3 Project Scheduling, Monitoring and Control

Syllabus

Scheduling Techniques, Program Evaluation and Review Technique (PERT), Gantt Chart, Critical Path Method (CPM), Automated Tools. Project Status Reporting; Project Metrics; Earned Value Analysis (EVA); Project Communication Plan & Techniques; Steps for Process Improvement.

Contents

3.1 Project Scheduling

- Project scheduling is the process of **breaking down a project into activities / tasks, resources, deliverables** and **milestones**. This means, dividing a project into phases. Then plotting these phases on a timeline along with milestones and dependencies.
- While a project plan provides a comprehensive overview of the project, i.e., a blueprint, a **project schedule** gives a step-by-step walkthrough of the project using a Gantt chart.
- A project schedule helps managers :
  - Understand what tasks need to be prioritized.
  - Assign them to the right team members.
  - Monitor and manage team workload.
  - And keep the project from going over-budget.

3.2 Need of Project Scheduling

Project scheduling is important since it plays an effective role in project success. The following are some of the advantages if you properly create your project schedule.

- Project scheduling, when done well, makes the entire project run more smoothly.
- Committing to the project scheduling process at the **beginning of your project** will give you a clear picture of the requirements set before you.
- It also gives you the chance to catch issues early and alert clients if a timeline isn't feasible. Besides being good for you as the project manager, project scheduling is good for **team management**.
- Everyone knows what to expect and when. Everyone is being held accountable for the same due dates.
- Other managers can allocate resources efficiently for your project and they'll be able to anticipate when resources will be available for other projects.

3.3 Benefits of Project Scheduling in Project Management

Project scheduling provides the following benefits :

- Assists with tracking, reporting and communicating progress.
- Ensures everyone is on the same page with tasks, dependencies and deadlines.
- Highlights issues and concerns, such as a lack of resources.
- Identifies task relationships.
- Monitors progress and identify issues early.

3.4 Scheduling Techniques

Following are three of the most basic project scheduling techniques :

1. **Critical Path Method (CPM) :** The CPM calculates the minimum and maximum time required to complete a project. Also, it helps identify the critical tasks, dependencies and bottlenecks in a project's schedule.

2. **Program Evaluation and Review Technique (PERT) :** PERT helps visualize tasks and milestones in a chronological order. But instead of estimating effort, it considers the optimistic, pessimistic and most-likely time required to complete a project.

3. **Gantt charts :** Simply put, Gantt charts help visualize tasks, milestones and the deadlines by which to complete them.

Apart from these three techniques, project managers also use duration compression, simulation, task lists and calendars to schedule projects.

3.5 CPM, PERT and Gantt Chart

CPM :

- Critical path method basically is a special application of analysis for planning and scheduling. Critical path method was basically developed with the objective of reducing duration and cost of the project. Critical path method is a special application of network analysis. It uses network analysis for scheduling production, construction projects as well as research and development activities. It is also useful in situations which require estimates of time and performance. Critical path method deals with repetitive type projects, such as overhaul of generating plant, which has to be carried repeatedly after set time intervals.
- The critical path, is the overall time, it will take to complete the project. It is the longest path in time through the network. In other words, the longest path in the network is called critical path. Identifying the critical path is of great importance as it determines the duration of entire project. Critical path method differentiates between the planning and scheduling of the project.
- A critical path method is a very important project management tool used to formulate a time frame for a project in order to determine where potential delays are most likely to occur. The process includes a step by step process that provides the developer with a visual representation of potential bottleneck, throughout the course of the project.
- **Identification of the critical path :** Project CP is the longest time path through the network. The path can be identified by determining the following parameters for each activity :

- **Earliest start time for activity (ES) :** It is the earliest possible time at which the activity should start if only the ongoing activities are first completed.
- **Earliest finish time (EF) :** It is the earliest possible time to finish the activity. It is equal to the earliest start time for activity plus the time required completing the activity.
- **Latest possible finish time for activity (LF) :** It is the latest time at which the activity can be completing without any postpone or within the time framework.
- **Latest possible start time for activity (LS) :** It is the latest start time for an activity and equal to the latest finish time minus the time required to complete the activity.
- **Slack time :** Slack time is the difference between earliest start time for activity and latest start time for activity or between earliest finish time for activity and latest finish time for activity.

❑ **Example :**

Job	Activity	Time duration
A	1 - 2	6 days
B	2 - 4	4 days
C	2 - 3	5 days
D	3 - 4	4 days
E	4 - 5	7 days
	Total	26

- From the given data, we can draw the following network diagram :

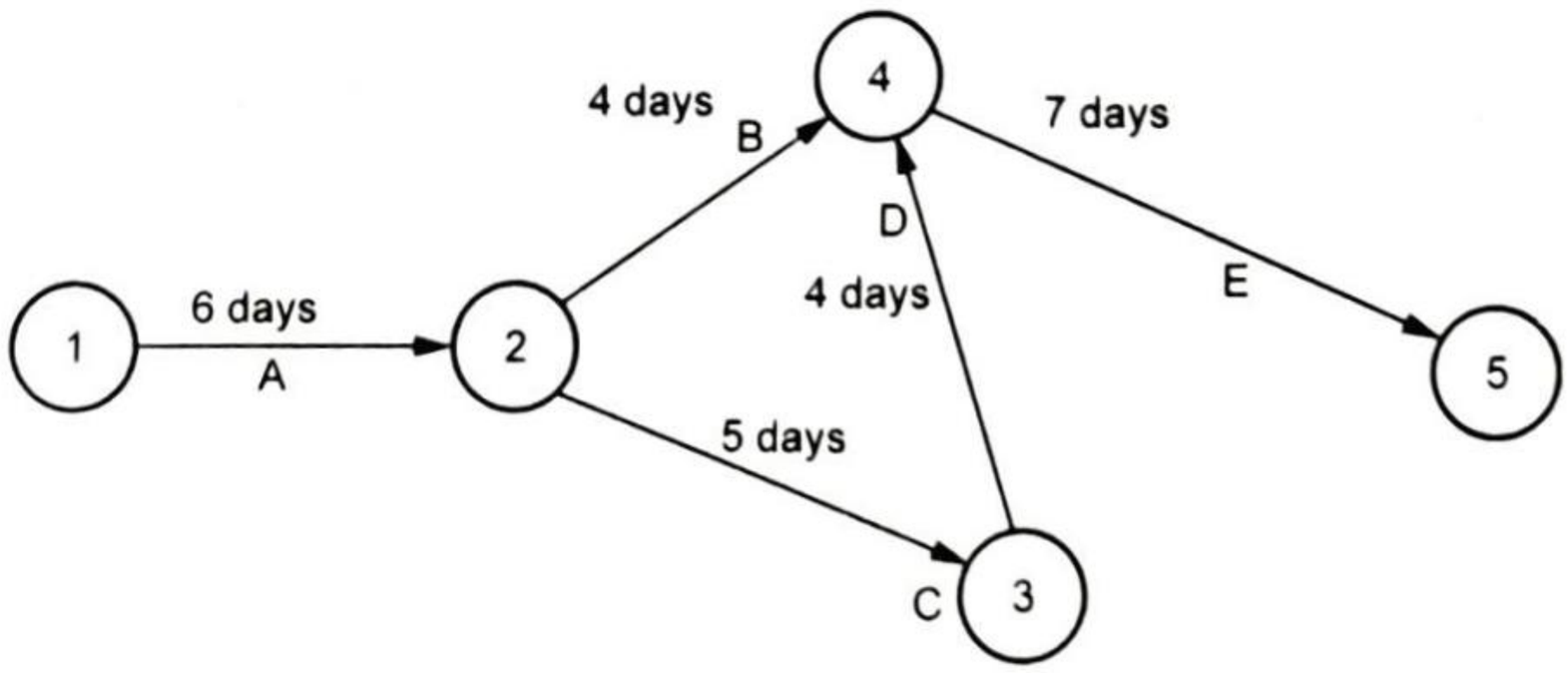


Fig. 3.5.1

- In this diagram, the jobs have been shown in the form of arrows leading from one circle to another. In simple words the arrow connecting circles 1 and 2 represents job A and so on. All the activities have been reduced to a network diagram together with the information as

regard to time required for the completion of different jobs. In this diagram, there are two paths - the first connects circles 1, 2, 4 and 5 and takes 17 days. The second path connects circles 1, 2, 3, 4 and 5 and takes 22 days. The longest path, called the critical path takes 22 days and hence the minimum time required to complete the project will be 22 days.

- So in order to complete the project within scheduled time, attention will have to be given to this path since any delay in time on any job or activity in this path will delay the completion of the project. In case the completion time is to be reduced, steps will have to be taken to reduce the time required for various activities of this path.

❑ PERT :

- PERT **(Program Evaluation and Review Technique)** is a method to analyze the involved tasks in completing a given project, especially the time needed to complete each task and identifying the minimum time needed to complete the total project.
- PERT is based on the assumption that an activity's duration follows a probability distribution instead of being a single value.
- Three time estimates are required to compute the parameters of an activity's duration distribution :

1. **Pessimistic time (t_p) -** The time the activity would take if things did not go well.
2. **Most likely time (t_m) -** The consensus best estimate of the activity's duration.
3. **Optimistic time (t_o) -** The time the activity would take if things did go well.

$$\text{Mean (expected time)} = \frac{(t_p - 4t_m + t_o)}{6}$$

$$\text{Variance } (\sigma^2) = \left(\frac{t_p - t_o}{6}\right)^2$$

- **Probability computation :** Determine probability that project is completed within specified time.

$$Z = \frac{X - \mu}{\sigma}$$

Where,

μ = Project mean time

σ = Project standard mean time

X = (Proposed) specified time.

❑ Float :

Float of an activity represents the excess of available time over its duration.

❑ Total float (F_t) :

The amount of time by which the completion of an activity could be delay beyond the earliest expected completion time without affecting the overall project duration.

i.e. Tf = (Latest start - Earliest start) for activity (i – j),

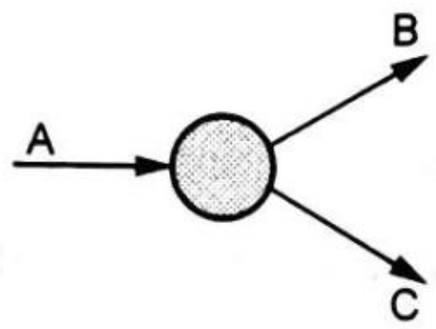
or $(Tf)_{ij} = (LS)_{jj} - (ES)_{ij}$

❑ Free float (F_f) :

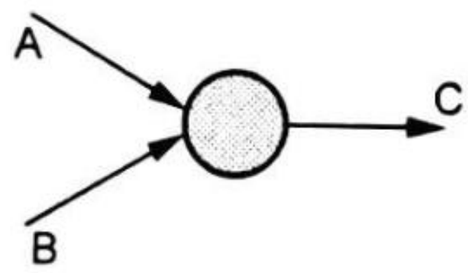
The time by which the completion of an activity can be delayed beyond the earliest finish time without affecting the earliest start of a subsequent (succeeding) activities.

❑ Situations in network diagram :

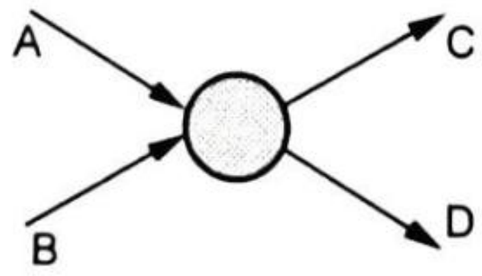
1. A must finish before either B or C can start



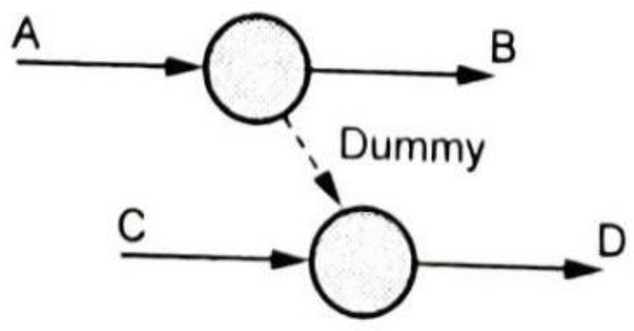
2. Both A and B must finish before C can start



3. Both A and C must finish before either of B or D can start



4. A must finish before B can start both A and C must finish before D can start



Example 3.5.1 : *The following table gives the activities of a construction project and other relevant information.*

Activities (i - j)	Normal duration (days)	Crash duration (days)	Crashing cost (₹ Per day)
1 - 2	9	6	20
1 - 3	8	5	25
1 - 4	15	10	30
2 - 4	5	3	10
3 - 5	10	6	15
4 - 5	2	1	40

A. *What is the normal project length and minimum project length ?*

B. *Determine the minimum crashing costs of schedule ranging from length down to and the minimum length schedule.*

C. *What is the optimal length schedule duration of each job for your solution ? Given that over head cost total ₹ 60 per day.*

Solution :

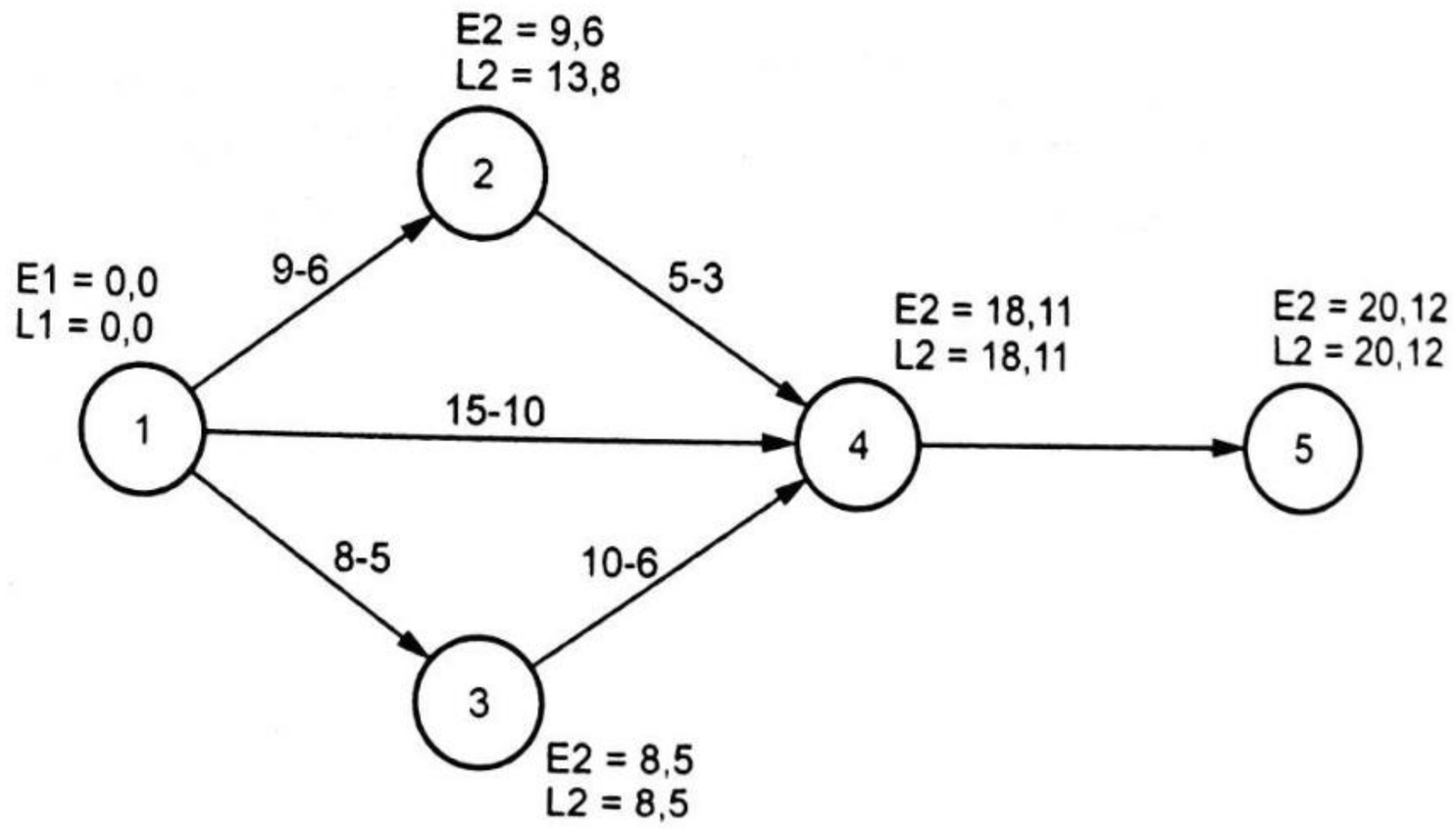


Fig. 3.5.2

A. The critical path is 1 2 3 2 4 2 5 with normal duration 20 days and minimum project length is 12 days.

Normal project length (days)	Crashing cost (days / ₹)	Overhead cost @ ₹ 60 / day	Total cost (₹)
20	--------	$20 \times 60 = 1200$	1200
19	$1 \times 15 = 15$	$19 \times 60 = 1140$	1155
18	$15 + 1 \times 15 = 30$	$18 \times 60 = 1080$	1110
17	$30 + 1 \times 13 = 45$	$17 \times 60 = 1020$	1065

Normal project length (days)	Crashing cost (days / ₹)	Overhead cost @ ₹ 60 / day	Total cost (₹)
16	$45 + 1 \times 40 = 85$	$16 \times 60 = 960$	1045
15	$85 + 1 \times 40 + 1 \times 30 = 145$	$15 \times 60 = 900$	1030
14	$145 + 1 \times 30 + 1 \times 10 + 1 \times 25 = 195$	$14 \times 60 = 840$	1035

B. Total cost increasing for 14 days duration, the minimum total cost ₹ 1030 occurs 15 days duration.

C. Optimum duration of each job is as follows :

D.

Job :	(1,2)	(1,3)	(1,4)	(2,4)	(3,4)	(4,5)
Optimum duration days :	9	8	14	4	6	1

Example 3.5.2 *: A small project consisting of eight activities has the following characteristics :*

Time - Estimates (in weeks)

Activity	Preceding activity	Most optimistic time (a)	Most likely time (m)	Most pessimistic time (b)
A	None	2	4	12
B	None	10	12	26
C	A	8	9	10
D	A	10	15	20
E	A	7	7.5	11
F	B, C	9	9	9
G	D	3	3.5	7
H	E, F, G	5	5	5

i) Draw the PERT network for the project.

ii) Prepare the activity schedule for the project.

iii) Determine the critical path.

iv) If a 30 - week deadline is imposed, what is the probability that the project will be finished within the time limit ?

v) If the project manager wants to 99 % sure that the project is completed on the schedule date, how many weeks before that date should he start the project work ?

Solution :

i) The network diagram for the given data is shown in Fig. 3.5.3. The earliest time and variance of each activity is computed by using the formula.

$$t_e = \frac{a + 4m + b}{6} \quad \text{and} \quad \sigma_t^2 = \left(\frac{b - a}{6}\right)^2$$

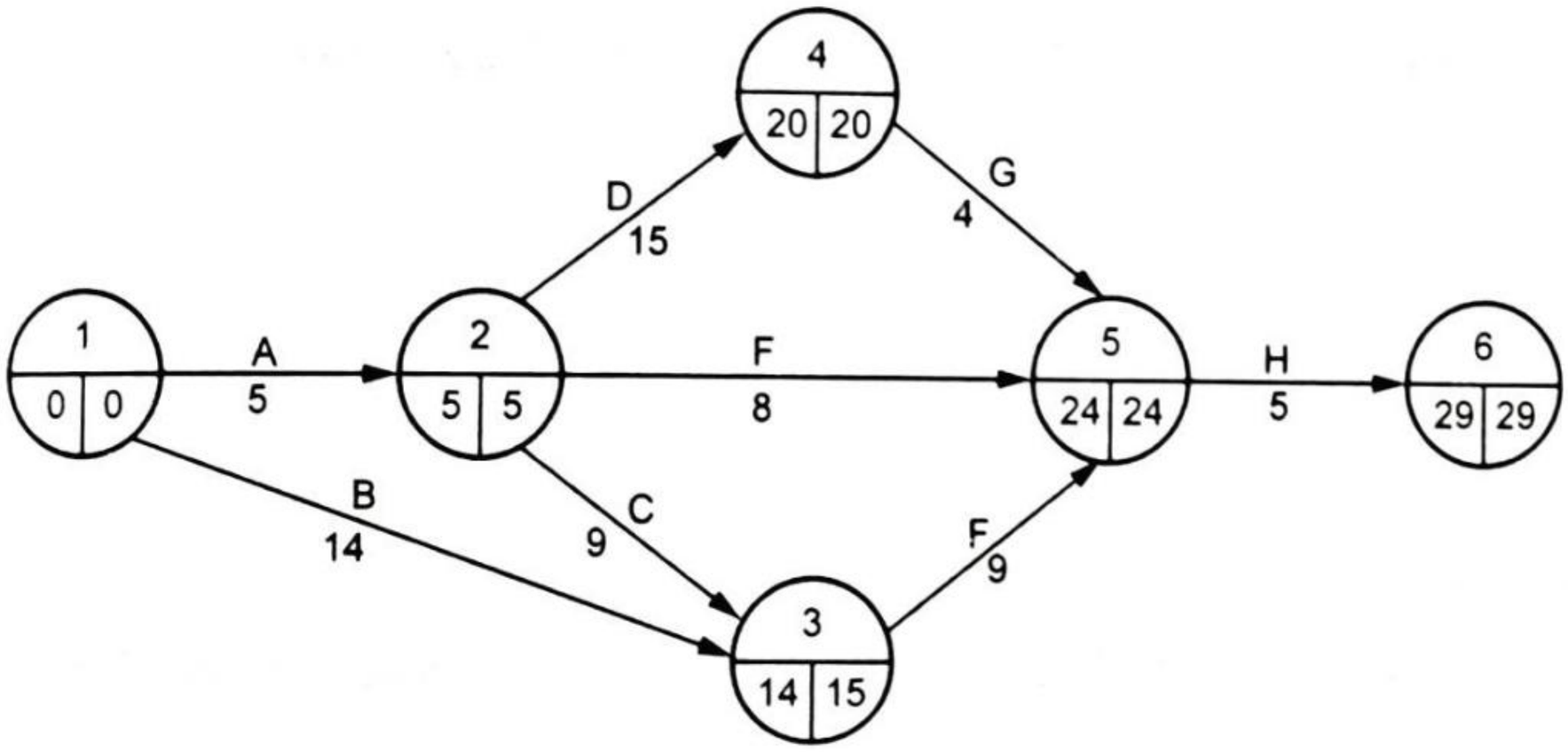


Fig. 3.5.3 : PERT network diagram

ii) Calculation activity duration and scheduling times.

Activity	Time estimates			t_e	(σ_t^2)	Earliest time		Latest time	
	a	m	b			Start	Finish	Start	Finish
A	2	4	12	5	25/9	0	5	0	5
B	10	12	26	14	64/9	0	14	1	15
C	8	9	10	9	1/9	5	14	6	15
D	10	15	20	15	25/9	5	20	5	20
E	7	7.5	11	8	4/9	5	13	16	24
F	9	9	9	9	0	14	23	15	24
G	3	3.5	7	4	4/9	20	24	20	24
H	5	5	5	5	0	24	29	24	29

iii) The critical path of the project is 1 - 2 - 4 - 5 - 6, critical activities being A, D, G and H.

The expected project length is the sum of duration of each critical activity. Expected project length = 5 + 15 + 4 + 5 = 29 weeks.

Variance project length is obtained by summing variance of each critical activity.

$$\text{Variance of project} = \frac{25}{9} + \frac{25}{9} + \frac{4}{9} + 0 = 6$$

iv) The required probability can be determined by finding the area under the normal curve to the left of X = 30.

Now, the probability of completing the project within the 30 week deadline is

$$P(X \leq 30) = 0.5 + P(\mu < x < 30) = 0.5 + P(0 \leq Z \leq 0.41)$$

$$= 0.5 + 0.1591 = 0.6591$$

Where $$Z = \frac{\text{Due date} - \text{Expected date}}{\sigma t}$$

$$Z = \frac{30 - 29}{\sqrt{6}} = 0.41$$

v) If the project start T weeks before the due date, the X will represent the ordinate under normal curve to the left of which 99 % of area lies.

The area between n and X- being 99 - 50 or 49 % and Z - value corresponding to this is 2033.

$$\therefore \quad 2.33 = \frac{T - 29}{\sqrt{6}}$$

$$T = 29 + 2.33\sqrt{6}$$

$$= 34.7 \text{ weeks}$$

Example 3.5.3 : *A small project consisting of ten activities has the following characteristics :*

Activity	Preceding activity	Time estimate weeks		
		Optimistic	Most likely	Pessimistic
A	-	4	5	12
B	-	1	1.5	5
C	A	2	3	4
D	A	3	4	11
E	A	2	3	4
F	C	1.5	2	2.5
G	D	1.5	3	4.5
H	B, E	2.5	3.5	7.5
I	H	1.5	2	2.5
J	F, G, I	1	2	3

Determine the critical path.

Solution : Network for the given project is drawn below :

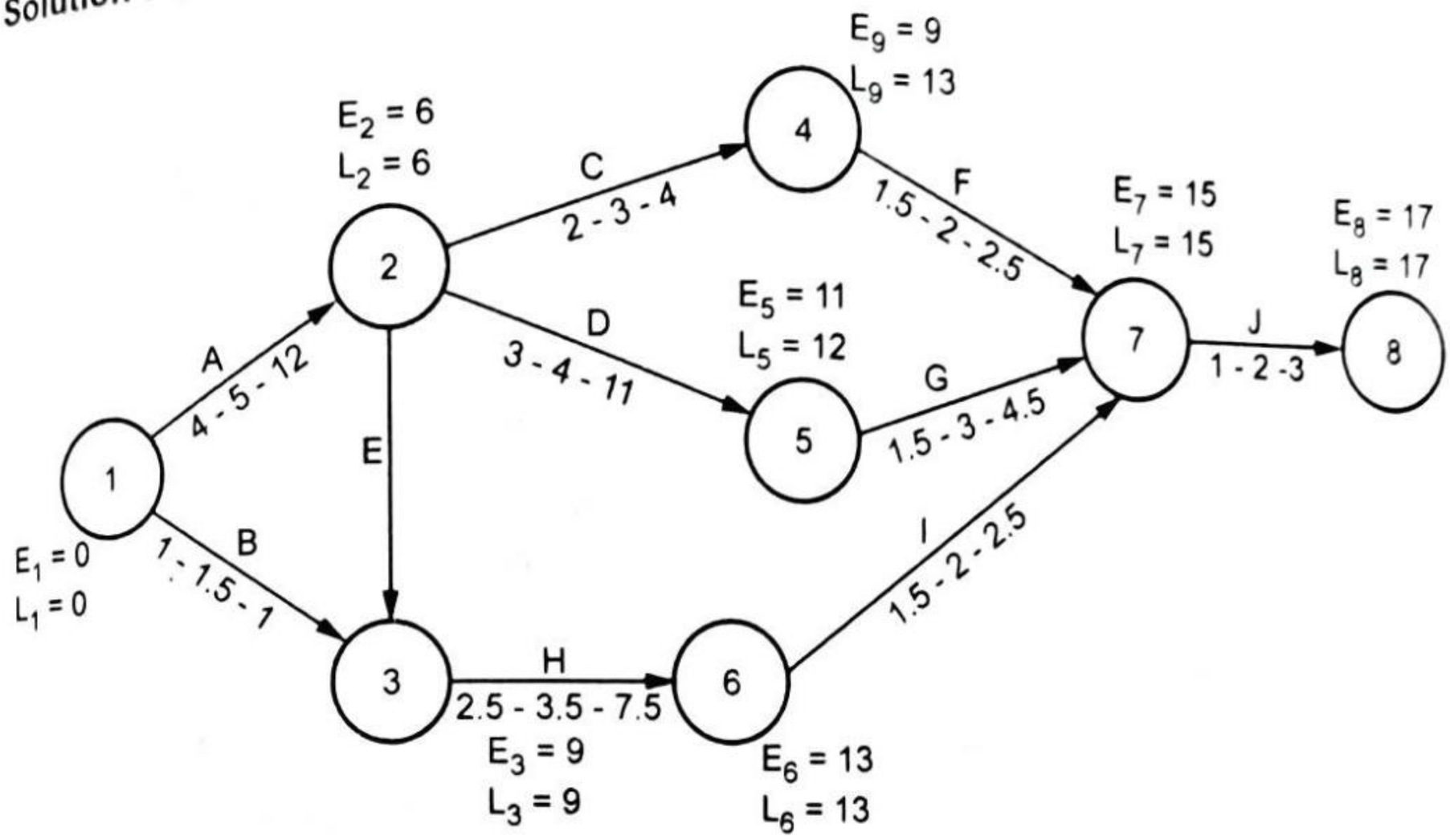


Fig. 3.5.4

Value of expected time for each activity is shown in following Table 3.5.1 :

Activity	Time estimate (Weeks)			
	Optimistic t_0	Most likely t_m	Pessimistic t_p	Expected $t_e = \frac{t_0 + 4t_m + t_p}{6}$
A (1 - 2)	4	5	12	6
B (1 - 3)	1	1.5	5	2
C (2 - 4)	2	3	4	3
D (2 - 5)	3	4	11	5
E (2 - 3)	2	3	4	3
F (4 - 7)	1.5	2	2.5	2
G (5 - 7)	1.5	3	4.5	3
H (3 - 6)	2.5	3.5	7.5	4
I (6 - 7)	1.5	2	2.5	2
J (7 - 8)	1	2	3	2

Table 3.5.1

Time [Earliest and latest] are calculated as follows :

Forward pass method	Backward pass method
$E_1 = 0$	$L_8 = E_8 = 17$
$E_2 = E_1 + t_{1,2} = 0 + 6 = 6$	$L_7 = E_8 - t_{7,8} = 17 - 2 = 15$
$E_3 = \text{Max}\,[E_1 + t_{1\text{-}3} ; E_2 + t_{2\text{-}3}]$	$L_6 = L_7 - t_{6\text{-}7} = 15 - 2 = 13$
$= \text{Max}\,[0 + 2 ; 6 + 3] = 9$	$L_5 = L_7 - t_{4\text{-}7} = 15 - 3 = 12$
$E_4 = E_2 + t_{2\text{-}4} = 6 + 3 = 9$	$L_4 = L_7 - t_{4\text{-}7} = 15 - 2 = 13$
$E_5 = E_2 + t_{2\text{-}5} = 6 + 5 = 11$	$L_3 = L_6 - t_{3\text{-}6} = 13 - 4 = 9$
$E_6 = E_3 + t_{3\text{-}6} = 9 + 4 = 13$	$L_2 = \text{Min}\,[L_3 - t_{2\text{-}3} , L_4 - t_{2\text{-}4}\ L_5 - t_{2,5}]$
$E_7 = \text{Max}\,[E_4 + t_{4\text{-}7} ; E_5 + t_{5\text{-}7} ; E_6 + t_{6\text{-}7}]$	$= \text{Min}\,[9 - 3; 13 - 3; 12 - 5] = 6$
$= \text{Max}\,[9 + 2 ; 11 + 3 ; 13 + 2] = 15$	$L_1 = \text{Min}\,[L_2 - t_{1\text{-}2} , L_3 - t_{1\text{-}3}]$
$E_8 = E_7 + t_{4\text{-}8} = 15 + 2 = 17$	$= \text{Min}\,[6 - 6; 9 - 2] = 0$

As we can see there are two critical paths along which E-values and L-values are similar, but the longest network of critical activities is known as critical path.

Critical path is 1-2-3-6-7-8

Expected length of critical path is = 6 + 3 + 4 + 2 + 2 = 17 weeks

Example 3.5.4 : *Product manager has planned a list of activities culminating in the inaugurate launch of the new products.*

These are given in the table below :

Activity	Pert 3 time estimates days			Immediate predecessor (s)
	P	M	O	
a	20	10	5	-
b	12	7	5	-
c	12	10	8	a
d	40	20	6	c
e	90	60	30	d
f	14	10	7	d
g	50	30	20	c
h	12	10	8	e, f, g
i	6	4	3	b
j	1	1	1	h, i

What is the probability that product manager will be able to complete the language launch within 80 days-time ?

Solution : Network diagram for given problem is shown in following Fig. 3.5.5 :

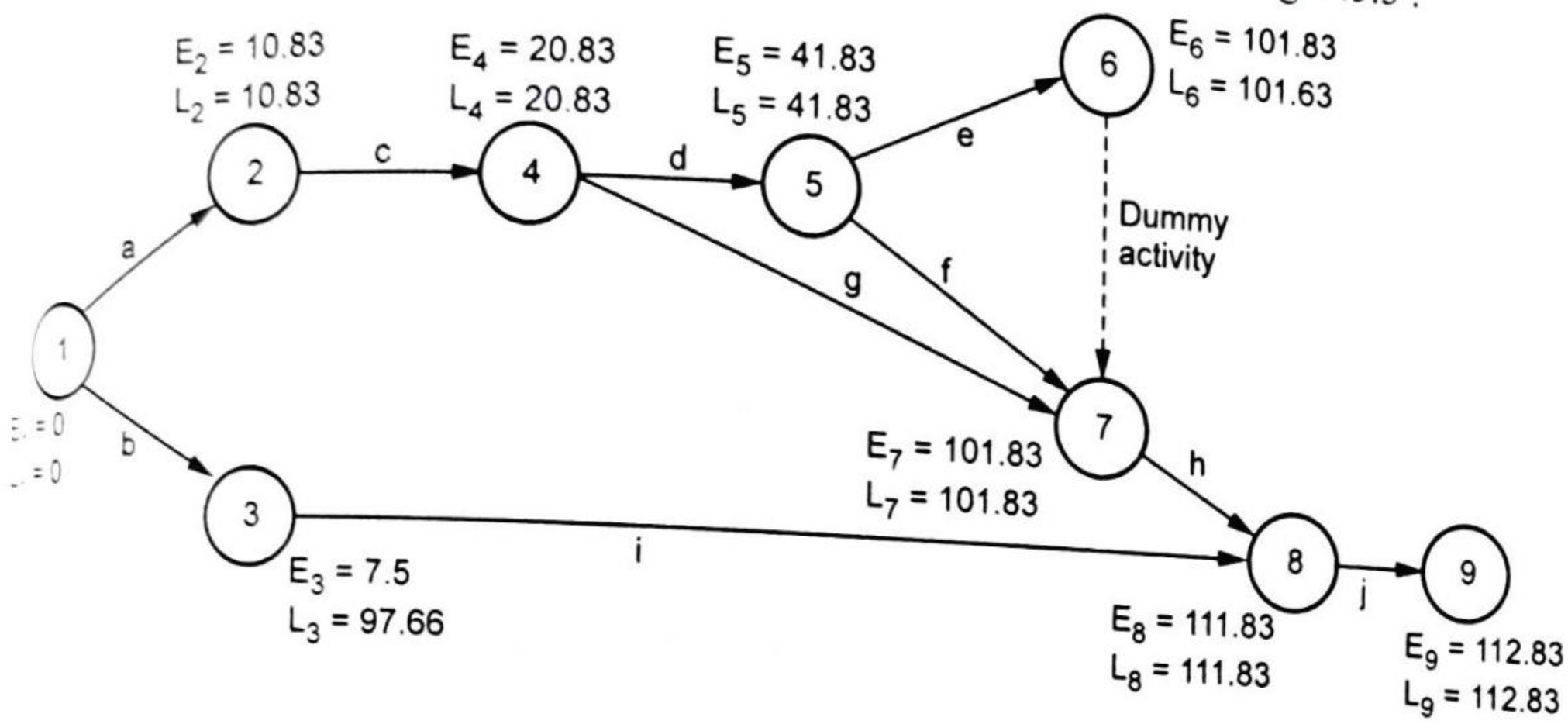


Fig. 3.5.5

Expected time value for each activity of given network is listed in Table 3.5.2 along with ...e variance.

Activity	Time estimates				Variance
	Pessimistic t_p	Most likely t_m	Optimistic t_0	Expected $t_e = \frac{t_0 + 4t_m + t_p}{6}$	$\sigma^2 = \left(\frac{t_p - t_0}{6}\right)^2$
a	20	10	5	10.83	6.25
b	12	7	5	7.5	1.36
c	12	10	8	10	0.44
d	40	20	6	21	32.11
e	90	60	30	60	100
f	14	10	7	10.17	11.36
g	50	30	20	31.67	25
h	12	10	8	10	0.44
i	6	4	3	4.17	0.25
j	1	1	1	1	0

Table 3.5.2

Value of earliest and latest time is calculated on the basis of expected time t_e as follows :

Forward pass method	Backward pass method
$E_1 = 0$	$L_9 = E_9 = 112.83$
$E_2 = E_1 + t_{1-2} = 0 + 10.83 = 10.83$	$L_8 = L_9 - t_{8-9} = 112.83 - 1 = 111.83$
$E_3 = E_1 + t_{1-3} = 0 + 7.5 = 7.5$	$L_7 = L_8 - t_{7-8} = 111.83 - 0 = 101.83$
$E_4 = E_2 + t_{2-9} = 10.83 + 10 = 20.83$	$L_6 = L_7 - t_{6-7} = 101.83 - 0 = 101.83$
$E_5 = E_4 + t_{4-5} = 20.83 + 21 = 41.83$	$L_5 = \text{Min}[L_6 - t_{5-6} ; t_7 - t_{5-7}]$
$E_6 = E_5 + t_{5-6} = 41.83 + 60 = 101.83$	$= \text{Min}[101.83 - 60; 10.83 - 10.17]$
$E_7 = \text{Max}[E_4 + t_{4-7} ; E_5 + t_{5-7} , F_6 + t_{6-7}]$	$= 41.83$
$= \text{Max}[20.83 + 31.67, 41.83 + 10.17 + 101.83 + 0] = 101.83$	$L_4 = \text{Min}[L_5 - t_{4-5} , L_7 - t_{4-7}]$
$E_8 = \text{Max}[E_3 + t_{3-8} , E_7 + t_{7-8}]$	$= \text{Min}[41.83 - 21; 101.83 - 31.67]$
$= \text{Max}[7.5 + 4.17 , 101.83 + 10]$	$= 20.83$
$= 111.83$	$L_3 = L_7 - t_{3-7} = 101.83 - 4.17 = 97.66$
$E_9 = E_8 + t_{8-9} = 111.83 + 1 = 112.83$	$L_2 = L_4 - t_{2-4} = 20.83 - 10 = 10.83$
	$L_1 = \text{Min}[L_2 - t_{1-2} , L_3 - t_{1-3}]$
	$= \text{Min}[10.83 - 10.83; 97.66 - 7.5]$
	$= 0$

Value of earliest and latest time is calculated on the basis of expected time t_e as follows :

Hence critical path along with E-value and L - value are same i.e., 1-2-4-5-6-7-8-9 expected project duration is 172.83 days.

Variance of project length = Sum of variance of each critical activity

$$= 6.25 + 0.44 + 32.11 + 100 + 1.36 + 44 + 0 = 140.6$$

Standard deviation is $\sigma = \sqrt{\text{Variance}}$

$$= \sqrt{140.6}$$

$$= 11.86$$

Thus, $$Z = \frac{t_s - t_e}{\sigma} = \frac{80 - 112.83}{11.86} = -2.77$$

For $Z = -2.77$ Probability of completing the project with 80 days-time i.e., 0.3 %.

Example 3.5.5 : *A project is composed of seven activities whose time estimates are listed in the following table. Activities are simplified by this beginning (1) ones ending (j) Node member.*

Activity		Estimated duration in weeks		
i	j	Optimistic	Most likely	Pessimestic
1	2	1	1	7
1	3	1	4	7
1	4	2	2	8
2	5	1	1	1
3	5	2	5	14
4	6	2	5	8
5	6	3	6	15

Calculate expected project length.

Solution :

Calculation of expected time for each activity is shown in following Table 3.5.3 :

Activity	Time estimates (Weeks)			
	Optimistic t_0	Most - likely t_m	Pessimistic t_p	Expected time $t_e = \frac{t_0 + 4t_m + t_p}{6}$
1 - 2	1	1	7	2
1 - 3	1	9	7	4
1 - 4	2	2	8	3
2 - 5	1	1	1	1
3 - 5	2	5	14	6
4 - 6	2	5	8	5
5 - 6	3	6	15	7

Table 3.5.3

E- values and L- values are calculated on the basis of expected time are as follows :

Forward pass method	Backward pass method
$E_1 = 0$	$L_6 = E_6 = 0$
$E_2 = E_1 + t_{1-2} = 0 + 2 = 2$	$L_5 = L_6 - t_{5-6} = 17 - 7 = 10$
$E_3 = E_1 + t_{1-3} = 0 + 4 = 4$	$L_4 = L_6 - t_{4-6} = 17 - 5 = 12$
$E_4 = E_1 + t_{1-4} = 0 + 3 = 3$	$L_3 = L_5 - t_{3-5} = 10 - 6 = 4$
$E_5 = \text{Max}[E_2 + t_{2-5} ; E_3 + t_{3-5}]$	$L_2 = L_5 - t_{2-5} = 10 - 1 = 9$
$= \text{Max}[2 + 1 ; 4 + 6] = 10$	$L_1 = \text{Min}[L_2 - t_{1-2} ; L_3 - t_{1-3} ; L_4 - t_{1-4}]$
$E_6 = \text{Max}[E_5 + t_{5-6} ; E_4 + t_{4-6}]$	$= \text{Min}[9 - 2 ; 4 - 4 ; 12 - 3] = 0$
$= \text{Max}[10 + 7 ; 3 + 5] = 17$	

Network diagram for given project along with E-values and L-values is shown by following Fig. 3.5.6 :

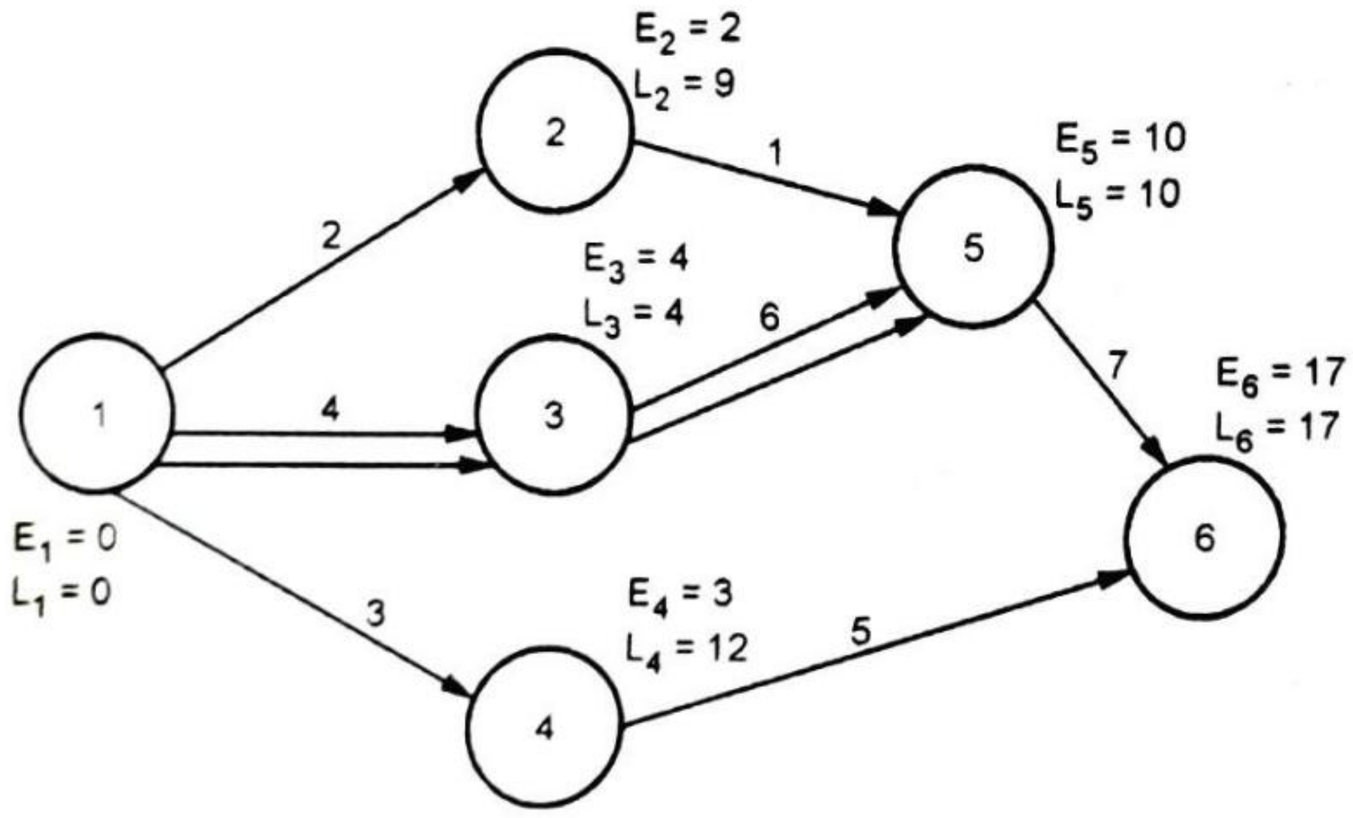


Fig. 3.5.6

Critical path for the above network 1-3-5-6 shown by double lines; along with E-values and L-values are same.

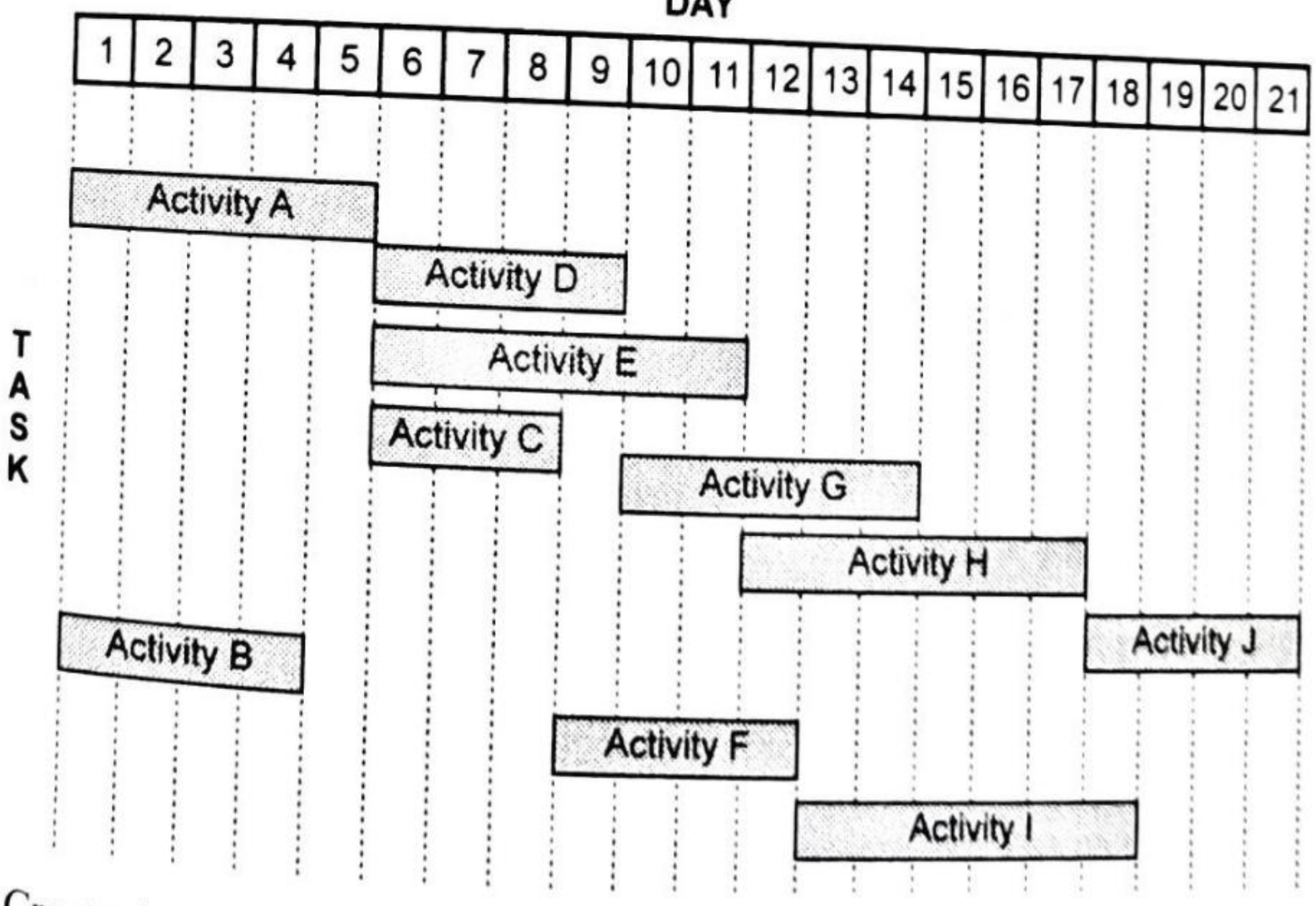
Expect project length will be = 4 + 6 + 7 = 17 weeks.

❑ Gantt chart :

This is a horizontal bar chart plotted over time (e.g. days, weeks or months). Each activity is shown as a bar (its length based on a time estimate). Depending on task dependencies and resource availability, these bars may be sequential or run in parallel. Each bar is plotted to start at the earlier possible start date. The plan laid out when the GANTT Chart was created can be compared with actual times taken (plotted below the planned time bars in the chart).

❑ **Example of Gantt chart :**

Activity	Predecessor	Duration (weeks)
A	/	5
B	/	4
C	A	3
D	A	4
E	A	6
F	B, C	4
G	D	5
H	D, E	6
I	F	6
J	H,G	4



- **Step 1 :** Create the top scale according to the data or the activities duration.
- **Step 2 :** At this point the dependencies of the activities have to be analysed. Task A and B don't have any predecessor and they can be the first two activities who the Gantt chart starts with. It's important to create every rectangle as long as the task's duration.
- **Step 3 :** The next step is looking at next activities that have as predecessors the activities already on the map. After A and B, it can be seen from the table that activities C,D,E and F are connected to them. At this point put on the map the new activities with their starting point afterwards the end of the previous activities.

3.6 Advantage, Limitation and Differences between PERT and CPM

❑ Advantages of PERT :

1. It is very helpful in determine the schedule for a project within time limit.
2. It helps the management to optimum allocation of resources for the project.
3. It helps in taking right decision for the projects at a right time.
4. It is very helpful in determine the expected duration of activities.
5. It helps the management in handling the uncertainties involved in the project.
6. It helps the management to reduce the risk element in the project.
7. It suggests area of increasing efficiency, decreasing cost and maximizing profits.
8. It helps in coordinating the various activities involved in a project.
9. It enables the use of statistical analysis.
10. It enables a manager to know in advance, where the trouble may occur, where more supervision needed and where resources may be transferred to keep the project on schedule.

❑ Limitations of PERT :

Although PERT have many advantages, but it also suffers from certain limitations. These are :

1. PERT emphasis only on time. It ignores the cost of a project.
2. It cannot be useful for programmes that are indefinite and vague.
3. Assumption of normal probability distribution is not true.
4. It does not consider the matter of resources required for various types of activities of a project.
5. It seems to be simple but in reality its application is too complex.
6. It is not practicable for routine planning of recurring events.

❑ Advantages of critical path method :

The following are the advantages of CPM :

- It is very useful for scheduling and controlling of large projects.
- It is simple concept and not mathematically complex.
- It is very helpful in pinpoint activities that needed to be closely watched.

- In CPM, project documentation and graphics point out who is responsible for various activities.
- It is applicable to a wide variety of projects.
- It is very useful in monitoring schedules and costs.
- It makes better and detailed planning possible.
- It is helpful at many stages of project management.
- It enables standard method for communicating project plans, schedules, time and cost performance.
- With the help of CPM most critical activities are identified and thus more attention can be paid to these activities for the successful completion of project.

❑ Limitations of CPM :

- It ignores to incorporate statistical analysis in determining the time estimates.
- It is presumed in CPM that there is a precise known time that each activity in the project will take. But in reality it is not happen.
- Basically it developed as a static planning model and not as a dynamic controlling device. So it cannot be used as a dynamic controlling device.

❑ Similarities between PERT and CPM :

PERT and CPM both are the networking techniques. Both are the important tools of project implementation. Below are the similarities between PERT and CPM :

- Both PERT and CPM have the same procedure and network diagrams are used in the both the techniques.
- Both PERT and CPM are used to determine the earliest / latest start and finish times for each activity.
- Both PERT and CPM techniques help management to plan, schedule and control the project.
- All significant task and activities are defined in the project by both the techniques.
- The networking principles used in both the techniques is more or less the same.

❑ Comparison between PERT and CPM :

Although both techniques share some common characteristics, yet there are some differences between them.

- **Origin :** The origin of PERT is military organization whereas origin of CPM is chemical plant (industry).
- **Uncertainty :** In PERT estimates are uncertain whereas in CPM does not allow any uncertainty.
- **Nature :** PERT is used for non-repetitive jobs whereas CPM is used for repetitive jobs.
- **Time / Cost :** PERT stresses on time based concept whereas CPM stresses on cost based concept.
- **Model :** PERT is a probabilistic model whereas CPM is a deterministic model.
- **Time estimates :** PERT has three time estimates whereas CPM has only one single estimate of time.
- **Critical activities / Dummy activities :** In PERT, critical activities is not used whereas in CPM dummy activities is not used.
- **Suitability :** PERT is suitable where high precision is required in time estimates such as defence projects whereas CPM is suitable where reasonable precision is required such as civil construction.
- **Event /Activity :** PERT is an event oriented whereas CPM is an activity oriented.

3.7 Automated Tools

1. Scoro :

- **Scoro** is known as one of the most comprehensive **business management software** for professional and creative services. For those who wish to bring structure to your work, scoro is the right pm tool for you.

Features :

- A single place for projects, clients and teams.
- Be organized in every aspect of your business with seamless workflow.
- Get a real-time overview and automated reports.
- Can be integrated with tools like dropbox, mailchimp, outlook and more.

2. Workzone

- Workzone is built by a highly dedicated team to help individuals and organizations gain better control and visibility in work management. It gives them a central place to manage and share work, so everyone stays on the same page.

Features :

- Get top-level reports so everyone knows what's next on the list.
- Makes way for faster communication.
- Features like creating tasks, to-do lists, sharing files easily improves collaboration.
- Set permission for different users including clients.

3. Filestage :

- Filestage is an enterprise-ready marketing project management software that helps teams to get their project deliverables reviewed and approved faster. Filestage streamlines, organizes and automates feedback on deliverables throughout the proofing process while reducing errors and ensuring compliance guides are met. Enable colleagues and clients to view and annotate project deliverables (such as documents, images or videos) in real - time for marketing projects, video production, website design, product catalogs or anything else - and to approve files when they are complete.

Features :

- Build consistent review and approval processes.
- Comment on videos, documents, images and audio files in real-time.
- Clear deliverable version management.
- Project dashboard to keep an overview of all deliverables.

4. Proprofs :

- Proprofs project is one of the simple and feature-packed project management tools designed to help businesses of all sizes manage, track and execute projects with ease. It brings all your projects under one roof allowing your teams to work on them collaboratively. They can share files on the go, discuss roadblocks, give feedback via task comments and get real - time notifications on project developments.
- From assigning and prioritizing tasks to tracking and executing them, the tool helps you do it all. You can even create timesheets for each team member, manage billable and non-billable hours and generate invoices.

Features :

- Gantt charts
- Shared calendar
- Kanban board

- Custom workflow
- Timesheets
- Insightful reports
- Invoice generation
- Drag and drop functionality

Pricing :

- Essentials - $2 / user / month
- Premium - $4 / user / month

❑ 5. Zoho projects :

- Without a doubt, zoho projects stands out as one of the **best simple project management software** that can help you streamline your upcoming work and tasks with a click.

Features :

- Effective file management.
- Gantt charts to oversee project progress.
- One tool for teams to create, collaborate and communicate.
- Can be integrated with ZOHO CRM and other tools to manage every aspect of a growing agency.

🕮 3.8 Project Status Reporting

- A *project status report* is a document that summarizes a project's overall progress against the projected project plan.
- The goal of a project status report is to keep all stakeholders informed of progress, to mitigate issues before they arise and to ensure that the project will land within the designated time frame.
- A project status report helps to improve communication across an organization, as everyone is kept in the loop on how the project is progressing. It also helps to simplify the communication process with a single, formalized report that everyone can refer to to stay up to date.
- Additionally, a project status report improves the organizational support for your project by maintaining tight communication among team members to ensure all goals and objectives are met.

3.8.1 The Purposes of Project Status Reports

- One of the many benefits of using a project status report is that it forces an organization to agree to certain project milestones and measures of progress at the very beginning of that project. A project manager gathers those important criteria and creates a project status report that will prove useful to everyone who needs to see it.
- Project status reports also facilitate the following :
  - Create and enable buy-in from stakeholders.
  - Provide transparency into the progress toward milestones.
  - Help identify issues and risks, so course correction can happen quickly.
  - Pinpoint the progress of work done by individuals, teams and resources, so you can rotate out and bring in staff in a timely manner.
  - Provide a high-level gauge of project health.
  - Prevent unpleasant surprises (to team members, clients and stakeholders).
  - Furnish a method for keeping project members and leaders accountable.
  - Provide a paper trail.
  - Prevent scope creep.
  - Present the right information to the intended audience(s).

3.8.2 Types of Project Status Reports

1. Weekly VS Monthly status reports

- Different types of data should be reported at different times. That's why we have monthly and weekly status report types. Here's a breakdown of what to expect from each.

Weekly status report :

- A project manager should maintain a weekly status report document constantly, jotting in updates and stats as they happen in real-time. You will most likely have a day of the week in mind for when to send it; however, the magic of a weekly report should be that it can be ready within the hour if a client requests it.

Monthly status report :

- A monthly- or bi-monthly status report should be a "bigger picture" document that can quickly get upper management caught up on progress and developments. Leave out minute details and focus on what matters to them : Budget, costs, the status of deliverables and any major risks or roadblocks.

❑ 2. Quarterly status reports :

- Quarterly status reports are, obviously, covering an extended period of time (anywhere from 3-4 months). Thus, if they are required, you are going to want to be mindful of their length. Come up with 3-4 top-level priorities or goals and report on them here. Focus on quantitative progress, not big ideas. Make it an "elevator pitch" of your work so far.

❑ 3. External Vs Internal status reports :

- Status reports, like any written document, must be tailored to an audience. Your client prefers different content in their status report than your internal team. Adjust your reporting to these wants and desires.

External status reports :

- Be straightforward and honest but also optimistic. The tone will be highly professional and it should be proofed by several people before it is sent out. Orient it around high-level goals, as external stakeholders won't necessarily care about the minutia. External status reports will most likely focus on a broader array of issues, rather than delving deep into one at a time (unless required by the client).

Internal status reports :

- The tone can be more transparent here. If you've hit the panic button, it's fine to let your team know why. Also, a vibrantly upbeat report is appropriate if you want to accentuate a job well done. No need to hold back. This report will also be more detail-oriented, fixating on individual tasks and items that are of value to your team. Internal reports may, sometimes, focus on fewer issues and just do a deep-dive where it's needed most.

3.8.3 How to Track Project Status

To track project status, follow these easy steps to ensure your project is completed on time :

1. **Create a project plan or project outline :** Before you officially start your project, create a rough outline of your project from start to finish, including all key details, resources and time constraints.
2. **Determine specific goals :** Identify what you want to accomplish with this project, whether it be a new marketing campaign, a product deployment, etc.
3. **Document key milestones :** Determine key parts of your project timeline that you want to pay specific attention to and that you need to hit on time.

4. **Establish clearly - defined deadlines :** Ensure you and your team have a good sense of all the deadlines that must be met in order for your project to land on time.
5. **Check on the project regularly :** As your project kicks off, continue to check in on the progress regularly, referring to your project plan to check progress against projected timeline.

Elements of project status reports :

- To make project status reports as useful and relevant as possible, there are key components that you should include. You may add more types of information, but these are the mission-critical elements that a project manager should be aware of :
  - **Project details :** List project name and project code, if applicable.
  - **Team :** List project manager and other key team members.
  - **Status date :** Also include cadence (weekly, bi-weekly, monthly, etc.).
  - **Schedule of project :** Have you met all of this period's milestones ?
  - **Scope :** Has the project stayed in scope during this period ?
  - **Budget :** Is the project on, under- or over-budget ?
  - **Quality :** This may not be applicable to every report during every period, but it's worth capturing if there are issues.
  - **Dependencies :** What factors are the team waiting on before being able to move forward ?
  - **Issues and roadblocks :** What roadblocks have come up during this period ? Give a brief description of what they are, what you're doing to remedy them and who owns them.
- These components may vary depending on the audience, but at the very least, the detailed weekly project status report should contain these elements. Moreover, the project manager should be able to speak about any of these factors if asked.

3.8.4 Benefits of Project Status Report Templates

You can save a lot of time by using templates to create project status reports. Of course, all project reports require tweaking and editing to properly reflect the project's individual ingredients, but a template can be a strong starting point. There are several benefits to using project status report templates :

- **Free :** Many templates are available free online.
- **Printable :** You can distribute reports for meetings, huddles and those stakeholders who would like a printable copy.

- **Professional appearance :** Using a template that's already been designed to look professional gives a project manager leverage.
- **Clean design :** As mentioned above, project status reports should be easy to scan and intuitive to interpret, even for those who are several places removed from the project.
- **Customizable :** The most useful templates will allow a project manager to add and subtract fields and items as needed for each project.
- **Collaboration features :** Web-based templates can give all team members access to the status report, so they can see where things stand, as well as contribute updates, if desired.
- **All tasks in one place :** A template can ensure that you're hosting every piece of a project in one place.

3.8.5 Challenges with Project Status Reports

Creating project status reports can be challenging and risky. Here are some of the risks to consider when creating project status reports and status report templates :

- **Forecasting costs, scheduling and estimating are guesswork :** Project managers can still only make educated guesses about these components of a report. Risks can be identified but not always quantified : For example, a company might know that another project will be starting during the time frame of your existing project, but no one may know the exact timing or breadth of that second project. If it's smaller, the risks it poses to your project in terms of staffing and other resources may be minimal. If it's larger than expected, it could pose a significant risk.
- **Going simpler is a strong but risky trend :** There's a greater chance of overlooking details that may be or become important.
- **You might leave a key person out :** Even under the most well-intentioned circumstances, not everyone who needs to may have buy-in or visibility.
- **You're relying on the strength of your report :** Any report is only as useful as the information that goes into it, as well as the actions taken as a result.

3.9 Project Metric

- Project metrics and Key Performance Indicators (KPIs) are particularly useful because they provide an objective measure of project health and allow project managers to make important decisions about a project.
- A metric is simply a measurement of something. When managing a project, you can choose to use project metrics to track progress.
- Metrics **are selected** based on the goals of the project and critical factors for success.

Examples of project metrics include :

- The estimated cost of the project.
- The number of issues that are late.
- The number of open tasks.
- The duration of a project.
- Earned value.

- Track how the project is performing relative to that measure over time to generate your metric.
- A metric is not the same as a key performance indicator. A **Key Performance Indicator** (KPI) is used to measure a specific metric related to business goals. Tracking KPIs helps teams to understand their efforts towards a particular goal.

3.9.1 Key Process and Project Metric Groups

Project managers have a wide variety of metrics to choose from. We can classify the most commonly used metrics into the following groups :

1. Process metrics :

- These are metrics that pertain to process quality. They are used to measure the efficiency and effectiveness of various processes.

2. Project metrics :

- These are metrics that relate to Project Quality. They are used to quantify defects, cost, schedule, productivity and estimation of various project resources and deliverables.

3. Product metrics :

- These are metrics that pertain to product quality. They are used to measure cost, quality and the product's time-to-market.

4. Organizational metrics :

- These metrics measure the impact of organizational economics, employee satisfaction, communication and organizational growth factors of the project.

5. Software development metrics examples :

- These metrics enable management to understand the quality of the software, the productivity of the development team, code complexity, customer satisfaction, agile process and operational metrics.

❑ Top 11 project metrics :

1. **Schedule variance :** Any difference between the scheduled completion of an activity and the actual completion is known as schedule variance.

   Schedule variance = ((Actual calendar days – Planned calendar days) + Start variance) / Planned calendar days × 100

2. **Effort variance :** Difference between the planned outlined effort and the effort required to actually undertake the task is called effort variance.

   Effort variance = (Actual effort – Planned effort) / Planned effort × 100

3. **Size variance :** Difference between the estimated size of the project and the actual size of the project (normally in KLOC or FP).

   Size variance = (Actual size – Estimated size) / Estimated size × 100

4. **Requirement stability index :** Provides visibility to the magnitude and impact of requirements changes.

   RSI = 1 – ((Number of changed + Number of deleted + Number of added) / Total number of initial requirements) × 100

5. **Productivity (Project) :** Is a measure of output from a related process for a unit of input.

   Project productivity = Actual project size / Actual effort expended in the project.

6. **Productivity (for test case preparation) :** Actual number of test cases / Actual effort expended in test case preparation.

7. **Productivity (for test case execution) :** Actual number of test cases / Actual effort expended in testing.

8. **Productivity (defect detection) :** Actual number of defects (Review + Testing) / Actual effort spent on (Review + Testing).

9. **Productivity (defect fixation) :** Actual no of defects fixed / Actual effort spent on defect fixation.

10. **Schedule variance for a phase :** The deviation between planned and actual schedules for the phases within a project.

    Schedule variance for a phase = (Actual Calendar days for a phase – Planned calendar days for a phase + Start variance for a phase) / (Planned calendar days for a phase) × 100

11. **Effort variance for a phase :** The deviation between a planned and actual effort for various phases within the project.

Effort variance for a phase = (Actual effort for a phase – A planned effort for a phase) / (Planned effort for a phase) × 100

Top 7 process metrics :

1. **Cost of quality :** It is a measure of the performance of quality initiatives in an organization. It's expressed in monetary terms.

Cost of quality = (Review + Testing + Verification Review + Verification Testing + QA + Configuration management + Measurement + Training + Rework Review + Rework Testing) / Total Effort × 100

2. **Cost of poor quality :** It is the cost of implementing imperfect processes and products.

Cost of poor quality = Rework effort / Total effort × 100

3. **Defect density :** It is the number of defects detected in the software during development divided by the size of the software (typically in KLOC or FP).

Defect density for a project = Total number of defects / Project size in KLOC or FP.

4. **Review efficiency :** Defined as the efficiency in harnessing / Detecting review defects in the verification stage.

Review efficiency = (Number of defects caught in review) / Total number of defects caught) × 100

5. **Testing efficiency :** Testing efficiency = 1 – ((Defects found in acceptance) / Total number of testing defects) × 100

6. **Defect removal efficiency :** Quantifies the efficiency with which defects were detected and prevented from reaching the customer.

Defect removal efficiency = (1 – (Total defects caught by customer / Total number of defects)) × 100

7. **Residual defect density** = (Total number of defects found by a customer) / (Total number of defects including customer found defects) × 100

3.9.2 Using Project Metrics for Better Reporting

Project metrics are a very efficient way to assess the health of a project and make informed decisions.

- Metrics reveal how the project is doing relative to the key performance indicators that have been selected. This makes it very easy to identify the areas of a project that require attention. Metrics are an early warning system and should be actionable!
- Let's look at why project metrics are incredibly useful if implemented and reported the right way with an example.
  1. Project team members execute their work and update their progress in the collaborative project site.
  2. If a change occurs to trigger a warning metric, for example, a new issue, that indicator will automatically update on all the dashboards reporting on that metric.
  3. As a project manager, you come into the project site and the KPIs will automatically light up green, amber or red on the project dashboard, immediately showing you if something is going wrong.
  4. You can address the issue at the earliest notice and get all the metrics back to green and then repeat the cycle.

3.10 EVA (Earned Value Analysis)

3.10.1 Meaning and Definition

- Earned Value Analysis (EVA) is one of the key tools and techniques used in ***Project Management***, to have an understanding of how the project is progressing. EVA implies gauging the progress based on earnings or money. Both, schedule and cost are calculated on the basis of EVA.
- Here are five other definitions :
  1. Englert and associates, inc. define it as, "a method for measuring project performance. It compares the amount of work that was planned with what was actually accomplished to determine if cost and schedule performance is as planned".
  2. Project magazine defines it as, "a methodology used to measure and communicate the real physical progress of a project taking into account the work complete, the time taken and the costs incurred to complete that work".
  3. The user guide for Microsoft project 2003 defines earned value as, "a method for measuring project performance. It indicates how much of the budget should have been spent, in view of the amount of work done so far and the baseline cost for the task, assignment or resources".

4. Field operative defines it as, "the physical work accomplished plus the authorised budget for this work. The sum of the approved cost estimates, (which may include overhead allocation), for activities (or portions of activities), completed during a given period, usually project-to-date".

5. NASA defines it as, "an integrated management control system for assessing, understanding and quantifying what a contractor or field activity is achieving with program dollars. EVM provides project management with objective, accurate and timely data for effective decision making".

3.10.2 Features of EVA

- Earned value analysis is an objective method to measure project performance in terms of scope, time and cost.
- EVA metrics are used to measure project health and project performance.
- Earned value analysis is a quantitative technique for assessing progress as the software project team moves through the work tasks, allocated to the project schedule.
- EVA provides a common value scale for every project task.
- Total hours to complete the project are estimated and every task is given an earned value, based on its estimated (%) of the total.
- Earned value is a measure of 'Progress' to assess 'Percentage of Completeness.'

3.10.3 Need for EVA

- EVA provides different measures of progress for different types of tasks. It is the single way for measuring everything in a project.
- Provides an 'Early Warning' signal for prompt corrective action. The types of signals can be the following :

a) **Bad news does not age well -** Holding on to the bad news does not help. The project manager needs to take an immediate action.

b) **Still time to recover -** In case, the project is not going as per schedule and may get delayed, the situation is needed to be taken care of by finding out the reasons that are causing delay and taking the required corrective action.

c) **Timely request for additional funds -** While there is time to recover, the need for additional resources or funds can be escalated with an early warning.

It allows 'rolling up' the progress of many tasks into an overall project status.

It provides with a uniform unit of measure (dollars or work-hours) for the progress.

3.10.4 EVM Measures

- EVM consists of the following primary and derived data elements. Each data point value is based on the time or date an EVM measure is performed on the project.

❑ Primary data points

- Budget At Completion (BAC).
- Total cost of the project.
- The amount expressed in pounds (or hours) of work to be performed as per the schedule plan

$$PV = BAC * \% \text{ of planned work}$$

- Budgeted Cost for Work Performed (BCWP) / Earned Value (EV).
- The amount expressed in pounds (or hours) on the actual worked performed

$$EV = BAC * \% \text{ of actual work}$$

- Actual Cost of Work Performed (ACWP) / Actual Cost (AC).
- The sum of all costs (in pounds) actually accrued for a task to date.
- For example say we should have completed £800 pounds of work by today. We completed £600 worth of work. The BCWP is £600. The BCWS is £800. And if we actually paid £700 then (ACWP) = £700.

❑ Derived data points :

Cost forecasting :

- Estimate At Completion (EAC).
- The expected TOTAL cost required to finish complete work

$$\begin{aligned} EAC &= BAC / CPI \\ &= AC + ETC \\ &= AC + ((BAC - EV) / CPI) \text{ (Typical case)} \\ &= AC + (BAC - EV) \text{ (Atypical case)} \end{aligned}$$

- Here atypical means it is assumed that similar variances will not occur in the future.
  - Estimate To Complete (ETC)
  - The expected cost required to finish all the REMAINING work

$$\begin{aligned} ETC &= EAC - AC \\ &= (BAC / CPI) - (EV/CPI) \\ &= (BAC - EV) / CPI \end{aligned}$$

Variances :

- Cost Variances (CV).
- How much under or over budget

$$CV = EV - AC$$

- NEGATIVE is over budget, POSITIVE is under budget.
- Schedule Variances (SV).
- How much ahead or behind schedule

$$SV = EV - PV$$

- NEGATIVE is behind schedule, POSITIVE is ahead of schedule.
- Variance At Completion (VAC).
- Variance of TOTAL cost of the work and expected cost

$$VAC = BAC - EAC$$

Performance indices :

- Cost performance index

$$CPI = EV / AC$$

- Over (< 1) or under (> 1) budget
- Schedule performance index

$$SPI = EV / PV$$

- Ahead (> 1) or behind (< 1) schedule

EVM Example

The best way to understand an EVM example is to solve it.

***Example 3.10.1** : A project has a budget of £10M and schedule for 10 months. It is assumed that the total budget will be spent equally each month until the 10th month is reached. After 2 months the project manager finds that only 5 % of the work is finished and a total of £1M spent.*

Solution :

$$PV = £2M$$

$$EV = £10M * 0.05 = £0.5M$$

$$AV = £1M$$

$$CV = EV - AC = 0.5 - 1 = -0.5\ M$$

$$CV\ \% = 100 * (CV / EV) = 100*(-0.5 / 0.5) = -100\ \%\ \text{overrun}$$

$$SV = EV - PV = 0.5 - 2 = -1.5\ \text{months}$$

$$SV\ \% = 100 * (SV / PV) = 100*(-1.5 / 2) = -75\ \%\ \text{behind}$$

$$CPI = EV / AC = 0.5 / 1 = 0.5$$

$$SPI = EV / PV = 0.5 / 2 = 0.25$$

$$EAC = BAC / CPI = 10 / 0.5 = £20M$$

$$ETC = (BAC - EV) / CPI = (10 - 0.5) / 0.5 = £19M$$

$$\text{Time to complete} = (10 - 0.5) / 0.25 = 38\ \text{Months}$$

This project will take TOTAL £20M (19 + 1) and 40 (38 + 2) months to complete.

3.10.5 EVM Benefits

EVM contributes to :

- Preventing scope creep.
- Improving communication and visibility with stakeholders.
- Reducing risk.
- Profitability analysis.
- Project forecasting.
- Better accountability.
- Performance tracking.

3.11 Project Communication Plan and Techniques

3.11.1 Project Communication Plan

- A project communication plan is a simple tool that enables you to **communicate effectively on a project with your client**, team and other stakeholders. It sets clear guidelines for how information will be shared, as well as who's responsible for and needs to be looped in on each project communication.

3.11.2 Importance of Project Communication Plan

A communication plan plays an important role in every project by :

- Creating written documentation everyone can turn to.
- Setting clear expectations for how and when updates will be shared.

- Increasing visibility of the project and status.
- Providing opportunities for feedback to be shared.
- Boosting the productivity of team meetings.
- Ensuring the project continues to align with goals.

3.11.3 What to Include in Communication Plans

While the specifics of your communication plan will vary depending on the project type and scope, there are a few key items that should be included in every project communication plan you create :

- **Key stakeholders :** Note all key **stakeholders**, including your primary client contact. Include contact information such as phone numbers and emails, so that anyone who accesses the communication plan is able to find this information.
- **Team members :** Include the main team members from your project team along with their roles. This is handy for anyone new to or unfamiliar with the project. List who on your team is involved in the communication of deliverables, leading strategic discussions or how you'll handle technical conversations between stakeholders and your team.
- **Communication methods :** Outline the main communication methods and different channels you will be using to contact stakeholders, such as email, phone calls, in-person meetings, video meetings, Slack, social media or any others. Include notes on stakeholder's preferred channels.
- **Communication type :** Include types of communication, how that communication will be shared, what will be included and who that communication will be with. For example, you might be providing weekly status reports to the client. Think about how you will provide this, who it will be provided to and what information needs to be in the report.
- **Communication style :** This can be broken down by stakeholder and communication methods. Does a certain stakeholder prefer formal communication only or can you be a little more casual in your tone ?
- **Meeting schedule :** While you can adjust this as needed throughout the project, having an initial idea of how often you'll be meeting with stakeholders is helpful. Depending on the **scope of the project**, you might also want to outline how often you'll be emailing the client. Include internal team meetings as well in your meeting schedule.

- **Key messages :** For each stakeholder, determine the key message or information that will need to be communicated with them throughout the project. This also includes any information or feedback you will need from them.
- **Communication goals :** A communication plan that includes communication goals can help ensure you make decisions based on what you're trying to achieve.

3.11.4 Project Communication Techniques

- **Communication** is a critical factor in project management. There are instances where projects have failed because of miscommunication and communication gaps. **Project managers** fill this gap by devising a good communication mechanism that will help him to communicate with the team members as well as stakeholders, sponsors, top-tier management and all the people who are connected to the project.
- If an effective communication methodology is not followed by the project manager, it may lead to many discrepancies and ultimately may also lead to project failure, which is not appropriate for the organization. It is also important that the right information is delivered to the right person. For instance, the information that is intended for stakeholders may not be appropriate or beneficial for the **project team** members and similarly team members information may not be useful for top level management officials or stakeholders. It may so happen that if an improper information is sent to the inappropriate recipient they might also overlook some messages or information which are important.
- So, project managers have the responsibility to properly channelize the communication process, so that right persons receive the right information. Another important point that project managers must make a note of is that the information sent must be clear, concise and informative. Sometimes improper information may also lead to miscommunication or they are interpreted by the recipient, which can lead to bad work quality.

❑ **Interactive communication :**

- Interactive communication is an effective communication, that allows all the stakeholders live interaction with all the people related to the project. Some of the best examples of interactive communication methods are video conferencing, live chat and phone calls. The interactive communication process is more suitable for the stake holders located in the different regions. According to the experts, video conferencing is considered as most effective in comparison to other modes of interactive communication. The project managers have to make a choice which communication medium they want to use to communicate with the stakeholders.

- Usually project managers prefer face-to-face communication method, as they have a better opportunity to explain the project status, with charts, analysis and can get their instant feedback, which will help them to alter project plans according to the inputs given by the stakeholders. Sometimes it is not viable for a stakeholder to attend the video conferencing, in that case, the project managers can make a call to them and pass on the information.

Push communication :

- In this communication type, the information is passed to the recipients and where the feedback is not required immediately. Project managers can use this medium of communication for sending meeting notes and other information. They can also use this mechanism to pass information to stakeholders through a press release. Project managers also can send faxes, letters, emails, memos, status reports using the push notification mechanism. One backdrop that this communication type is that, the project managers are not really sure that the information sent to the recipient is understood by him or not. They only get acknowledgments that the message is sent to the recipient.

Pull communication :

- As the name itself suggests, this communication method is suitable for the large-scale audience, who like to access information at their own convenient time. The project managers store this information in the data repository on the company server or a place where it can be accessed by the team members or stakeholders. The information can be anything ranging from slide shows, study materials or training sessions.
- Project managers can make use of any of the communication methods listed above. Before selecting the communication the project managers must check all their options and the number of audience and their locations. These are few factors the project managers have to take care of before selecting the communication type.

3.12 Steps for Process Improvement

- Software Process Improvement (SPI) methodology is defined as a sequence of tasks, tools and techniques to plan and implement improvement activities to achieve specific goals such as increasing development speed, achieving higher product quality or reducing costs.
- SPI can be considered as process re-engineering or change management project to detect the software development lifecycle inefficiencies and resolve them to have a better process. This process should be mapped and aligned with organizational goals and change drivers to have real value to the organization.

- SPI mainly consists of 4 cyclic steps as shown in the Fig. 3.12.1, while these steps can be broken down into more steps according to the method and techniques used. While in most cases the process will contain these steps.

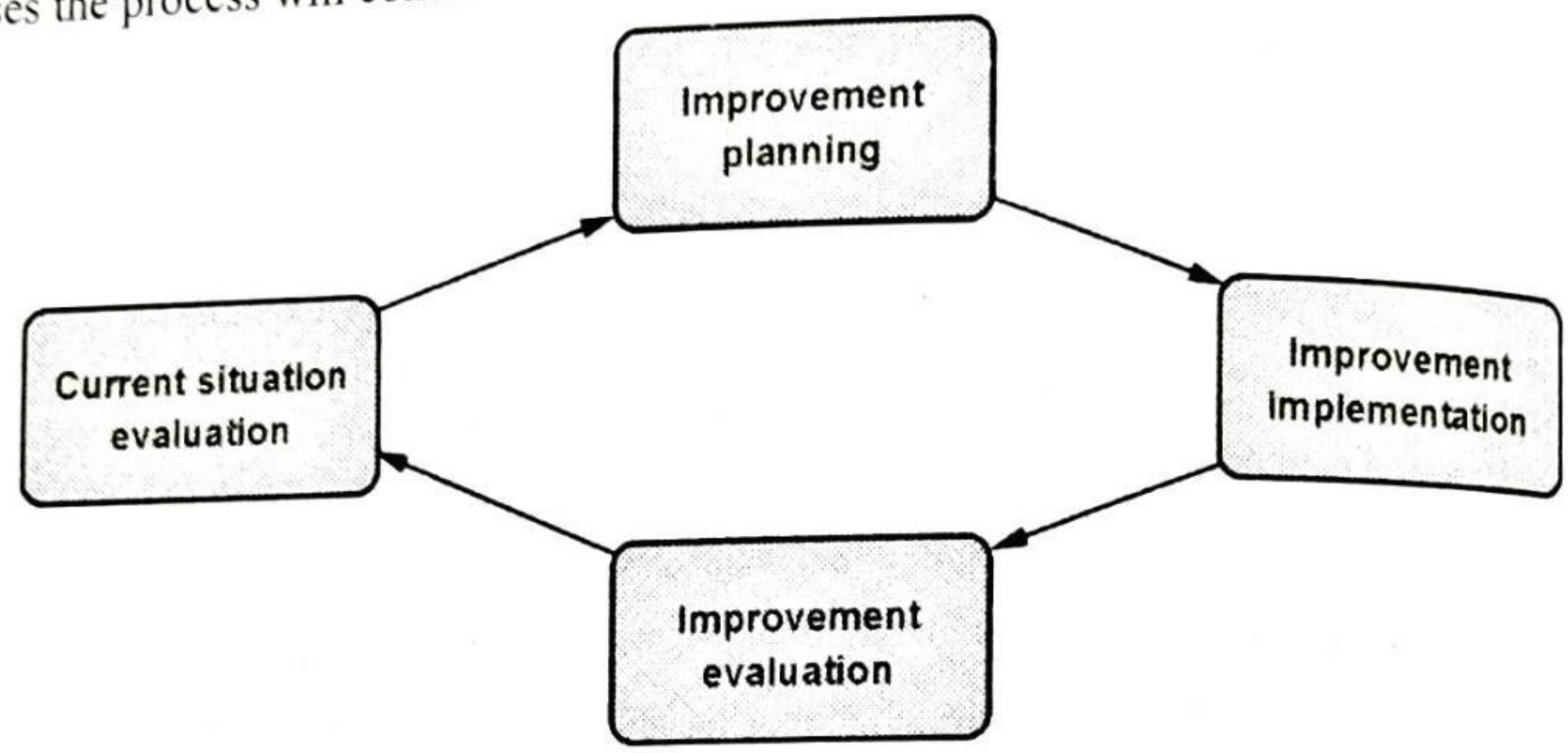


Fig. 3.12.1 : SPI 4 cyclic steps

❑ Current situation evaluation :

- This step is the initial phase of the process and it is mainly to assess the current situation of the software process by eliciting the requirements from the stakeholders, analyzing the current artifacts and deliverables and identifying the inefficiencies from the software process. The elicitation can be conducted through different techniques. For example, individual interviews, group interview, use-case scenarios and observations.
- The key considerations in this step to identify organization goals and ask the solution-oriented questions. Moreover, identifying the measurement using the GQM (Goal - Question - Metric) technique that will help in measuring the current status and measuring the effectiveness of the improvement process.

❑ Improvement planning :

- After analyzing the current situation and the improvement goals, the findings should be categorized and prioritized according to which one is the most important or have the most severity. We should observe what is the new target level of improvements should look like.
- Moreover, in this step, the gap between the current level and the target level should be planned in terms of a set of activities to reach that target. These activities should be prioritized with the alignment of the involved stakeholders and the organization goals. for example, if the project is using the CMMI model, the target could be reaching maturity level 4 and the company at level 3, in that case, the plan should be focused on the process areas and their activities which is related to that level of improvement with the alignment of the organization goal.

Improvement implementation :

- In this step, the planned activities are executed and it puts the improvements into practice and spreads it across the organization, what can be effective at the 2nd, 3rd and 4th step that planning and implementation could be an iterative way, for example, implementing improvement for improving requirements first, then implementing the reduction for testing process time and so forth. This iterative way of implementation will help the organization to realize the early benefits from the SPI program early or even adopt the plan if there is no real impact measured from the improvement.

Improvement evaluation :

- What is cannot be measured cannot be improved, that's why in this step, the impact measurement is applied compared with the GQM. The before improvement measures, after the improvement measures and the target improvement measure. Measurement, in general, permits an organization to compare the rate of actual change against its planned change and allocate resources based on the gaps between actual and expected progress.

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