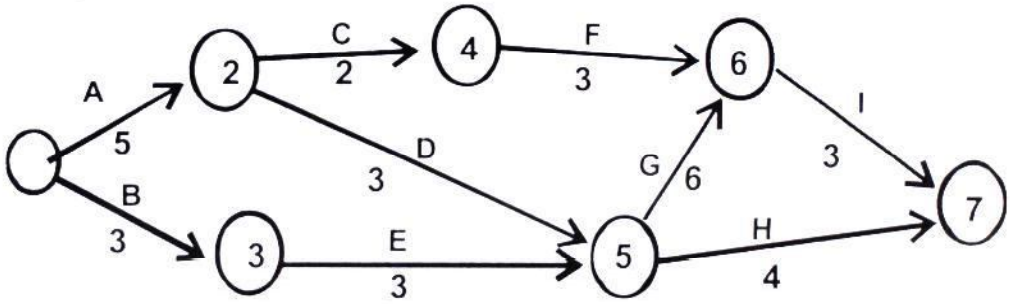


Figure 26.2 *Network with Time Estimate*

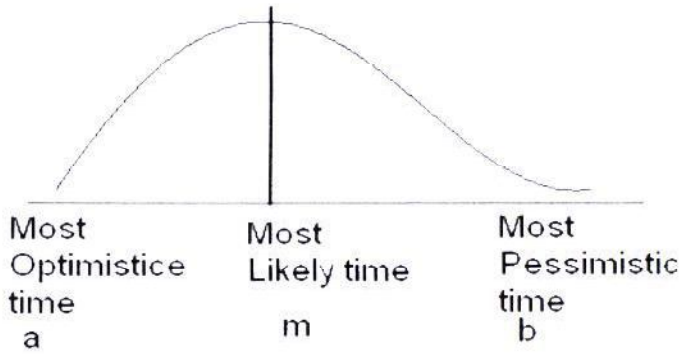
After planning a job or project, you determine the necessary milestone of a particular activity, when the average duration of each job is estimated, then Network time scale can be indicated as shown above.

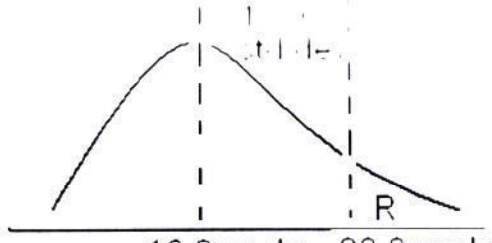
The time estimates are placed beside the appropriate arrows.
Timing calculations follow after time estimates are obtained.

PERT TIME ESTIMATE

$$te = \frac{a + 4m + b}{6}$$

Where te equal the expected time for the activity, or expected elapsed time.





probabilty of finishing before 20 weeks

$$\frac{20 - 16.8}{2.3} = 1.39 \text{ std.dev.}$$

Figure 26.3 *Probability Curve*

std.dev. for TE event 4

$$= \sqrt{\left(\text{std.dev. activity 1-2}\right)^2 + \left(\text{std.dev. activity 2-3}\right)^2 + \left(\text{std.dev. activity 3-4}\right)^2}$$

$$= \sqrt{1.0^2 + 2.0^2 + .5^2} = \sqrt{1 + 4 + .25}$$

$$\sqrt{5.25} = 2.3\text{weeks}$$

$$\sqrt{\left(\frac{b - a}{6}\right)^2}$$

Prob. $\frac{\text{Pro - TE}}{\text{std.dev}}$

26.10 PERT DIAGRAM WITH EXPECTED ACTIVITY PERFORMANCE TIME

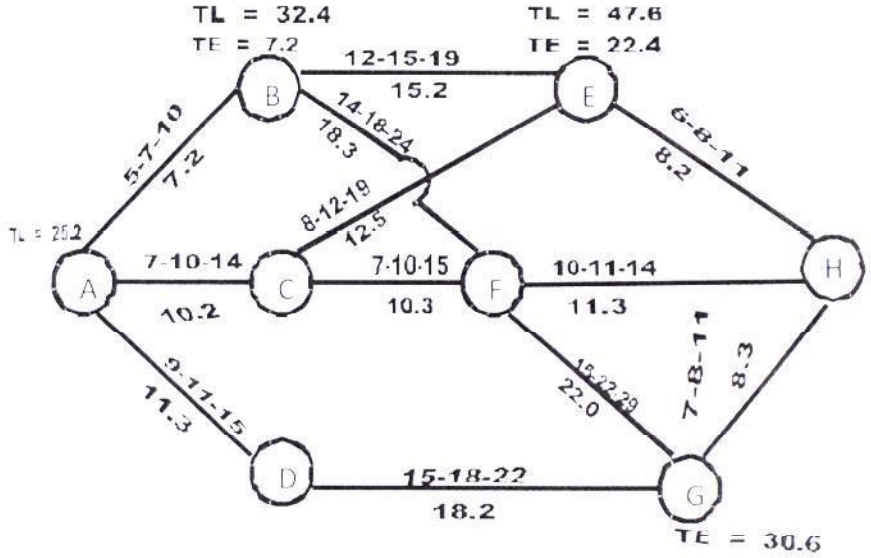


Figure 26.3 Expected Time For The Activities

Table 26.2 PERT Time Estimate

Activity		Time estimates (The numbers are Weeks of time.)			
Beginning Event	Ending Event	Optimistic	Most likely	pessimistic	weighted average te $\frac{a+4m+b}{6}$
A	B	5	7	10	7.2
A	C	7	10	14	10.2
A	D	9	11	15	11.3
B	E	12	15	19	15.2
B	F	14	18	24	18.3
C	E	8	12	19	12.5
C	F	7	10	15	10.3
D	G	15	18	22	18.2

E	H	6	8	11	8.2
F	H	10	11	14	11.3
F	G	15	22	29	22.0
G	H	7	8	11	8.3

Table 26.3 Expected Time in Weeks

	PATH	EXPECTED TIME IN WEEKS	TOTAL
I.	A - B - E - H	7.2 + 15.2 + 8.2	30.6
II.	A - B - F - H	7.2 + 18.3 + 11.3	36.8
III.	A - B - F- G - H	7.2 +18.3 + 22.0 + 8.3	55.8
IV.	A - C - E - H	10.2 + 12.5 + 8.2	30.9
V.	A - C - F - H	10.2 + 10.3 + 11.3	31.8
VI.	A - C - F - G - H	10.2 + 10.3 +22.0 +8.3	50.8
VII.	A - D - G - H	11.3+18.2+8.3	37.8

This listing shows that pathway A – B – F – G – H , The "critical path" requires 55.8 weeks. Its time sets the minimum possible time for completing the project. If activities in this path are not done on time the project cannot finish on time.

E	H	6	8	11	8.2
F	H	10	11	14	11.3
F	G	15	22	29	22.0
G	H	7	8	11	8.3

Table 26.3 Expected Time in Weeks

	PATH	EXPECTED TIME IN WEEKS	TOTAL
I.	A - B - E – H	7.2 + 15.2 + 8.2	30.6
II.	A - B - F – H	7.2 + 18.3 + 11.3	36.8
III.	A - B - F- G – H	7.2 +18.3 + 22.0 + 8.3	55.8
IV.	A - C - E – H	10.2 + 12.5 + 8.2	30.9
V.	A - C - F – H	10.2 + 10.3 + 11.3	31.8
VI.	A - C - F - G - H	10.2 + 10.3 +22.0 +8.3	50.8
VII.	A - D - G – H	11.3+18.2+8.3	37.8

This listing shows that pathway A – B – F – G – H , The "critical path" requires 55.8 weeks. Its time sets the minimum possible time for completing the project. If activities in this path are not done on time the project cannot finish on time.

Table 26.4Time Estimate with Earliest , Latest and Slack estimates

PATH	EVENT	ESTIMATED TIME (te)	EARLIEST POSSIBLE TIME (TE)	LATEST POSSIBLE TIME (TL)	SLACK TIME
	1	2	3	4	5
I	A	0	0	25.2	0
	B	7.2	7.2	32.4	0
	E	15.2	22.4	(47.6)	25.2
	H	8.2	30.6	55.8	0
II	A	0	0	19.0	0
	B	7.2	7.2	26.2	0
	F	18.3	25.5	44.5	0
	H	11.3	36.8	55.8	0
III	A	0	0	(0)	0
	B	7.2	7.2	(7.2)	0
	F	18.3	25.5	(25.5)	0
	G	22.0	47.5	(47.5)	0
	H	8.3	55.8	(55.8)	0
IV	A	0	0	24.9	0
	C	10.2	10.2	35.1	0
	E	12.5	22.7	47.6	0
	H	8.2	30.9	55.8	0
V	A	0	0	24.0	0
	C	10.2	10.2	34.2	0
	I	10.3	20.5	44.5	0
	H	11.3	31.8	55.8	0
VI	A	0	0	5.0	0
	C	10.2	10.2	(15.2)	5.0
	F	10.3	20.5	22.5	0
	G	22.0	42.5	47.5	0
	H	8.3	50.8	55.8	0
VII	A	0	0	18.0	0
	D	11.3	11.3	(29.3)	18
	G	18.2	29.5	47.5	0
	H	8.3	37.8	55.8	0

Table 26.5 above sums up the "te" times cumulatively from the start of each path. The calculation provides the basis for finding out where the slack exists.

Earliest possible time = forward pass. add each activity along the path. where two paths intersect, use the higher duration time of the activity.
Latest time is the opposite of Earliest which is backward pass. Slack is Earliest Start (ES) minus Latest Start (LS) or Earliest Finish (EF) Minus Latest Finish (LF)

Table 26.5 TIME ESTIMATE

ACTIVITIES	OPTIMISTIC	PESSIMISTIC	DIFF-ENE	DIFFERENCE SQUAE	VARANCE te^2	CUMULATED VARIANCE (EARLIEST Te^2)	STANDARD DEVIATION (Te)
A – B	5	10	5	25	0.69	0.69	0.8
B – F	14	24	10	100	2.78	3.47	1.9
F – G	15	29	14	196	5.44	8.91	3.0
G – H	7	11	4	16	0.44	9.35	3.1

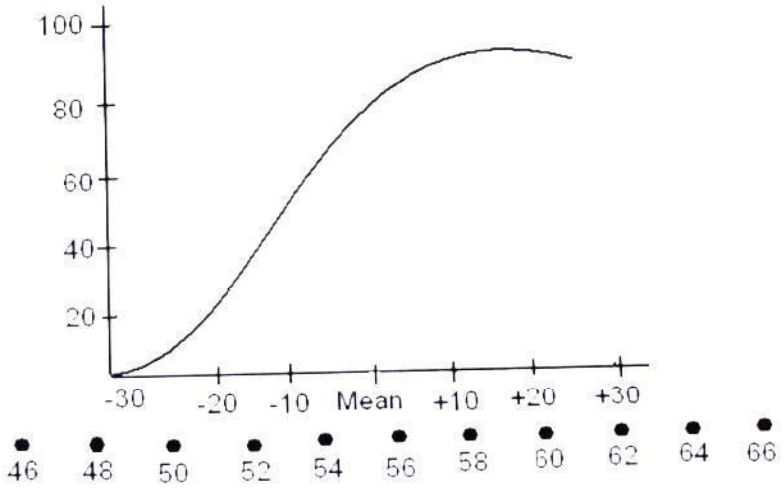


Figure 26.4 WEEKS CHART

Example

Your company is to project manage the construction of a private residential building in Owerri, as the project manager of your firm , your boss directed you to give him a detailed network plan that will ensure the successful execution of the project. How would you comply with this directive? See below for your guide.

List all the major activities in all the stages of the building execution.

Assign PERT time estimate to the activities. Convert the three time estimates to one time estimate. Then, (a) Construct a project network indicating the critical path and sub-critical activities? (b)What is the probability of completing the building in 24 months?

Solution; Assume the activities to be:

A – clearing site, B – Excavation of foundation, C – Foundation work to DPC

D – Block work to decking, E – Elevation of block work to roofing, F – Roofing

G – Plumbing work, H- Plastering, I – Painting

26.11 USING PERT TIME ESTIMATE

Table 26.6 PERT TIMED ACTIVITY TABLE

activity	title		a	m	b	AT
1-2	A	-	5	2	3	2.67
1-3	B	-	6	2	4	3.67
2-4	C	A	7	5	3	5
2-5	D	A	6	2	4	3
3-5	E	B	4	2	3	2.5
4-6	F	C	3	2	2	2.17
5-6	G	E	5	3	4	3.5
5-7	H	G	6	2	3	2.83
6-7	I	F	4	2	2	2.3

PERT Formula

$$T_e = \frac{a + 4m + b}{6}$$

Where a= Optimistic Time, m= Most likely Time, b= Pessimistic Time

$$A = \frac{+ 4(2) + 3}{6} = 2.67$$

$$B = \frac{6 + 4\,(3) + 4}{6} = 3.67$$

$$C = \frac{7 + 4\,(5)}{6} + 3 = 5$$

$$D = \frac{6 + 4\,(2)}{6} + 4 = 3$$

$$E = \frac{4 + 4\,(2)}{6} + 3 = 2.5$$

$$F = \frac{3 + 4(2) + 2}{6} = 2.17$$

$$G = \frac{5 + 4(3) + 4}{6} = 3.5$$

$$H = \frac{6 + 4(2) + 3}{6} = 2.83$$

$$I = \frac{4 + 4(2) + 2}{6} = 2.3$$

26.12 A PROJECT NETWORK PLAN

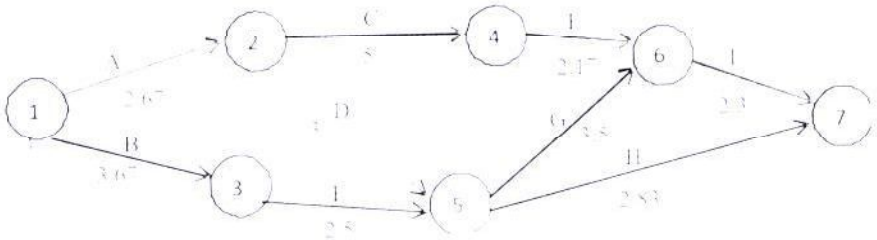


Figure 26.5 *Network Plan*

Determine the critical path

Part 1 = ACFI = 2.67 + 5+ 2.17+ 2.3 = 12.14

Part 2 = ADGI = 2.67 + 3+ 3.5 + 2.3 = 11.47

Part 3 = ADH = 2.67 + 3 + 2.83 = 8.5

Part 4 = BEGI = 3.67 + 2.5 + 3.5 + 2.3 = 11.97

Part 5 = BEH = 3.67 + 2.5 + 2.83 = 9

A C F I is the critical path

The probability of completing the project in 24 months

Standard deviation and variance formula

$t_o = \frac{b}{6} - a$

A C F I = 12.44

$A = \frac{3 - 5}{6} = -0.3$

$$C = \frac{3 - 7}{6} = -0.67$$

$$F = \frac{2 - 3}{6} = -0.17$$

$$I = \frac{2 - 4}{6} = -0.3$$

$$\sigma t_o = \sqrt{A} + \sqrt{C} + \sqrt{F} + \sqrt{I} = \sqrt{-0.3} + \sqrt{-0.67} + \sqrt{-0.17} + \sqrt{-0.3}$$

$$= \sqrt{(-0.3)2} + \sqrt{(-0.67)2} + \sqrt{(-0.17)2} + \sqrt{(-0.3)2} = 2.33$$

$$= \frac{24 - 12.14}{2.33}$$

$$\therefore t_o = 5.09$$

Example

As a project manager of a reputable building construction firm, your boss expected you to plan for the execution of a story residential building and find out the possibility of completing the structure in 30 weeks.

For your guide;

a. list all the major activities in all the stages of the building execution.

b. Assign PERT time estimate to the activities.

c. Convert the three time estimate to one time (te) estimate.

Then;

Construct a project network indicating the critical path and sub- critical activities?

Find the possibility of completing the project in 30 weeks?

Table 26.7 Network Design Plan

S/N	ACT.NAME	PRE.ACT	a	m	b
I	A	-	.05	1	2
2	B	A	1	2	3
3	C	A	1	3	5
4	D	B	3	4	5

5	E	C	2	3	4
6	F	C	3	5	7
7	G	D	4	5	6
8	H	F	6	7	8
9	I	GF	2	4	6
10	J	I	5	6	8
11	K	I	1	2	3
12	L	J	3	5	7

CONSTRUCT A PERT NETWORK

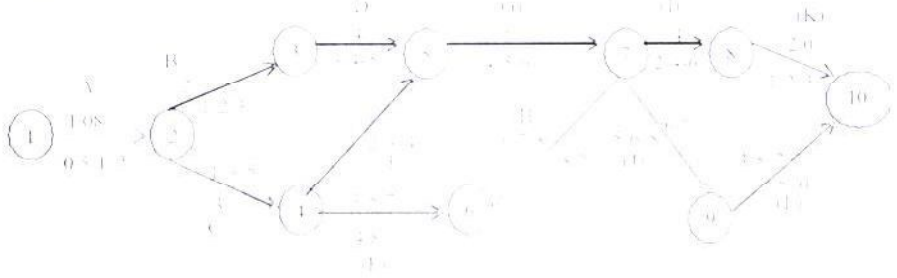


Figure 20 Network Plan of the above question

$$A = te = a + \frac{4m + b}{6} \; (e.g)\; 1-2 = \frac{0.5 + (4 \times 1) + 2}{6} = \frac{6.5}{6} = 1.08$$

$$B = 2-3 = \frac{1 + [4 \times 2] + 3}{6} = \frac{12}{6} = 2$$

$$C = 2-4 = \frac{1 + (4 \times 3) + 5}{6} = \frac{18}{6} = 3$$

$$E = 4-5 = \frac{2 + (4 \times 4) + 5}{6} = \frac{24}{6} = 4$$

$$F = 4-6 = \frac{3 + (4 \times 5) + 6}{6} = \frac{29}{6} = 4.8$$

$$G = 5-7 = \frac{4 + (4 \times 5) + 6}{6} = \frac{30}{6} = 5$$

$$H = 6 - 7 = \frac{6 - (4 \times 7) - 8}{6} = \frac{49}{6} = 8.2$$

$$I = 7 - 8 = \frac{2 + (4 \times 4) + 6}{6} = \frac{24}{6} = 4$$

$$J = 7 - 9 = \frac{5 + (4 \times 6) + 8}{6} = \frac{37}{6} = 6.7$$

$$K = 5 - 10 = \frac{1 + (4 \times 2) + 3}{6} = \frac{12}{6} = 2$$

$$L = 9 - 10 = \frac{3 + (4 \times 5) + 7}{6} = \frac{30}{6} = 5$$

DETERMINE THE VARIOUS PATHS AND INDICATE THE CRITICAL PATH

1.	ABDGIK	=	1.1+2+4+5+4+2	= 16.1
2.	ACEGIK	=	1.1+3+3+5+4+2	= 18.1
3.	ACFHIK	=	1.1+3+4.8+8.2+4+2	= 23.1
4.	ACEGJL	=	1.1+3+3+5+6.7+5	= 23.8
5.	ACFHJL	=	1.1+3+4.8+8.2+6.7+5	= 28.8

The critical path is;

ACFHJL with tick line on the graph above.

What is the probability that the project will be completed within 30 weeks?

1. Find the standard deviation of the time along the critical path.

Standard deviation is given at

$$dte = \frac{b - a}{6}$$

Critical path is ACFHJL

$$A = \frac{2 - 0.5}{6} = 0.25$$

$$C = \frac{b-a}{6} = \frac{5-1}{6}$$

$$F = \frac{b-a}{6} = \frac{7-3}{6} = 0.67$$

$$H = \frac{b-a}{6} = \frac{8-6}{6} = 0.33$$

$$J = \frac{b-a}{6} = \frac{8-5}{6} = 0.50$$

$$L = \frac{b-a}{6} = \frac{7-3}{6} = 0.67$$

Standard deviation

$$\delta t_c = \sqrt{0.25} + \sqrt{0.67} + \sqrt{0.67} - \sqrt{0.33} + \sqrt{0.50} + \sqrt{0.67}$$

$$= \sqrt{(0.25)^2 + (0.67)^2 + (0.67)^2 + (0.33)^2 + (0.50)^2 + (0.67)^2}$$

$$= \sqrt{(0.0625) + (0.4489) + (0.4489) + (0.1089)}$$

$$= \sqrt{1.765}$$

$$\delta t_e = 1.33$$

To find the probability of completing the project in 30 days

$$Z = \frac{30 - 28.8}{1.33} = \frac{1.2}{1.33} = 0.50$$

From the standard normal curve table $(0.50)\% = (0.5 - 0.5) = 0$

Probability of completing the project in 30 days is 100% or 98%.

In preparing the network schedule, the under listed procedures are followed: prepare work breakdown structure from the bill of quantities (project documented plan), identify activities relationships; draw the network, calculate activity times, determine the critical part and project duration, carry out network time analysis, variability of project duration and crashing the network.

The list of activities in the installation of factory power plant complex are given in Table26.8 below and its network diagram is given in Fig.

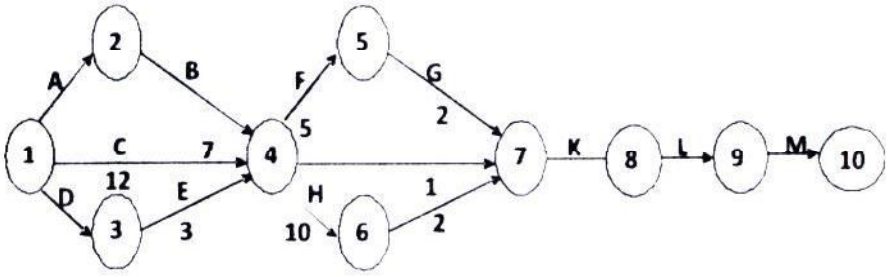


Fig. 26.6: Network flowchart for factory power plant complex

Table 26.8 Activity list and expected duration

S.NO	Activity	Activity path	Activity code	Expected duration	Predecessor	Immediate predecessor
	Burdine main power house	1-2	A	12	-	B
	Building base plants and cable channels	2-3	B	7	A	EIH
	Procure equipment and accessories	2-4	C	12		EIH
	Pay all statutory and NEPA charges	3-4	D	2		J
	Statutory inspection of site by NEPA	3-4	I	3	D	EIH
	Install transformers	4-5	E	5	BCI	G
	Install NEPA meters	4-5	G	2	I	K
	Install generators	3-6	H	10	BCI	I
	Install changeover switches	6-7	J	3	H	K
6	Install control panels	4-7	I	6	BCI	K
1	Run and connect cables	7-8	K	5	GH	L
2	Powered by power mains	8-9	L	2	K	M
	Testing and Commissioning of installation	9-10	M	7	L	-

The method of slack is used where:

Activity in series: Activity A must be completed before activity B can commence.

Activity in parallel: Activity B can proceed while activity A is still proceeding. These are listed in Fig. 2 above, showing also the float.

The following are the steps and procedures for the analytical calculations involved:

Earliest Start Time: allocating zero to the starting activity (expected time) to obtain the earliest start of the proceeding activity. Thereafter, add the duration of the activity to the earliest start of the proceeding activity. Where two or more

[illegible] are involved, add the activity duration to the largest value of the start time of the proceeding activities.

Earliest Finish Time: starting from the end event, add activity duration (earliest time to earliest start time of the activity). Thereafter, work backward by deducting the activity duration from the earliest finish time of the proceeding activity.

Latest Start Time: this is obtained by subtracting the duration of activity from the latest finish time.

Latest Finish Time: taking the latest finish time of the end event to be same as its earliest finish time, then work backward by deducting the duration of the proceeding activity from its latest finish time to obtain the latest finish time of the proceeding activity.

Total Float: subtract latest start from latest finish and subtract activity duration from the result. Or subtract earliest finish from latest finish of activity (LF- LS or LF- EF).

Free Float: earliest start time of succeeding activities (latest) minus earliest start time of the activity minus duration of the activity.
Independent Float: earliest start time of succeeding activities (latest) minus latest finish time of proceeding activities (highest) minus duration of the activity.

In calculating activities, the PERT three-time estimate procedures are followed.

$$t_e = \frac{(t_o + 4k_c + t_p)}{6}$$

Where t_e = expected activity time; t_o = optimistic time, K_c = most likely time and t_p= pessimistic time

These estimates are into a weighted average for each activity. This is the estimate of the average time the activity would take if it were repeated many times. The time estimate most heavily weighed is the most likely time.

26.13 DETERMINING THE CRITICAL PATH/PROJECT DURATION:

The duration of the project is the time required on the critical path. For the factory complex power project, the duration of the different path are as calculated below:

Path 1: A(42) + B(7) + F(5) + G(2) + K(5) + L(2) + M(5) = 70 days

Path 2: A(42) + B(7) + J(6) + K(5) +L(2) + M(7) = 69 days

Path 3: A(42) + B(7) + H(10) + I(2) + K(5) + L(2) + M(7) = 75 days

Path 4: C(12) + F(5) + G(2) + K(5) + L(2) + M(7) = 33 days

Path 5: C(12) + J(6) + K(5) + L(2) + M(7) = 32 days

Path 6: C(12) + H(10) + I(2) + K(5) + L(2) + M(7) = 38 days

Path 7: D(7) + E(3) + F(5) + G(2) + K(5) + L(2) + M(7) = 31 days

Path 8: D(8) + E(3) + H(10) + I(2) + K(5) + L(2) + M(7) = 30 days

Path 9: D(7) + E(3) + H(10) + I(2) + K(5) + L(2) + M(7) =36 days

The critical path 3: A-B-H-I-K-L-M = 75 days

The project duration is 75 days.

26.14 EVALUATION OF THE NETWORK-TIME ANALYSIS:

The table below shows the time analysis of the factory power plant project being considered.

Table 20: Time Analysis and Evaluation of the Network.

S/No	Activity	Activity code	Time in days									Float			CP
			t_o	t_l	t_p	t_e	S^2	ES	EF	LS	LF	Total	Free	Indep.	
1	1-2	A	32	42	52	42	11.11	0	42	42	42	0	0	0	*
2	2-4	B	4	6	1	7	2.78	42	49	49	49	0	0	0	

					4										
3	1-4	C	8	12	16	12	1.78	0	12	49	49	37	37	37	
4	1-3	D	5	7	9	7	0.44	0	7	46	46	39	0	0	
5	3-4	E	1	3	5	3	0.44	7	10	49	49	39	33	0	
6	4-5	F	2	5	8	5	1.00	49	54	59	59	5	0	0	
7	5-7	G	1	2	3	2	0.11	54	56	61	61	5	5	0	
8	4-6	H	8	10	12	10	0.44	49	59	59	59	0	0	0	*
9	6-7	I	1	2	3	2	0.11	59	61	61	61	0	0	0	*
10	4-7	J	4	6	8	6	0.44	49	55	61	61	6	6	6	
11	7-8	K	3	5	7	5	0.44	61	66	66	66	0	0	0	*
12	8-9	L	1	2	3	2	0.11	66	68	68	68	0	0	0	*
13	9-10	M	5	7	9	7	0.44	68	75	75	75	0	0	0	*

26.15 EVALUATION OF THE NETWORK-VARIABILITY OF PROJECT DURATION

As previously stated, the critical path determines the duration of the entire project. Note that variation of non-critical activities will ordinarily have no effect on the project duration because of the slack usually associated with them. However, if a non-critical activity is delayed longer than its slack, it will become a critical activity.

For our project under consideration, the critical path and project duration have been identified as A-B-H-I-K-L-M = 75 days. Having the 3-times estimates (PERT procedure) to evaluate the project completion date, to test the variability of their values therefore, we use the standard deviation of the duration calculated above to complete the probability of meeting the 14 week deadline as contained in the project plan.

Therefore, the standard deviation (S): calculated from the formula below using the values in table 20:

S^2 (variance) = $S^2A + S^2B + S^2H + S^2K + S^2L + S^2M$

= 11.11 + 2.78 + 0.44 + 0.11 + 0.11 + 0.44 = 15.43

$S = \sqrt{15.43} = 3.93$

The project team works 6-days in a week i.e. Mondays to Saturdays. Consequently, only 84 days constitute the working time within the deadline. Assuming that the project is normally distributed, the project completion time must be equal or less than 84 days to evaluate the number of standard deviation (Z) between 75 days and 84 days, we apply the formula:

$$Z = \frac{84 - 75}{S} = \frac{9}{3.93} = 2.29$$

Using the table of normal standard distribution, we determine the value of Z. Therefore, there is 98.9 percentage chance of finishing the project before the 84 days deadline.

Crashing the Network: The decision about which activity to crash depends on the least cost and how much you need to reduce project cost. To reduce the project duration therefore, you must develop time/ cost trade- offs to see which activity can be reduced at the least cost. In most cases, we crash the critical path. It should be noted that crashing activities in critical path have the tendency of throwing up another critical path when the number of days crashed is more than the cumulative free float on any other path, that path automatically becomes the new critical path.

26.16 PROJECT CONTROL

The mere fact that one has devoted great resources and time on the planning process and had hopefully come up with what meets with the criteria of an effective plan, does not necessarily guarantee that when the plan is put into action it would automatically achieve the desired goal. Facts of life hardly work that way. The unexpected do often happen irrespective of how meticulous the planning process might have been.

Control provides management with the litmus paper to immediately detect the moment the unexpected starts to show signs.

A well formulated plan would have inbuilt mechanism to ensure all necessary guidelines are in place to enhance success based on the plan. These guidelines

are known as the control mechanism. Control- mechanism ensures that actions intended to implement established plans of action are compatible with set objectives, and capable of realizing the plan. How does the project manager know he is about to exceed his budget? Or given the rate of progress, he is bound to experience at a later date, both time and cost overruns? Or that the quality or standard of operation, even before the project is completed, are below requirements? The answer to all these lie in established control systems.

A control system is normally put in place during the planning process so as to compare actual performance during plan implementation, with the established planned standards. In a nutshell the system entails the social comparing of actual performance with pre-determined standards, if performance differs from the established goals, corrective action is immediately put into effect. A control process is therefore, not feasible without standards against which observed performances are to be compared with, and not complete until control decision is made and put to action.

It is not always that a deviation from planned action occurs. If no significant deviation is detected by the control system in place, the project manager never relents but continues to monitor his project. If on the other hand the project manager detects that an activity is behind schedule, his first reaction must be to set in motion the mechanism of getting the activity back on planned course and not concern himself unduly on what went wrong or who was responsible for the lapse. If in the course of effecting corrective action he discovers that the activity still has a float, he should do nothing in terms of expediting action but cautiously monitor the progress of the activity. If the delay is such that if no immediate corrective action is taken, the delay eventually affects the other activities, the project manager could then resort to project shortening procedures.

26.17 PROJECT CONTROL PROCEDURES

Project implementation is a phase in the project life cycle. There are two distinct sub-phases within the implementation phase, the planning phase and

the execution phase. Project execution is both the act of putting a project plan into action and simultaneously tracking the effectiveness of the plan in the attainment of the set objectives. This is nothing but project control in action. The function has been defined as the periodic preplanning of the remainder of a project at any point in time based upon current realities and revised expectations. This is understandable as the constraints and even objectives of a project can change during execution.

Control is an essential follow up to a plan. Planning must therefore be sufficiently detailed to make control feasible, as it readily losses its usefulness if deviations from it cannot be readily detected and corrected.

Project control, the process of making project events conform to plan is accomplished through the following sequential actions:

a) Tracking, reporting and documentations of project progress.
b) Comparing of observed actual progress, in terms of time, cost, quality and quantity with the corresponding planned progress and output.
c) Managerial action in the form of control decision, taken to correct any deviations or variances from (b) above.
d) Updating the remaining portion of the project in line with the realities of item (c) above.

In order to effectively execute these actions, the establishment of an efficient information system, which maintains a continuous flow of feedback and feed-forward information among all those concerned with the project is crucial. Accurate up to date information is the basis of all management functions. Without it, management is unable to forecast, plan or control.

The project network technique in addition to its usage as a tool could also provide a ready tool for the control of two important parameters of a project; cost and time.

Project time control is the mechanism usually put in place by management to ensure that project events and activities conform to a predetermined project

schedule. The objective being in the main to keep the execution of the project plan on schedule, and its functional base anchored on project time schedule developed for the project along with an information system geared to the provision of timely data that facilitate the comparing of the planned with the actual time performance. Periodic Project monitoring and reporting provide the information for determining the time status of current individual activities and the entire project. The frequency of measuring and reporting progress depends on the level of time control that is both desirable and feasible, as well as the effectiveness of the information system on the ground.

If the rate of general progress or the completion of a critical activity is slowed, then immediate corrective action must be put in motion to avoid or minimize the possible time overrun. In this regard the project manager should bear in mind that activities with limited floats are only slightly less sensitive to delay than the critical ones. However, in real life situation a delay detected during the execution of an activity is seldom recoverable during the execution life span of the activity. This is understandable when it is realized that an activity is generally of limited time span. In general, attempts at recovering lost times should better be made on subsequent activities in line with procedures outlined. The example we' gave earlier using Network Analysis can effectively be used to monitor scheduled time and actual time realized. However, There is another method that can compare cost, time scheduled against cost and time realized. This is earned value analysis, which is discussed below.

26.18 BUDGETARY CONTROL

Earned Value Analysis

This measures project implementation performance by comparing the amount of work planned with what was actually accomplished. It helps the project manager to detect deviations from plan as soon as they occur so that corrective actions can be taken to put the project back to plan. These are basic values used in the analysis:

Budgeted cost of work schedule (BCWS)-Original budget allocation at the start of work, or level of effort scheduled to be expended.

Budgeted cost of work performed (BCWP) this is the budgeted cost of work actually performed in a given period or the budgeted level of effort actually expended. This is earned value - the measure of the naira value of the work actually accomplished in the period being monitored.

Actual cost of work performed (ACWP)- This is the amount of money (or effort) actually spent in completing work in a given period.

Variance thresholds can be established to define the level at which reports must be sent to various levels of government. By combining cost and scheduled variances, an integrated cost/scheduled reporting system can be developed. Two formulas are used in performing earned value analysis.

Cost Variances (CV): (BCWP BCWS); work performed is compared with what was scheduled, if it is negative, it means time overrun.

Scheduled Performance Index (SPI): (BCWP/BCWS) If SPI < 1, project is over budgeted.

For purposes of reporting, we combine the two as Cost Scheduled Index (CSI)
CPI x SPI = $BCWP^2/ACWP$ x BCWS.
If this index (CSI) < 1, it shows that there is a problem and corrective action has to be taken to put the project back to plan.

Again, earn value analysis can also be reported using curves, called spending curves. Variances are often plotted using spending curves. Consider a project that has 8 weeks duration with the major activities, the weekly and the cumulative spending given in the table below

Table 26.9 Weekly and Commutative Spending in a Project

Weeks	1	2	3	4	5	6	7	8
Amount "000"	800	3800	6200	5400	5400	2400	2400	2400
Cumulative "000"	800	4600	10800	16200	21600	24000	26400	28800

The spending curve for the project is called 3 BCWS curve. Since it is derived directly from the schedule, it represents planned performance and therefore is called a baseline plan. Control is exercised by comparing actual progress to planned progress, this curve can be used as the basis for such comparisons. Considering a normal curve for the above given data, the budgeted cost of work scheduled (BCWS) is behind the actual cost of work performed (ACWP). Again the budgeted work performed is under the budgeted cost of work scheduled. Under these conditions, the project would be behind schedule and overspent. The project manager has to put corrective measures, otherwise the project will incur more money than what is budgeted.

CHAPTER TWENTY SEVEN

REAL ESTATE PROJECT MAINTENANCE

For buildings and their facilities to exist for decades, remain habitable and durable, they require proper and constant maintenance.

27.1 CLASSIFICATION OF BUILDINGS:

Buildings are designed and built for different purposes which affect the facilities they provide. Building classes include;

- **Residential Building:** These are buildings specifically developed for dwelling; for social, recreational, educational activities and worship places. For example schools, libraries, churches, sport centers, museums, cinemas, court, civic centers, and so on.
- **Commercial Buildings:** These are buildings developed and used for commercial activities by the public. Such as shops, banks, restaurants/garage, showrooms, offices, insurance houses, and other places.

- **Business and Industrial Buildings:** These types of building are mainly used for industrial production purpose. Such include offices, laboratories warehouses, factories, laundries, etc.

27.2 BUILDINGS MAINTENANCE POLICY:

Buildings and their associated infrastructural facilities deteriorate; depreciate in value, aesthetics and in function due to ageing processes, exposure to adverse weather condition and hostile environment.

According to FMW (2001) draft of National Building Maintenance Policy, it is estimated that the planned average physical, functional and economic life spans in this part of the world for building classes are 50 years, 25 years and 10-15 years respectively.

Our buildings require a good level of maintenance to attain there life span. Also another factor that may still help the lifespan of a building is the kind of policy on building maintenance evolved.

Building maintenance policy is taken to mean a set of ideas, a plan of action, tactics, discretion or wisdom aimed at improving the quality and conditions of the buildings and infrastructural facilities.

27.3 THE NEED FOR MAINTENANCE POLICY:

According to FMW (2001) Draft of National Building Maintenance Policy, the reasons for such policy are to:

- Retain value of investment on the building
- Maintain the building in a condition in which it continues to fulfill its functions
- Preserve its aesthetic value.

27.4 THE STRUCTURE AND THE CONTENT OF A BUILDING MAINTENANCE POLICY:

According to Queen's Land Government Policy Framework (1999) building maintenance policy should be structured to include:

- A statement of intent and purpose
- The scope of the policy
- The details of the policy
- The responsibilities associated with the policy, and
- The continuous improvement arrangement for the policy such as policy review procedures.

The essence of a maintenance policy is to ensure that there is consistency in maintenance activities and compliance with relevant policies and statutory requirements. It will assist maintenance service providers to manage, and undertake maintenance effectively and efficiently. Moreover, a well articulated maintenance policy will result in having a healthy state of buildings that will definitely reflect public pride, level of prosperity, social values, customs, etc which combine to give the country its unique character.

27.5 INFORMATION MANAGEMNT:

According to Holts (1990), information is the result of thoughtful analysis and communication of data in a form useful to recipients.

Information means a fact or knowledge about something; for instance real estate maintenance work may require studying building production information such as drawings, schedules, specifications, maintenance manuals, etc.
Indeed, maintenance work generates complex sets of information, and the management of these bulk information to ensure accuracy is a very important task to a maintenance manager. Poor or inadequate information can lead to delays in maintenance work.

According to Sengupta (1995); more and better information can lead to more effective control. He recommended the use of the computer, because it manipulates and provides information for decision making with an unprecedented speed and accuracy. Since the nature and form of information produced and required by maintenance activity is extremely diverse,

maintenance information should be stored on an integrated computer database, so that it can easily be retrieved at any point in time.

27.6 THE MEANING OF MAINTENANCE

As a result of the wideness in scope and multiplicity in meaning, maintenance of property has been viewed from so many perspectives. In its generic terms, following the biblical saying, that, cleanliness is next to Godliness, Oguno (2005), stated that property maintenance has to do with general cleanliness, preservation of fittings and fixtures through regular repairs, and replacement in a property.

The importance of maintenance cannot be over emphasized as it is the only essential component in the life cycle of a building and also that of occupant of a building.

According to advanced learner's dictionary, maintenance is defined as:

i. To cause something to continue
ii. To keep something in existence at the same level of standard.

Professional Estate Surveyors and Valuers refer to maintenance as all works and practices, undertaken in a building with a view to updating, improving, and retaining the original shape, form, function and utility values served by the building.

However, maintenance can be referred to as "work undertaken in order to keep or restore every facility i.e every part of a site building and contents to an acceptable standard.

Hence BSC 3811(1964) says that "maintenance is a combination to retain an item in or restore it to an acceptable condition.

Considering the fact that one of the prime functions of maintenance is to ensure that the use of which a building is put to is the most suitable, having regards to its physical character, legal status, economic returns and general environmental factors. Furthermore, maintenance is seen as "work such as external painting

which are necessary to prevent deterioration that may or may not arise from any defects or breakages in the part or whole of the property".

27.7 TYPES OF MAINTENANCE

According to the definitions of maintenance in British standard 3811; maintenance is divided into "planned and unplanned" maintenance.
Planned maintenance can further be divided into preventive and corrective maintenance. Planned preventive maintenance are all those works geared towards improving the facility as well as that required to replace or repair the product after it has achieved or attained a useful lifespan.

Avoidable maintenance are works required to rectify failures caused by incorrect installation or the use of faulty and or inferior materials for construction. Planned preventive maintenance can be referred to as "running" maintenance, this is because once carried, it runs through the life of the facility over a period of time.

Unplanned preventive maintenance can be referred to as emergency maintenance. Under unplanned preventive maintenance, we have small alterations, additions and improvements required to keep a building functional, also we have random maintenance that is derived from condition survey of dilapidations and include major repairs and replacements, and minor works

There is the need to identify the type of maintenance techniques to be adopted in any maintenance activity. This will help to ensure that the problem is rectified to a measurable standard.

1. **Preventive Maintenance:** This is an irregular maintenance activity together with regular inspection of the building and its equipment. Such work as periodic renovation and repainting which could be done from time to time as the need arises.

2. **Corrective Maintenance:** This is work carried out in order to restore the building, equipment, utilities and amenities to the state in which they function to the satisfaction of the purpose.
3. **Routine Maintenance:** This is a day to day maintenance or interval maintenance of the building components or equipment to keep its standard and sustain a prolonged life span.

27.8 REAL ESTATE MAINTENANCE IN RELATION TO INVESTMENT:

There is utmost need to adopt the most acceptable programmes for an efficient and economic maintenance of any building for it to stand the test of time.

Maintenance has to do with general neatness; day to day care and preservation of fittings and fixtures of property through regular repairs, replacement and modification.

A plan taken to save capital costs might prove more expensive in the future as a further expenditure of capital cost becomes imperative if the property is to fulfill its functions.

The manger of a property might notice that decision taken initially to save capital cost during the construction has increased not only the running cost on the structure but as well as the kind of people in such neighborhood which forms part of the value determinant.

It is very necessary to maintain properties properly to ensure that the economic life of such properties is well improved to last longer. To ensure that the property is worthwhile in the open market and that it generates the open market rent for a very long time. Real estate value and yield increases overtime depending on the structure, the facilities provided and general state of repairs.

There are numerous reasons why investing in real estate is favorable to maintain. They are:

i. Availability of cash flows
ii. Financial leverage

iii. Shelter benefit
iv. Elongated life span
v. Investment scarcity.

27.9 AVAILABILITY OF CASH FLOWS:

Cash flows are one of the major components in the estimation of investment value of income producing property. This is because since positive cash flows enable the investor to acquire new investment or permit additional achievement of personal goals. Positive cash flows are always attractive to potential investors while effective cash flow is money spent on maintenance of the value.

27.10 FINANCIAL SECURITY:

An investor can use his valuable real estates to serve as collateral to access loan. In this regard, maintenance helps to maintain the value of real estates so that it worth the value of the sum to be borrowed and also the attendant rate of return.

27.11 INVESTMENT SCARCITY:

Investment on real estate involves a huge sum of money as capital sum. This tends to limit the supply, in other words, it is scarce in relation to its supply. When properties are well maintained, it ensures the viability of such property to still serve the need of the masses. Some properties are of monumental aesthetics and unique that they need to be preserved to last for centuries. Maintenance is proven to be the surest means for such.

27.12 SHELTER BENEFIT:

An investor may decide to make use of one apartment in his estate and by so doing save the cost of living as a tenant. He can use what would have been the expected return if he had rented it out to maintain his property.

27.13 ELONGATED LIFE SPAN:

Real estate property that have structured maintainance policy last longer than those without maintenance policy. There will be an extension of the life span of the real estate as maintenance on its components and infrastructure helps to keep the property in a good state of repair over a long period of time. Its productivity and value are also guaranteed when efficiently and effectively maintained.

27.14 THE MAINTENANCE AND ECONOMIC GROWTH:

Most developers after completion of projects abandon them carelessly without proper maintenance and leave the property to dilapidate thereby causing health hazards to the occupants and unpleasantness on the environment.

Efficient and economic maintenance cannot be achieved without adequate planning of maintenance activates. Therefore it is advisable to adopt the most acceptable programmes which have practically stood the test of time.
Programmes are defined by Holt (1999) in his book titled "Management principles, and practice" as a single-use plan comprising multiple activities orchestrated to achieve one important objective.

Consequently, a building maintenance programme can then be defined as a plan of maintenance activities to be carried out in a particular way at a particular time. Lee (1976) therefore identified three levels of maintenance programmes in his book "Building Maintenance"

1. Long term
2. Medium term – Annual
3. Short term – Monthly, weekly, daily.

Obodo (1999) broke down these levels of maintenance programmes as follows:

1. **Long term maintenance programme**: This has to do with a maintenance programme for a long time interval say, every 10 years or above. According to him, the purpose of long term progrmames include:

a. To determine the general level of expenditure on maintenance to achieve the desired standard.
b. To avoid large fluctuation in annual expenditure by spreading large items and any back-log
c. To determine the structure and staffing of the maintenance organization and whether it will be advantageous to employ operatives directly to carry out part or the whole of the work.
d. To determine the optimum time for carrying out major repairs and improvements so as not to interfere with users of the building.
e. To gear the maintenance programme to company policy so that it is compatible with decisions relating to the use of the building, eg decisions to demolish and rebuild or to move to other premises.
f. To consider the effect of proposed capital works on the maintenance organizations.

2. **Medium Term Programming:** This involves the maintenance of a property annually. The object of the medium and annual programming is to provide a more accurate assessment of the amount of work to be carried out during the fourth coming year and to form the of basis of the financial budget. In these programmes, the major considerations are:

a. Timing the work in relation to needs of the organization.
b. Apportioning the amount included in the budget to specific jobs or areas of work for control purposes.
c. Fixing an appropriate time scale for the protection of contract documents and tendering procedures where work is left to outside contractors and for the advanced purchase of materials where the work is to be carried out by direct labour.
d. Providing a uniform and continuous flow of work for all trades, indirect labour force so as to avoid idle periods due to insufficient work or the need for men to work overtime at enhanced rates of pay to deal with periods of excessive demand.

3. **Short Term programmes:** This is usually carried out monthly, weekly or on a daily basis. In this case, the total work load is normally allocated to the months of the year in which the works will be carried out. Where the work will be carried out by outside contractors the commencement and completion dates should be entered on a bar chart, which should also indicate the dates when the various pre-contract processes should be initiated and completed.

27.15 NATURE OF BUILDING MAINTENANCE

Maintenance of building covers many aspect of work which may be divided into four categories (Son and Yuen 1993). Thus:

- **First:** Planning and execution of day-to-day maintenance which includes such activities as servicing and cleaning. Also the inspection of facilities and components. For example floors are usually swept daily and polished weekly; while paintings are usually done every 3 to 5 years.
- **Secondly**: Rectification work may be needed quite early in the life of the building because of design shortcomings; inherent faults in the use of materials or faulty construction. Those short coming as often affect the performance of the components.
- **Thirdly**: There is the need to consider the replacement of costly items in the building thus the flat roof covering to an apartment block may be re-laid.
- **Finally**: Maintenance may have to do with the aspect of modernization or restoring of fittings. Modernization is concerned with alteration, addition and enhancement to existing buildings on both small and large facilities. While retrofitting works include all work designed either to expand the capacity of facilities or to enable the facility to perform some new function.

27.16 REAL ESTATE MAINTENANCE CAN ALSO TAKE THE FOLLOWING FORM:

Servicing: This is to maintain and repair the real estate components or cleaning operation undertaken at regular intervals. Regular sweeping of the floor of the building, etc.

Rectification: This means to correct a fault in a building as a result of poor design fault construction and damages of building materials and components on transit. Typical examples are wrongly done electrical wiring, painting, etc.

Replacement: Due to the fact that certain conditions cause materials and component of buildings to decay at different rates. For instance peeled PVC floor tiles, broken window Louvre blades, door keys, etc may be replaced when there is deterioration of appearance on the element.

Renovation or Retrofitting: This is to restore to good condition of an existing structure of a real estate on both small and large scale. It has to do with all works designed either to expand the capacity of a facility or to enable the facility to perform some new functions. It may also involve changing of old and obsolete part of property to a more modern form. In other words it can be termed modernization. For example, some old existing residential buildings in big towns and cities are being converted to commercial buildings such as banks, hotels, office blocks, etc.

27.17 REASONS AND IMPORTANCE OF MAINTENANCE

There is no gain saying that the importance of maintenance cannot be over emphasized. One of the benefits is to maintain an acceptable quality standard particularly to the existing building and facilities in order to promote the economically gainful life of the building. Maintenance of buildings will minimize the chance of building failures, and where such a failure would have undesirable consequences eg. Reduce safety or environmental damage.

Ikpo (1998) opined that maintenance helps bring buildings back to their original standards, near to it or well above such standards. In another view, Lawal (1997) said that the purpose of building maintenance is to reduce the rhythm of depreciation upon the facilities and enable residents of the estate enjoy the benefits of a planned modern environment.

And yet another view has it that the main aim for building maintenance is to delay the deterioration process in real estates for as long as it is physically

possible and economically viable to do so (Kakulu 1990). She opined that deterioration is an inevitable phenomenon, but it can be controlled by proper and adequate maintenance practices. She further observed, that the main purposes of maintenance is to preserve the building in its critical stage as far as it is economically viable and practicable so that it effectively serves the purpose for which it was built, retain the value of investment, present a good appearance; keep the building wind and water tight; and also make the building attractive.

Seety (1994) agreed that the main aim of maintenance is to preserve a building in its critical stage as far as practicable so that it effectively serves its purpose. Other reasons according to Ikpo (1998) include the perpetuation of the life of the building to avoid danger to the life and property, satisfaction of legal requirements and for economic reasons such as avoiding heavier future expenses or justifying an increase in rental value.

Some of the benefits include:

1. Improved productive life of all capital replacement.
2. Available data enables the compilation replacement programmers for future maintenance work.
3. Organization of work and control which consequently reduce loss of production.
4. Statutory; legal and professional responsibilities are met.

According to Wahab, (2003), the major reason or importance of building maintenance can be classified as follows.

1. To ensure that assets are maintained at reasonable standard at least cost.
2. To ensure that the structure continues to attain the functions expected of it.
3. To enhance the quality of the facility to meet modern day requirements.
4. To prolong the lifespan of the building
5. To preserve the physical characteristics of the facility and eliminate the probability of early failure.
6. To ensure the safety of the users.

The estate surveyors and valuers co-ordinate the activities of all other professionals in building maintenance environment as the property manager.

Real estate development without maintenance is waste and this is why Sanya (1983) says that a country that goes on building but will not effectively mange what is has built is quite simply making history and destroying it immediately, it is burning its wealth in a furnace, it is country without pride.

According to Inyang (1995) materials used in construction are subjected to weathering and ageing. A real estate is therefore expected to accommodate the progress of time, safety from collapse and resistance to physical harsh weather. Unfortunately, apart from daily wear and tear by its occupants or users, a number of factors affect building fabrics, materials and components and hence call for maintenance, Oguno (2005).

There is no building that is maintenance free and therefore if not properly maintained could result in building dilapidation and collapse.
Furthermore, properties are being maintained in order to retain their values and to effective functionality.

27.18 VALUE DEFINED

Value can be described as a measure or an estimate of worth. A property value therefore can be described as worth-whileness of an interest in landed property, which can only be ascertained by a fully trained and experienced professional.
Value could be seen as the present worth of anticipated future benefit from ownership. It represents the price at which supply and demand coincide on the market. Again it is the capacity of an economic good to command other goods in exchange.

Types of value

i. Open market value
ii. Mortgage
iii. Compensation value
iv. Insurance value

Rental value

vi. Ratable

vii. Going Concern Value

viii. Probate Value

ix Liquidation Value

i. **Open Market Value:** this is the worth of an interest in property which reasonable buyers and sellers would agree to when referred to the market with all existing conditions for a competitive market applicable.

ii. **Mortgage Value:** This is the worth of an interest in property for the purpose of offering it as collateral security for a loan facility.

iii. **Insurance value:** This is the worth of an interest in property for the amount of compensation in case of sustenance of loss from a policy existing on same.

iv. **Compensation value:** This is the sum of money payable on property compulsorily acquired. The process of determination of this is specified by the appropriate countrie's/ Act concerning compulsory acquisition:. In Nigeria today, the principle for determining compensation value of a property compulsorily acquired is set out in the "land use Decree of 1978".

v. **Rental Value:** This is the worth of lease of property on a periodic basis. When this sum is equivalent to what any similar basic property would attract, it is often market rental value. The process of determining the rental value is similar to the process of determining the capital value of a property taking into account the conditions and terms of the lease are being assessed.

vi. **Retable Value**: This is the worth of a property for the purposes of assessing the rate payable in it. The procedure for determining ratable value is often set out in the relevant rating act or legislation of appropriate authority in-charge which is an urban revenue strategy. The object for valuation could be developed or undeveloped land, plant and machinery, etc.

vii. **Going Concern value**: this is the value of land and building; plant and machinery to a purchaser who is acquiring them for the purpose of the business or satisfaction for which they were designed, constructed, installed and used.

viii. **Probate Value**: This is the worth of an interest in property for the purpose of assessing estate duties on the interest of the deceased owner. Valuation of this is often approached by laid down procedure and contained in the relevant legislation concerning estate duty. But in most cases, the approach is often that of open market with necessary allowance for whatever might be the relevant legislation.

ix. **Liquidation of Forced Sale Value:** this is the open market value of an interest in property when the owner of such property is declared bankrupt by appropriate legislation giving grounds to offer his property into the market for the purpose of paying his creditor on its condition that the transaction in this regard would be completed within a specified period.

27.19 FACTORS THAT AFFECT REAL ESTATE VALUE:

The ability of a property or object to satisfy man's need and desires together with its degree of scarcity and utility compared with others makes man to ascribe value to it. These factors include utility, scarcity, transferability or appropriatability, durability, facilities, location, capability of ownership, accessibility and complementarily.

i. **Utility:** This is a pre-requisite for determining the value of real estate property. It is the significance or advantages the purchaser or buyer of a property derives from it. The use of landed property could really affect its value, if the property is fully utilized, with the hope to attract the best and highest use of the property its value will increase but if the property is not adequately used, the value will decrease.

ii. **Scarcity:** There must be an element of scarcity in supply in order for a property to command its value regardless of its utility. Otherwise, it would be a free gift. When demand for landed property is higher than its supply,

that landed property will command great value. But in a situation where the supply is more than demand, the values will be low.

iii. **Transferability or Appropriability:** Regardless of the presence of the other component mentioned above in the item, if that item or property cannot be transferred the concept of economic value become quite misleading as far as real estate is concerned. Transferability does not necessarily imply physical movement but right that constitute ownership, that is a sandal of right which permits the possessor to:

a. Use the property
b. Sell it "as a freehold"
c. Mortgage the property
d. Lease or let the property
e. Give the property away as gift
f. Grant easement

iv. **Durability:** A property in a bad state of repair will not command a commercially high value. This is because after a while such property will need to be redeveloped or renovated in order to elongate its life span.

v. **Facilities:** This is another attribute of landed property that tends to influence its value. A landed property that is located with all the necessary facilities needed to make life comfortable will command a higher value than one, which has non or inadequate facilities.

vi. **Location:** The location of a property influences its value to a great extent. In a situation where in the neighbourhood of the landed property location, there is the provision for social amenities, infrastructural facilities and adequate conveniences, definitely the property will be of utmost value.

vii. **Capability of Ownership:** real property or estate apart from being brought into use must also belong to someone either by freehold "landed" or will or long lease.

viii. **Accessibility:** An estate that is accessible will have a higher value than the one sited in an area that is not accessible.

ix. **Complementarity:** Land uses have to complement with each other, complementarity will influence the value of the landed property in the same area, that is to say in an area where industrial properties are located, it will be unheard of to locate a residential property as the value will be very low because they do not complement each other.

27.20 Risk on Building Maintenance:

The risk on managing a property is to ensure a better maintenance of that property. The objective of taking a risk is to enable the owner of property to secure maximum returns on their properties from a single residential building to industrial and commercial estates.

As a result of this, the manager of any estate should be a qualified estate surveyor or valuer who has graduated through years of vigorous training and practical experience in estate management. This qualification will help the manager to take positive risks and also to attain the greatest possible net returns over the economic life of property through effective maintenance programmes and marketing.

27.21 General Causes of Deterioration in Residential Buildings

In line with the saying that it is difficult to produce buildings that are entirely maintenance free, based on the fact that every material used in the construction of a building is subject to wear and tear through weathering and ageing.

The cumulative effect of rain, wind and sun, atmospheric pollution and chemical action, all constitute one part of the causes of the deterioration and erosion of the building fabric.

Moisture is one of the common factors that leads to deterioration of building components. A lot of materials used in building are porous and susceptible to moisture penetration. This can be in the form of rain penetration, condensation, leaks from services carrying water or drainage (like air conditioner, drain-pipes) and rising damp. Apart from insect attacks from wood, boring beetle, the

decay of timber can be traced to the pressure of moisture, thermal and structural movements from paths for moisture penetration.

Some building defects have their origins in the building process itself due to inaccuracies during construction.
A variation in load bearing capacity of the strata may cause foundation movement thereby resulting in serious defects.

Intensity of use of a building is another source of defect to buildings. It can cause wear and tear and when this is not adequately provided for, could lead to serious damage.

The deterioration of buildings set in naturally from the day the building construction ends. This can be seen in the attitude of the landlord or tenant occupier of the building towards their maintenance responsibilities and mishandling of the buildings. In some buildings, where some tenants are fond of fighting on daily basis and end up damaging one thing or the other, gradually, door locks and flush handling are spoilt, floor title and doors are broken, damages occur on the wash hand basin and sinks, paints on walls are defaced, ceiling boards punctured and glass panels broken and so on. The damages are most times not repaired thereby causing more and more damages.

A thorough inspection tour round some of the buildings and other infrastructures in many cites of the federation shows that many residential properties are uncared for and this has been blamed mostly on the carless attitude of most tenants. For instance, one can see writings on the walls with chalk and crayon; others continue to change one fixture or the other on the walls, A lot of tenants still insist on spreading their washed cloths on the external rails, removing the cobwebs on the ceiling and edges are not done by some tenants. All these help to degenerate the external physical appearance of real estate. Worse still, the tenants out of carelessness and misuse of facilities spoilt most of the fittings and fixtures, which were put in place by the Landlord.

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27.22 LIST OF COMMON DEFECTS ON RESIDENTIAL REAL ESTATES

A brief survey with sampling of some residential real estate some Nigerian cities reveal defects in the following areas of the building.

1. **Walls and Wall Finishes**

   Block work and disintegration of block work due to frost or salt action and sometimes inadequate foundation, soft mortar, stone work wrongly bedded, surface deterioration, rusting of metal built in walls, cracking of rendering, blistering of paints on rendering, wearing of paint, coupled with the growth of plants and other fungal effects as a result of concentration of moisture on the wall and at areas that bear services carrying water like the air conditioner, loosely applied tile finishing's, damaged hanging and damaged tiles hanging (Building Maintenance management by Lee Reginald).

2. **Floors**

   Suspended Floors: Collapse of a suspended timber floors as a result of insect (termite and beetle) and fungal attacks. Excessive deflection joist not properly wedged onto sleeper walls.

   In suspended concrete floors: inadequate sub-floor ventilation, leakage of water into sub-floor, sinking of surface of sub-floor causing sleeper walls to settle, excessive dampness in timber, excessive gasps between boards, loose boards, rotten boards, no sub-floor access. (Building techniques by H. King and D. Nield.)

ii. **Solid Ground Floors:** Lack of and improper use of damp proof course causes passage of moisture at the edges of the floor, condensation at the edge of floors. Screeds cracking or breaking up, screeds lifting or hallow. (Building techniques by H. King and D. Nield).

3. **Roofs:** Spread of structural roof as a result of structural elements not tied together, rot or beetle or termite attack, leaking roof, decay of fascia

boards as a result of moisture penetration, broken asbestos ceiling boards. Some defects seen in flat roof includes: condensation on underside of flat roofs. This is as a result of internal condensation, sagging of roof due to rot in timbers, sagging of roof due to inadequate falls, blistering of asphalt, no ventilation to timber roof, rot, beetle or termite attack in timbers. Expansion of concrete flat roofs causing cracking of block work, dampness from residential construction water.

Defects to other roof coverings include: cracked asbestos sheets, rusting galvanized sheets, perforated cooper or zinc sheeting, defective attack (Building techniques by H. King and D. Nield).

4. **Chimneys:** In need for pointing (the joints to be filled with cement and mortar). Stacks leanings, stacks cracking or splitting, loose pots, flashing loose.

5. **Rain Water :** Rotten timber, gutters, corroded metal gutter, wrapped plastic gutters, spilt or corroded metal down pipes, bowing plastic, down pipers, blocked rain water pipes defective lead lining to gutters, inadequate falls to gutters, gutters needing cleaning out.

6. **Windows:** Rotten or decayed timber frames, defective putty of paintworks, broken or cracked glass, loosed or twisted casement, casement needing easing, missing weights to sliding sachet, broken./missing ironmongery, inadequate natural ventilation, defective mastic painting work externally, dampness penetrating jambs and sills, rusting metal frames, excessive condensation gutters, failed double glaze sealed units, mould/fungi growth on timber frames.

7. **Doors:** Rot in timber doors and frames/twisted and distorted doors, ironmongery needing repairs/replacement, doors requiring easing, door binding on floor, door frames out of squares, dangerous glazing, doors badly fitted, draughty doors, water getting under doors, mastic pointing needed around frames, mould/fungi growth in door frames, door handles broken, decayed timber frames caused by termite attacks.

8. **Stairs:** Broken/worn out trade, unduly steep stairs, no handrails, loose handrails, balustrades, excessive deflection open trend stairs, and dangerous wide gaps between balustrade rails.

9. **Wall Finishes:** Other defects noticed with wall finishes include: cracked or crazed plaster, loose or hollow-sounding plaster, plaster finish coat shelling, blowing or pitting of plaster, perished plaster, loosed and falling filling, rot or beetle in timber paneling, blistering paintworks, loose wall paper, flaking and or fading paintwork.

10. **Floor Finishes:** Woodblocks lifting or arching, clay tiles lifting or arching, P.V.C tiles lifting, magnesium oxychloride tiles lifting, P.V.C sheet cutting at edges. Magnesium chloride curling at edges, floor title cracked or worn, other finishes badly worn. Holes created by ants from underneath the floor to the surface of the floor finish. (*Building techniques* by H. King and D. Neild).

11. **Ceiling:** falling ceiling materials (joists and asbestos), rotten batten infestation by cobweb and dampen markings, lath and plaster ceiling collapse, plaster board-ceiling cracks between boards at edge, loss of plaster adhesion, paint flaking, loose wall paper, noggin and batons.

Defects in Service

1. **Water:** Inadequate pressure leading to insufficient
supply of water to the upper floors, leaking pipes/joints, defective wall valve/leaking water overflows, leaks in galvanized tanks, dripping taps, mishandling or carelessness in the sue of the tap head resulting in lack of control of water rushing out of the tap.

2. **Electricity:** Obsolete socket outlets, switches and others, failure of insulation, loose cables, rewiring needed, defective/broken switches sockets outlets, damaged light engines (especially fluorescent).

3. **Heating/Air condition:** Damaged fire backs, perforated back boiler, old fashioned/defective gas fires, electric fires, damaged solid fire/store, old

fashioned central heating system, furring of central heating pipe work, loose radiator, inadequate system, leaks at joints, leaks in oil supply tank or pipe, inadequate ventilation for boilers, clocks/thermostat defective.

4. **Drainage:** Drains blocked, drains broken, brickwork to manholes needing painting, manhole cover loose, vent pipes leaking, defective septic tanks, defective sewage pump, water pipes, leaking, water pipes sagging infiltration and overflow of affluent from the pipes giving rise to foul odor in the residential environment. (A manual on building maintenance by Miles D).

27.23 RESPONSIBILITY DEFINED:

It is a duty with which a person is responsible. For instance, there is need to sweep and clean the house; and so any person who is supposed to carry out those functions are taken to have responsibility of the sweeping. In real estate there is an utmost need to have maintenance responsibilities known to both Landlord and tenants.

27.24 AN OVERVIEW OF MAINTENANCE RESPONSIBILITIES:

The emphasis on maintenance of property is mainly on health. The public health Act contains provisions for the compulsory repair of dilapidated properties while housing Act includes provisions for the compulsory repair of houses unfit for human habitation and to this end, imposed responsibility for structural maintenance and repairs of residential properties on their owners and occupiers. These responsibilities have been shared out between the Landlord and tenant by the lease. The lease usually contains a number of terms and conditions agreed upon between the parts (Landlord and tenant) among these are covenants as to repair and maintenance.

Under the lease, the tenant covenants to keep and deliver up the premises in good state of repair and allow the Landlord to enter and view the state of repair.

Often, the tenant is made liable for repairs, fair wear and tear expected but not for disrepair due to the normal actions of the element (wing and rain) or to normal use by him. The landlords are made expressly liable for external repairs while the tenants are responsible for internal repairs. The responsibility for repair of the damage will normally be covered by insurance provision in the lease whereby the property is insured by the payment of premium.

Based on the adequacy of the amount of insurance, the insurance company carries out the repair and reinstates the owner of the property to the position he was before the damage. The question of who insures the property is dependent upon the provision of the lease document between the landlord and the tenant. The responsibilities of the tenant as regards the internal repairs include the repairs and maintenance of any defect(s) to the sanitary fittings (water closet, bathroom fittings and kitchen fittings caused by him, defective door handles, keyholes, broken window louvers painting and or re-decoration of his unit of occupation. It also includes helping in evacuation of the septic tank and soak away pit, cleaning of gutters, grasslands, and others. The duties of the landlords as regards external repairs includes: maintenance of the landscaping and grass lands, proper maintenance and lighting of the common parts like the staircase, corridors and passages and other structural maintenance such as defects to the fabric of the building and includes leaking roof, cracks on walls and other works (manual on building maintenance by Miles D.)

27.25 CAUSES OF NEGLECTS OF MAINTENANCE RESPONSIBILITIES:

Individuals and the government tend to neglect their maintenance responsibilities for the following reasons:

1. **General Apathy:** lack of interest, indifference. This is found in both the Landlords and tenants
2. **Ignorance and Disregard of Maintenance Responsibility:** people and government tend to neglect the duty of maintenance of property because they do not seem to know why they should spend money or waste time in

carrying out maintenance work. Therefore, even when they have seen the property dilapidating, they are not bothered to put it in place.

3. **High Cost Involved and Lack of Finance:** The cost of purchase of materials to carry out repair on a defect might be much. Sometimes the money is not available as much as to meet the cost of maintenance work needed.
4. **Carelessness and Mishandling of the property:** This is usually the fault of the tenants and the occupiers, many of whom do not realize the need to maintain a neat and healthy environment. They mishandle the properties and do not even bother to carry out the repair or replacement of any damage done to them.

A tenant or an occupier might have to continue managing a broken door handle or Louvre blade for so many years and may not be bothered with paining or cleaning cobwebs in their unit of occupation. The Landlord too, on noticing the above, he leaves his duty waiting for the tenant (as the case may be) to pack out to enable repair on his property. Such properties are left dilapidating by more damage occurring to it as result of a lack of a body of maintenance (A manual on building maintenance by Miles D.)

5. **New Development:** Most people pay attention to development of new structures these days than maintaining existing ones because they consider it easier and more economical to erect a building than concentrating on old ones.
6. **Delay in payment of rents and rates:** There is this complaint from the Landlord that some tenants do not pay up their rents and rates on time and sometimes do not pay at all. When this is the case, Landlords will find it difficult to set aside some amount of money from the property for repairs and maintenance. Moreover, when this money is not set aside maintenance of such property will be a difficult case.

27.26 EFFECTS OF MAINTENANCE AND NON-MAINTENANCE OF PROPERTIES

Taking a sample of a well-maintained property and a poorly or non-maintained property, one would be able to make the following observations.

1. That a well maintained property looks stronger and durable physically when viewed from a distance and that a well maintained real estate adds beauty to the environment with its good appearance and attractive look, it lasts longer and continues looking younger than its age.
2. A well maintained real estate commands high open market rent, for a longer period than that whose remaining life is determined (Estate Management Gazette vol. 11 of 1961 by Leach W.A)
3. Property maintenance promotes good health and sanity, ensures certainty of security of life and property of dwellers
4. Furthermore, property maintenance promotes the social stand of an environment. In contrast, a non-maintained property looks weak, worn out and its remaining life is determined. (estate Management Gazette Vol.11 of 1961 by leach W.A.)

Non-maintenance of property leads to complete dilapidation of the property. A non-maintained property commands rent which might not be up to the open market rent passing on similar property that are well-maintained. On a short time basis, it attracts tenants of lower social class. (Urban Estate management state Management Gazette Vol. 11 1961 by each WA).

Non-maintenance of property in an area contributes to health hazards. Socially and economically, such area is said to be in decline (Urban Estate management, Estate management Gazette Vol. 11 of 1961 by Leach W.A)

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