Risk Management

Contents

What is Project Risk?

- An uncertain event or condition that, if it occurs, has a positive or negative effect on a project’s objectives
- Keys attributes of Risk
  - Uncertainty
  - Positive and Negative
  - Cause and Consequence

Categories of Risk

- Risks have been categorized in other ways.
- Kalle Lyytinen and his colleagues, have proposed a *sociotechnical model* of risk, a diagrammatic representation of which appears in Figure below.

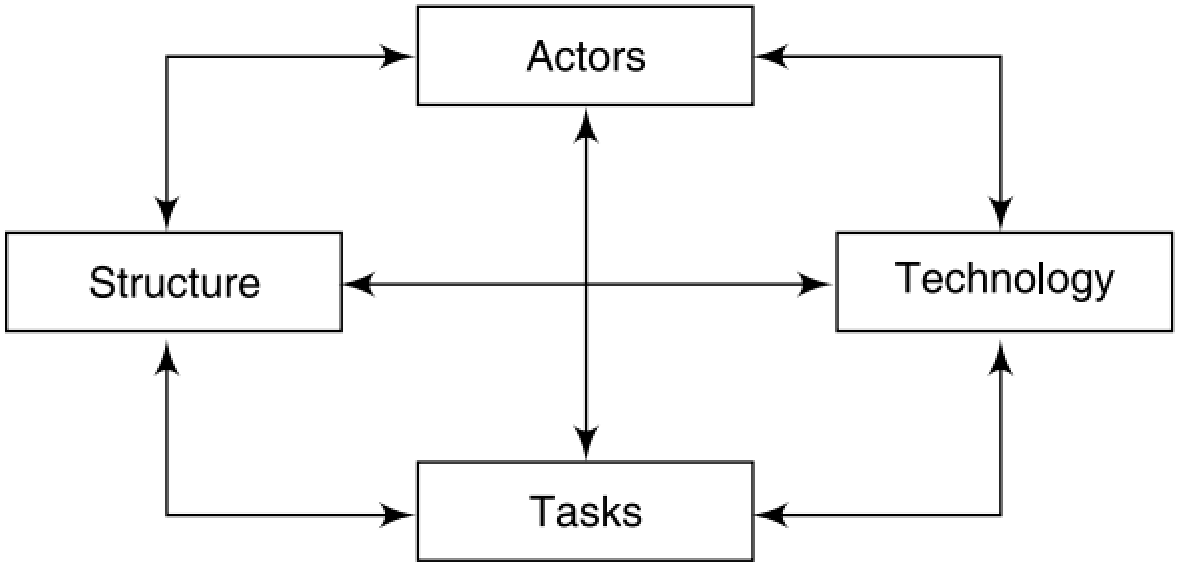


Fig: The Lyytinen–Mathiassen–Ropponen risk framework

- The box labelled **Actors** refers to all the people involved in the development of the application in question. A typical risk in this area is that high staff turnover leads to expertise of value to the project being lost.
- The box labelled **Technology** encompasses both the technology used to implement the application and that embedded in the delivered products.
- Risks here could relate to the appropriateness of the technologies and to possible faults within them, especially if they are novel (innovative).
- **Structure** describes the management structures and systems, including those affecting planning and control.
- For example, the implementation might need user participation in some tasks, but the responsibility for managing the users' contribution might not be clearly allocated.
- **Tasks** relates to the work planned. For instance, the complexity of the work might lead to delays because of the additional time required integrate the large number of components.

- In above Figure all boxes are interlinked.
- Risks often arise from the relationships between factors – for example between technology and people.
- If a development technology is novel then the developers might not be experienced in its use and delay results.
- The novelty of the new technology is really a characteristic of the developers: once they are used to the technology, it is no longer ‘novel’.

Categories of Risk:

- A broad categories of risks are described on the questionnaires developed by many organizations. Some of them are given below.
- **Market risk**: If the information technology project is to produce a new product or service will it be useful to the organization or marketable to others?. Will user accept the product or service?. Will someone else make a better product or service faster, making the project a waste of time and money.
- **Financial risk:** Can the organization afford to undertake the project?. How confident are the stakeholders in the financial projections?. Will the project meet NPV,ROI, and payback estimates?. If not van the organization afford to proceed the project?. Is this project the best way to use the organization’s financial resources?
- **Technology risk:** Is the project technically feasible?. Will it use mature, leading edge or bleeding edge technologies? When will decisions be made on which technology to use? Will H/w, S/w and network function properly?. You can also breakdown the technology risk into h/w, s/w, and network technology if required.

- **People risk:** Does the organization have or can they find people with appropriate skills to complete the project successfully?. Do they have enough experience?. Does senior management support the project?. Is the organization familiar sponsor/customer for the project?. How good is the relationship with the sponsor/customer?
- **Structure/process risk**: What is the degree of change the new project will introduce into user areas and business procedures? How many distinct user groups does the project need to satisfy? With how many other systems does the project need to interact? Does the organization have processes in place to complete the project successfully?

Risk Management

- Risk management is concerned with identifying risks and drawing up plans to minimise their effect on a project.
- A risk is a probability that some adverse (or positive) circumstance will occur
  - Project risks affect schedule or resources;
  - Product risks affect the quality or performance of the software being developed;
  - Business risks affect the organization developing or procuring the software.
- Steps
  - Risk Management Planning
  - Risk Identification
  - Qualitative/Quantitative Risk Analysis
  - Risk Response Planning
  - Risk Monitoring & Control

A Framework for Dealing with Risk / The Risk Management Process

- Planning for risk includes these steps:
  1. **Risk Identification:** Identifying the possible risks in project, product and business.
  2. **Risk analysis and prioritization:** After identifying the risks, the following consequences of the risk and what might cause the risk are then analyzed and prioritization.
  3. **Risk planning:** After identifying the risks, the following consequences of the risk and what might cause the risk are then analyzed.
  4. **Risk monitoring:** The risk has to be monitored to bring necessary changes to the plan of addressing the risk.
- Steps (i) to (iii) above will probably be repeated.
- When risks that could prevent a project success are identified, plans can be made to reduce or remove their threat.
- The plans are then reassessed to ensure that the original risks are reduced sufficiently and no new risks inadvertently introduced.

Risk Identification

- The two main approaches to the identification of risks are the use of **checklists** and **brainstorming.**
- **Checklists** are simply lists of the risks that have been found to occur regularly in software development projects.
- A specialized list of software development risks by Barry Boehm appears in Table below in a modified version.

Table. Software project risks and strategies for risk reduction

Risk	Risk reduction techniques
Personnel shortfalls	Staffing with top talent; job matching; teambuilding; training and career development; early scheduling of key personnel
Unrealistic time and cost estimates	Multiple estimation techniques; design to cost; incremental development; recording and analysis of past projects; standardization of methods
Developing the wrong software functions	Improved software evaluation; formal specification methods; user surveys; prototyping; early user manuals
Developing the wrong user interface	Prototyping; task analysis; user involvement
Gold plating	Requirements scrubbing; prototyping; cost–benefit analysis; design to cost

Late changes to requirements	Stringent change control procedures; high change threshold; incremental development (deferring changes)
Shortfalls in externally supplied components	Benchmarking; inspections; formal specifications; contractual agreements; quality assurance procedures and certification
Shortfalls in externally performed tasks	Quality assurance procedures; competitive design or prototyping; contract incentives
Real-time performance shortfalls	Simulation; benchmarking; prototyping; tuning; technical analysis
Development technically too difficult	Technical analysis; cost–benefit analysis; prototyping; staff training and development

- **Brainstorming** is done with a group of people who focus on identification of risk for the project.
- Brainstorming is a creativity method for developing ideas in a group.
- Its essential characteristic is the collection of as many spontaneous utterances in response to a particular question or problem as possible.
- The advantage of brainstorming in a group is mutual stimulation of all participants;
- Disadvantage is that the group will focus too quickly on a certain area.
- After collecting ideas through brainstorming, you have to sort the risks into further steps and roughly evaluate them.

Other approaches

Interviewing: Interviewing is a fact-finding technique for collecting information in face-to-face, phone, e-mail, or instant messaging discussions. Interviewing people with similar project experience is an important tool for identifying potential risks.

Diagramming Technique: This method include using cause and effect diagrams or fishbone diagrams ,flow charts and influence diagrams .Fishbone diagrams help you trace problems back to their root cause. Process flow charts are diagrams that show how different parts of the system interrelate.

Risk Assessment

- A common problem with risk identification is that a list of risks is potentially endless.
- A way is needed of distinguishing the damaging and likely risks. This can be done by estimating the **risk exposure** for each risk using the formula:

risk exposure = (potential damage) *(probability of occurrence)

Say a project depended on a data centre vulnerable to fire. It might be estimated that if a fire occurred a new computer configuration could be established for £500,000. It might also be estimated that where the computer is located there is a 1 in 1000 chance of a fi re actually happening, that is a probability of 0.001.

The risk exposure in this case would be: £500,000 * 0.001 = £500

- Table below provides an example, based on Amanda’s IOE group accounts project, of where this has been done(range 0 to 10).

Table. Part of Amanda's risk exposure assessment

Ref	Hazard	Likelihood	Impact	Risk
R1	Changes to requirements specification during coding	8	8	64
R2	Specification takes longer than expected	3	7	21
R3	Significant staff sickness affecting critical path activities	5	7	35
R4	Significant staff sickness affecting non-critical activities	10	3	30
R5	Module coding takes longer than expected	4	5	20
R6	Module testing demonstrates errors or deficiencies in design	4	8	32

Table. Qualitative descriptors of risk probability and associated range values

Probability level	Range
High	Greater than 50% chance of happening
Significant	30–50% chance of happening
Moderate	10–29% chance of happening
Low	Less than 10% chance of happening

Table. Qualitative descriptors of impact on cost and associated range values

Impact level	Range
High	More than 30% above budgeted expenditure
Significant	20 to 29% above budgeted expenditure
Moderate	10 to 19% above budgeted expenditure
Low	Within 10% of budgeted expenditure.

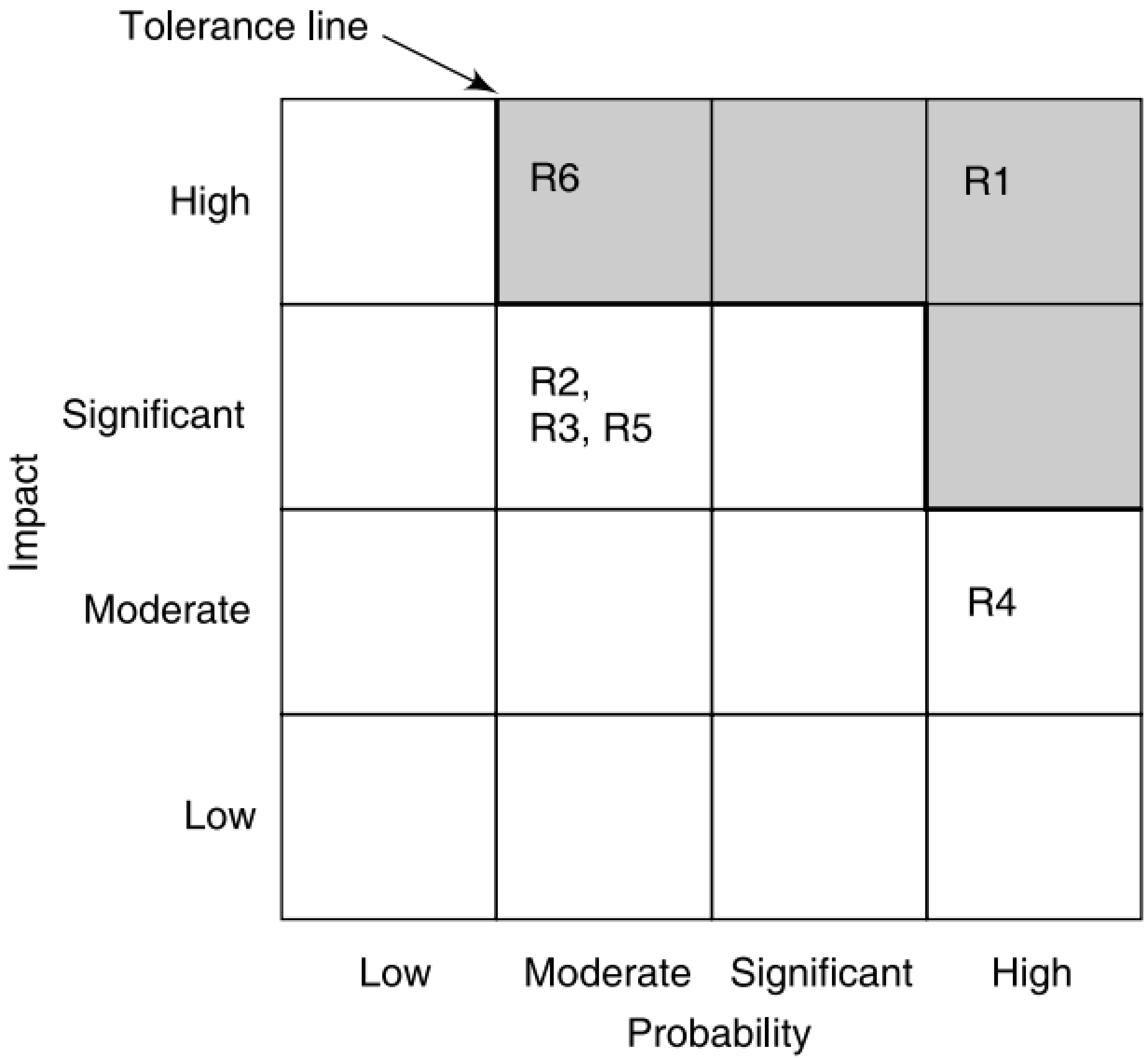


Fig: A probability impact matrix

Risk Planning

- Having identified the major risks and allocated priorities, the task is to decide how to deal with them. The choices discussed will be:
  - **Risk acceptance:** This is the do-nothing option. We could decide that the damage inflicted by some risks would be less than the costs of action that might reduce the probability of a risk happening
  - **Risk avoidance:** Some activities may be so prone to accident that it is best to avoid them altogether . For example, given all the problems with developing software solutions from scratch, managers might decide to retain existing clerical methods, or to buy an off-the-shelf solution.
  - **Risk reduction and mitigation:** Risk reduction attempts to reduce the likelihood of the risk occurring. Risk mitigation is action taken to ensure that the impact of the risk is lessened when it occurs.
  - For example, taking regular back-ups of data storage would reduce the impact of data corruption but not its likelihood. Mitigation is closely associated with contingency planning which is discussed presently.
  - **Risk transfer:** In this case the risk is transferred to another person or organization. With software projects, an example of this would be where a software development task is outsourced to an outside agency for a fixed fee.

- She might have come across Richard Fairley’s four COTS (commercial off-the-shelf) software acquisition risks – see Table below – where one risk is difficulty in integrating the data formats and communication protocols of different applications.

Table. Fairley’s four commercial off-the-shelf (COTS) so ware acquisition risks

Integration	Difficulties in integrating the data formats and communication protocols of different applications.
Upgrading	When the supplier upgrades the package, the package might no longer meet the users’ precise requirements. Sticking with the old version could mean losing the supplier’s support for the package.
No source code	If you want to enhance the system, you might not be able to do so as you do not have access to the source code.
Supplier failures or buyouts	The supplier of the application might go out of business or be bought out by a rival supplier.

Risk Management

Contingency (emergency plan):

- Risk reduction activities would appear to have only a small impact on reducing the probability of some risks, for example staff absence through illness.
- While some employers encourage their employees to adopt a healthy lifestyle, it remains likely that some project team members will at some point be brought down by minor illnesses such as flu. These kinds of risk need a **contingency plan.**
- This is a planned action to be carried out if the particular risk materializes. If a team member involved in urgent work were ill then the project manager might draft in another member of staff to cover that work.

Deciding on the risk actions:

- In many cases experts have produced lists recommending practical steps to cope with the likelihood of particular risks.
- Whatever the countermeasures that are considered, they must be cost-effective. On those occasions where a risk exposure value can be calculated as a financial value using the (*value of damage*)* (*probability of occurrence*) formula.

- The cost-effectiveness of a risk reduction action can be assessed by calculating the *risk reduction leverage* (*RRL*).

risk reduction leverage(RRL)= (RE_{before} – RE_{after})/(cost of risk reduction)

- RE_{before} is the risk exposure, before risk reduction actions have been taken. RE_{after} is the risk exposure after taking the risk reduction action.
- An RRL above 1.00 indicates that the reduction in risk exposure achieved by a measure is greater than its cost.

Creating and maintaining the risk register:

- When the project planners have picked out and examined what appear to be the most threatening risks to the project, they need to record their findings in a *risk register*.
- After work starts on the project more risks will emerge and be added to the register. At regular intervals, probably as part of the project control life cycle, the risk register should be reviewed and amended.

Evaluating Risks to the Schedule

- This shows the probability of a task being completed in four days (5%), then five days (10%), and so on.
- The accumulated probability for the seventh day (65%) means that there is a 65% chance that the task will be finished on or before the seventh day.
- We can show that a job might take five days but that there is small chance it might need four or six days, and a smaller chance of three or seven days, and so on.
- If a task in a project takes longer than planned ,we might hope that some other task might take less and thus compensate for this delay.

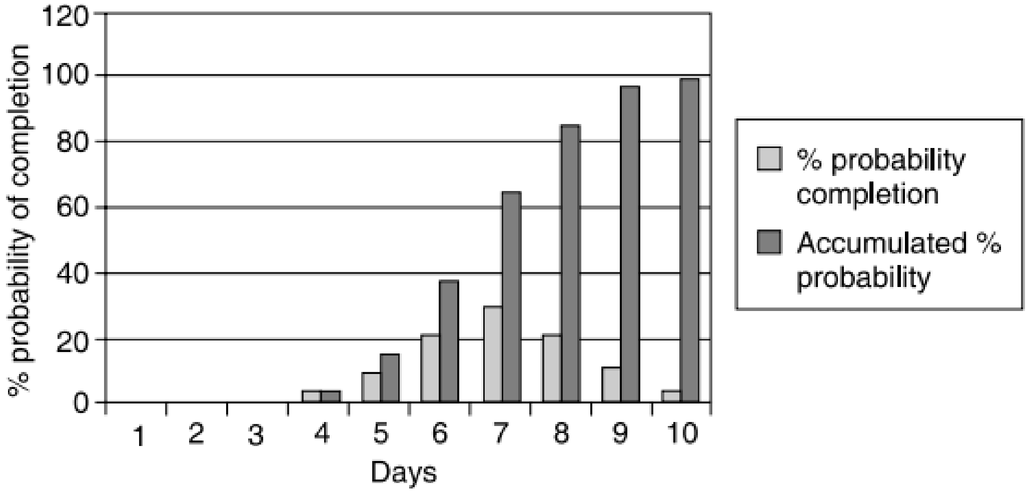


Fig: Probability chart

- **PERT,** a technique which takes account of the uncertainties in the durations of activities within a project.
- **Monte Carlo simulation**, which is a more powerful and flexible tool that tackles the same problem.
- A drawback to the application of methods like PERT is that in practice there is a tendency for developers to work to the schedule even if a task could be completed more quickly.
- Even if tasks are completed earlier than planned, project managers are not always quick to exploit the opportunities to start subsequent activities earlier than scheduled. Critical chain management will be explored as a way of tackling this problem.

Using PERT to evaluate the effects of uncertainty

- PERT was developed to take account of the uncertainty surrounding estimates of task durations.
- It was developed in an environment of expensive, high-risk and state-of-the-art projects – not that dissimilar to many of today’s large software projects.

PERT requires three estimates.

- **Most likely time**: the time we would expect the task to take under normal circumstances. We shall identify this by the letter *m*.
- **Optimistic time:** the shortest time in which we could expect to complete the activity, barring outright miracles. We shall use the letter *a* for this.
- **Pessimistic time:** the worst possible time, allowing for all reasonable eventualities but excluding 'acts of God and warfare' (as they say in most insurance exclusion clauses). We shall call this *b*.
- PERT then combines these three estimates to form a single expected duration, t_e, using the formula

$$t_e=(a+4m+b)/6$$

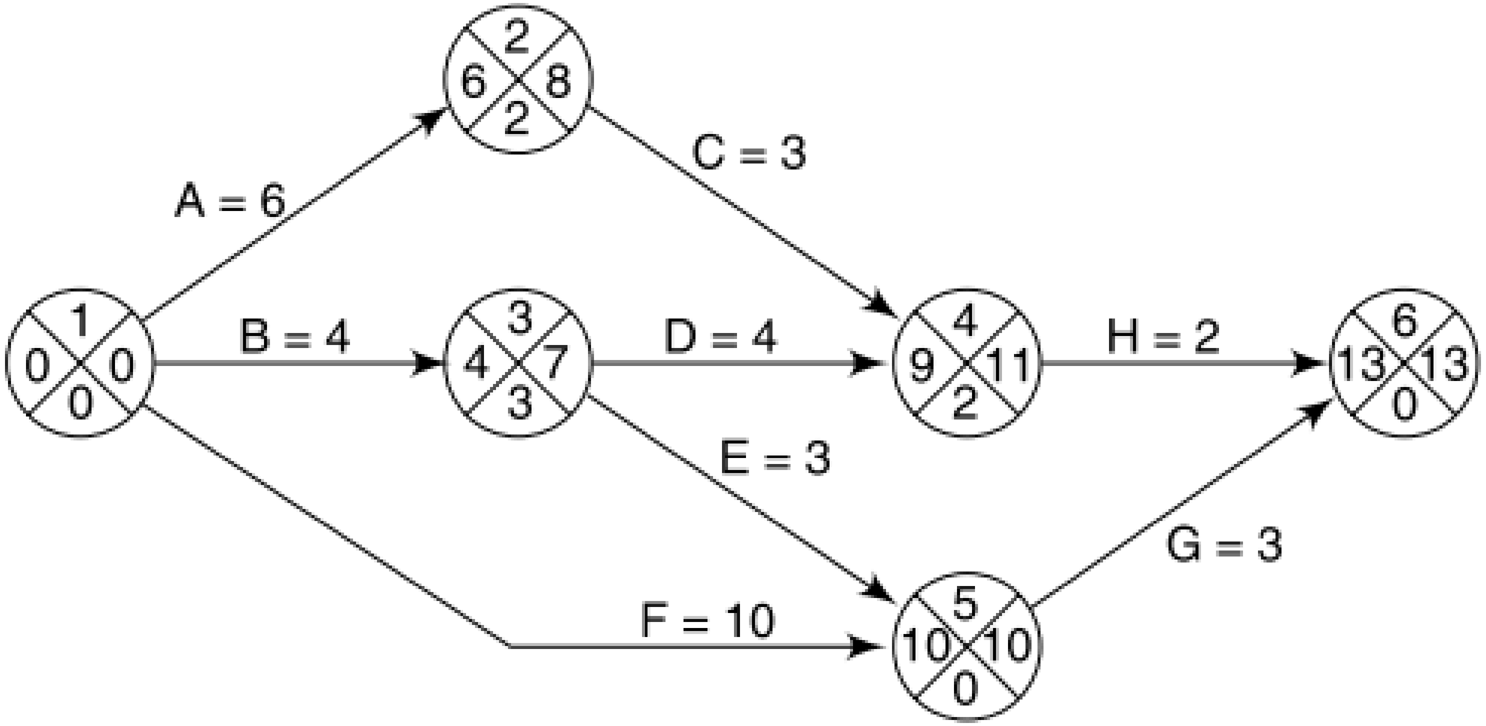


Fig: The critical path

- There are new estimates for *a* and *b* and the original activity duration estimates have been used as the most likely times, *m*. Calculate the expected duration, t_e,

Table. PERT activity time estimates

Activity	Optimistic (*a*)	Activity durations (weeks). Most likely (*m*)	Pessimistic (*b*)
A	5	6	8
B	3	4	5
C	2	3	3
D	3.5	4	5
E	1	3	4
F	8	10	15
G	2	3	4
H	2	2	2.5

- The PERT network illustrated in Figure below indicates that we expect the project to take 13.5 weeks.
- In Figure we have used an activity-on-arrow network as this form of presentation makes it easier to separate visually the estimated activity data (expected durations and, later, their standard deviations) from the calculated data (expected completion dates and target completion dates).

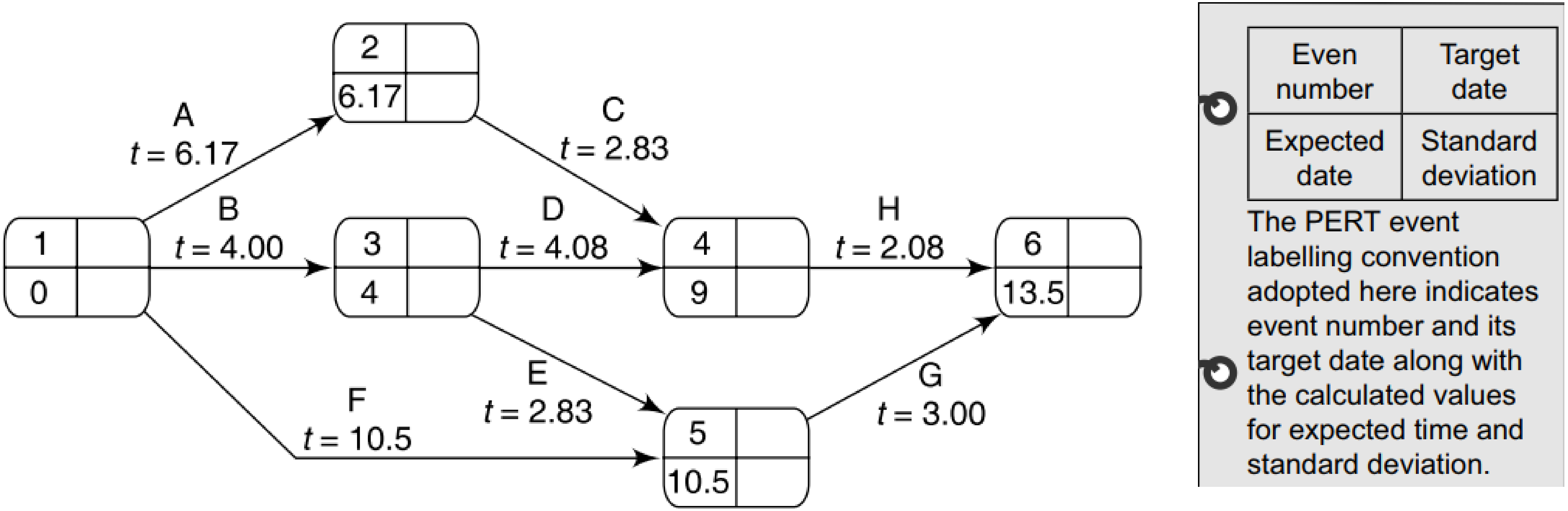


Figure: The PERT network a er the forward pass

Activity standard deviations

- A quantitative measure of the degree of uncertainty of an activity duration estimate may be obtained by calculating the standard deviation *s* of an activity time, using the formula

$$s=(b-a)/6$$

- The activity standard deviation is proportional to the difference between the optimistic and pessimistic estimates, and can be used as a ranking measure of the degree of uncertainty or risk for each activity.

Table. Expected times and standard deviations

Activity	Activity durations (weeks)				
	Optimistic (a)	Most likely (m)	Pessimistic (b)	Expected (t_e)	Standard deviation (s)
A	5	6	8	6.17	0.50
B	3	4	5	4.00	0.33
C	2	3	3	2.83	0.17
D	3.5	4	5	4.08	0.25
E	1	3	4	2.83	0.50
F	8	10	15	10.50	1.17
G	2	3	4	3.00	0.33
H	2	2	2.5	2.08	0.08

- Suppose that we must complete the project within 15 weeks at the outside. We expect it will take 13.5 weeks but it could take more or, perhaps, less.
- In addition, suppose that activity C must be completed by week 10, as it is to be carried out by a member of staff who is scheduled to be working on another project, and that event 5 represents the delivery of intermediate products to the customer, which must take place by week 10.
- These three target dates are shown on the PERT network in Figure .

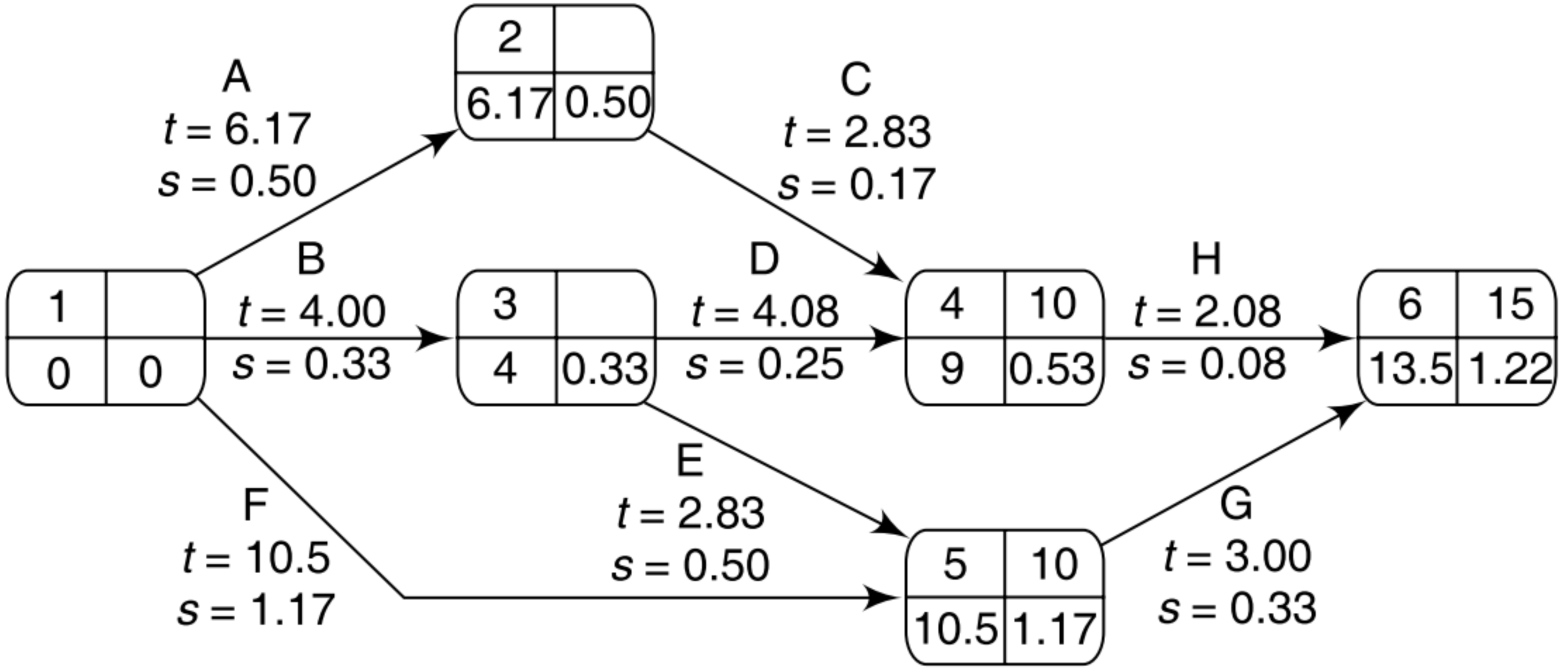


Figure. The PERT network with three target dates and calculated event standard deviations

- The PERT technique uses the following three-step method for calculating the probability of meeting or missing a target date:
  - Calculate the standard deviation of each project event;
  - Calculate the *z* value for each event that has a target date;
  - Convert *z* values to a probabilities.

Calculating the *z* values

- The *z* value is calculated for each node that has a target date. It is equivalent to the number of standard deviations between the node's expected and target dates. It is calculated using the formula

$$z=(T-t_e)\ /s$$

- Where t_e is the expected date and T the target date.

Converting *z* values to probabilities

- A *z* value may be converted to the probability of not meeting the target date by using the graph in Figure below.

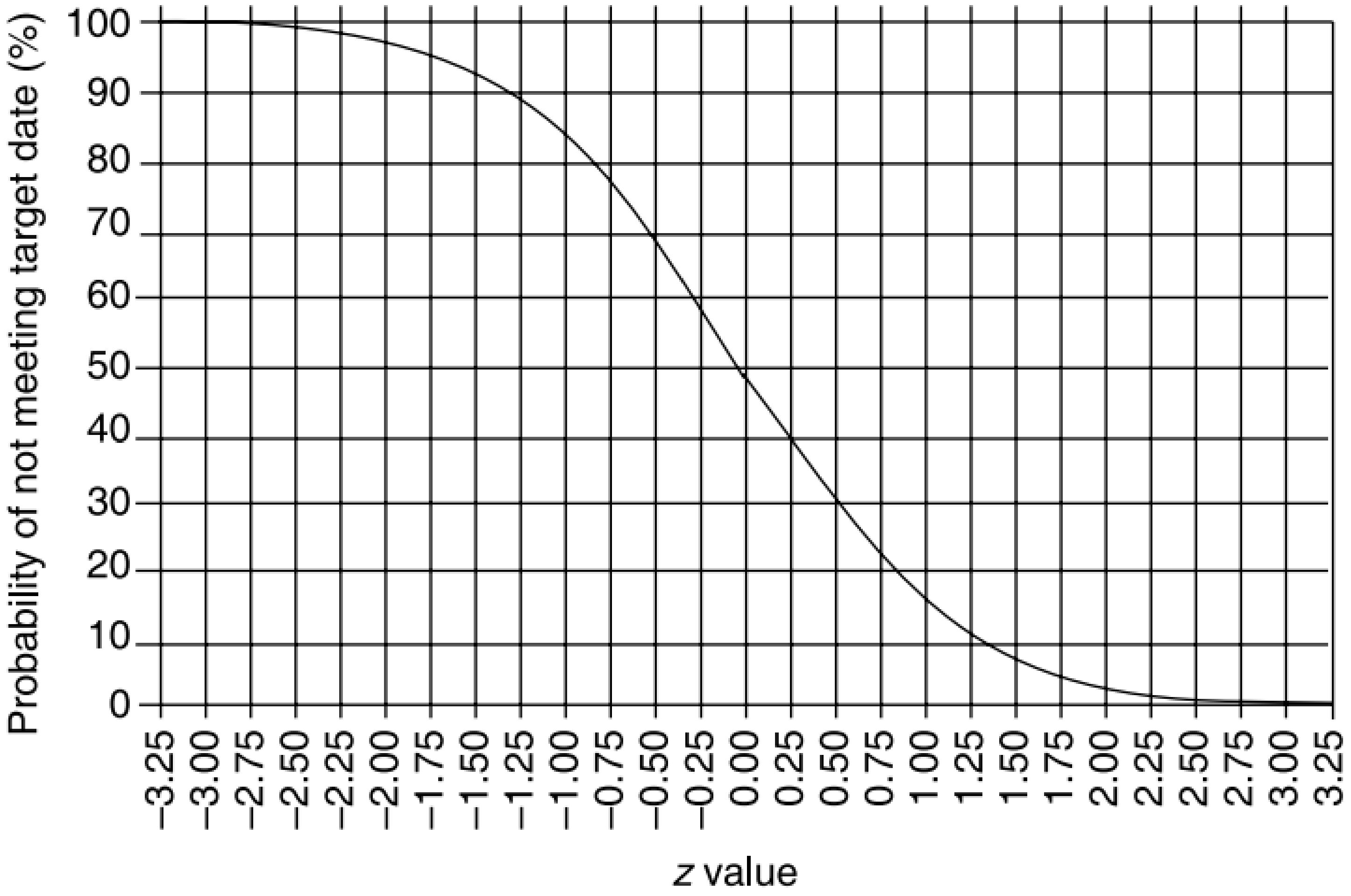


Figure: The probability of obtaining a value within *z* standard deviations of the mean for a normal distribution

- The *z* value for the project completion of any event for example is 1.23. Using Figure above we can see that this equates to a probability of approximately 11%, that is, there is an 11% risk of not meeting the target date of the end of week 15.

Q: In the PERT network illustrated in the figure below, the targeted date for the completion of the project is nine (9) weeks.

Tasks	Optimistic (a)	Most likely (m)	Pessimistic (b)
A	1	2	3
B	3	4	5
C	2	3	4
D	1	2	3
E	3	4	5

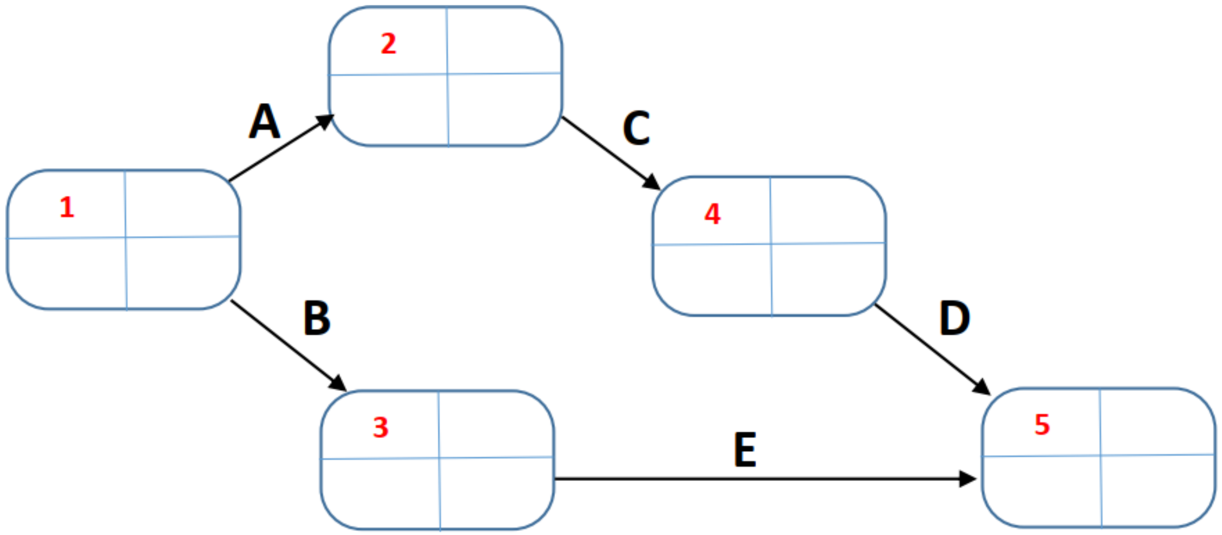


Figure: PERT network

Use the table above to calculate the following:

1. Calculate the **expected (t_e)** values and **standard deviation (s).**
2. Indicate the $\mathbf{t_e}$ and **s** values on the diagram.
3. Calculate the Z value on the last event.
4. According to figure 7.5 in your textbook, what is the probability of not meeting the target date?

Solution:

Use the following formula for t_e values: t_e=(a+4m+b)/6

t_e value for activity A=(1+4(2)+3)/6=12/6=2

t_e value for activity B=(3+4(4)+5)/6=24/6=4

t_e value for activity C=(2+4(3)+4)/6=18/6=3

t_e value for activity D=(1+4(2)+3)/6=12/6=2

t_e value for activity E=(3+4(4)+5)/6=24/6=4

Use the following formula for s values: S = $(\boldsymbol{b}\text{-}\boldsymbol{a})/\mathbf{6}$

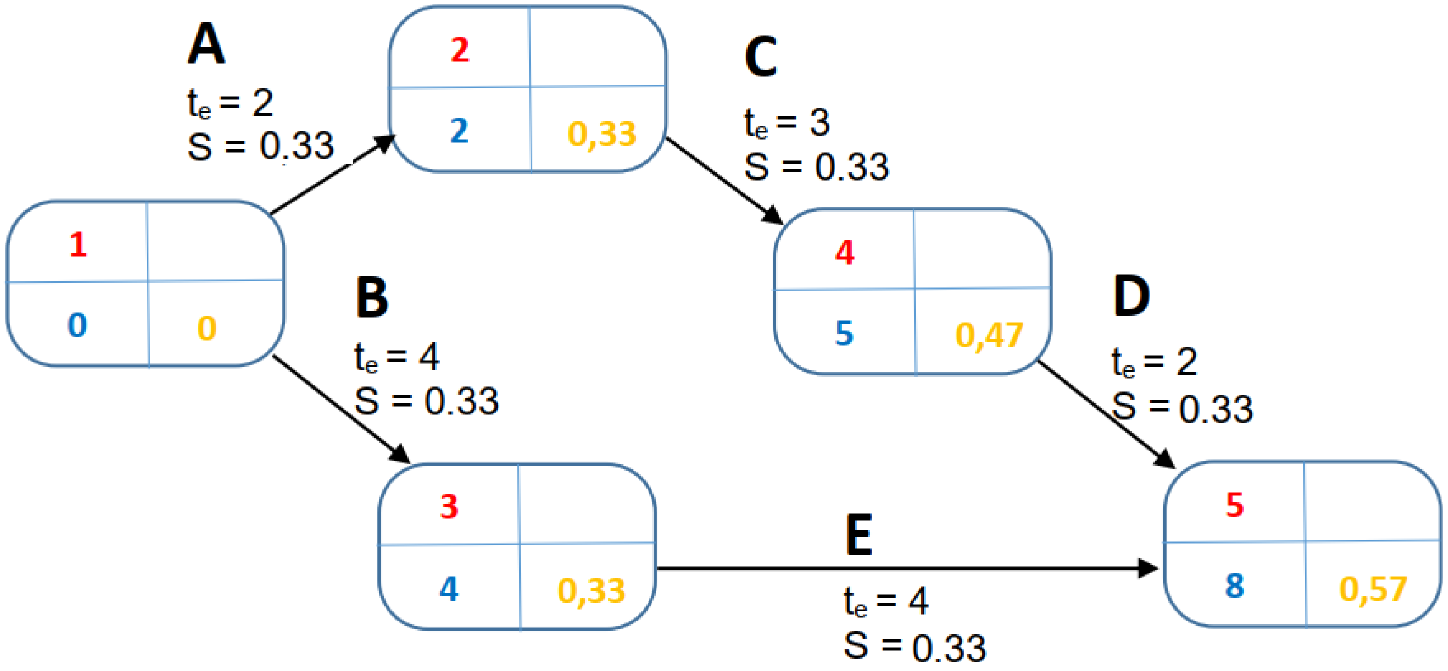
s value for activity A= (3-1)/6=2/6=1/3= 0.33

s value for activity B= (5-3)/6=2/6=1/3= 0.33

s value for activity C= (4-2)/6=2/6=1/3= 0.33

s value for activity D= (3-1)/6=2/6=1/3= 0.33

s value for activity E= (5-3)/6=2/6=1/3= 0.33



Standard deviation of event 5 is calculated as follows:

Two paths are possible i.e. **A-C-D-E or A-B-E**

The standard deviation selected will be the greater of the standard deviations of activities

- Standard deviation of A-C-D-E:

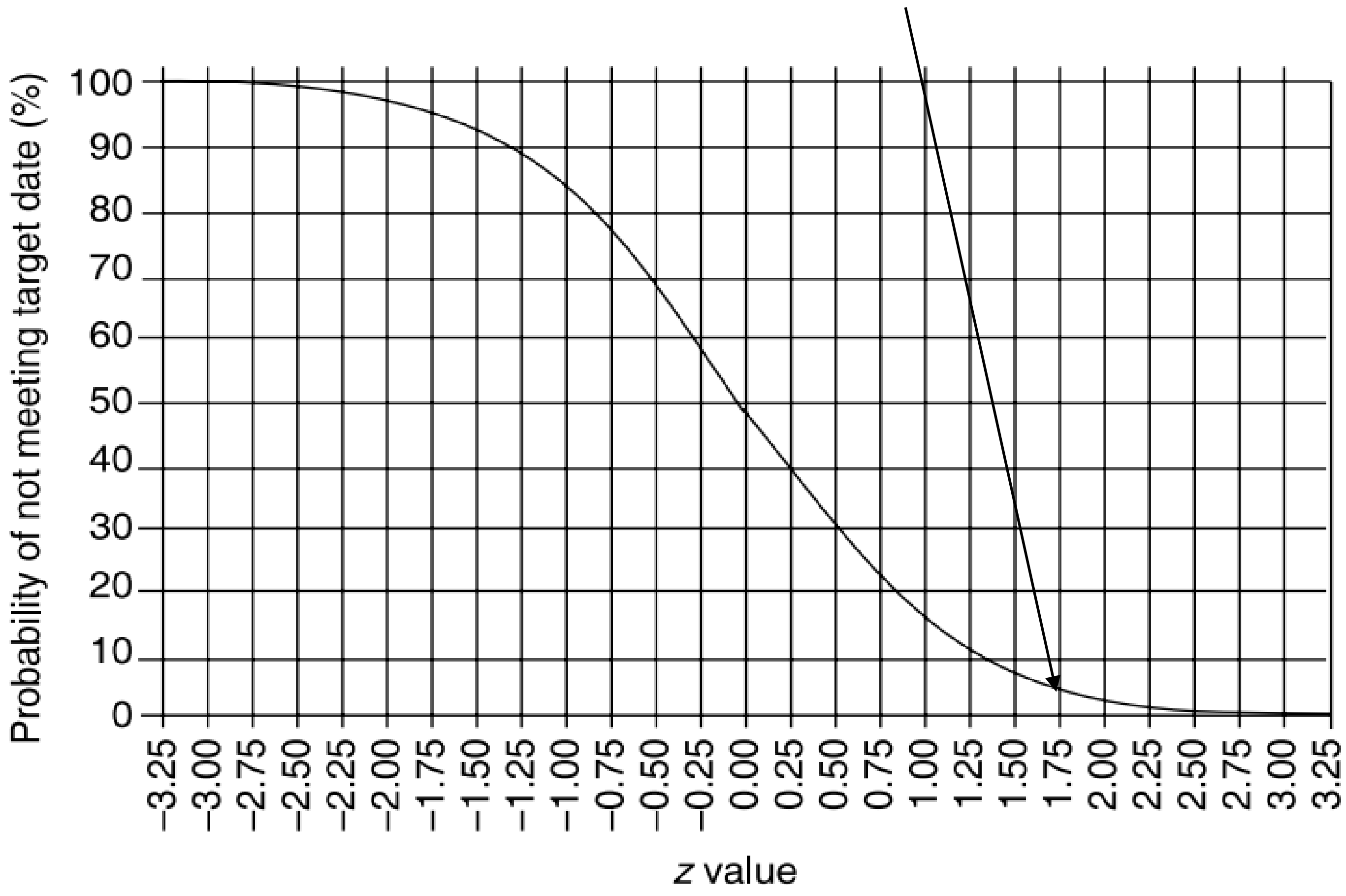
S = $\sqrt{A^2} + \sqrt{C^2} + \sqrt{D^2} = \sqrt{(0.33)^2} + \sqrt{(0.33)^2} + \sqrt{(0.33)^2} = 0.57$

or the standard deviation of activity E = 0.57

Therefore, the standard deviation for event 5 is 0.57.

Calculate the Z value on the last event Z =(**T** – **t**$_e$)/**S** =(9 – 8)/0.57=1/0.57 = 1.75

The probability of not meeting the target date is approximately 5%. Any value from 4% to 6% is acceptable because it is not easy to pinpoint the precise value from the graph.



Monte Carlo simulation

- As an alternative to the PERT technique, we can use Monte Carlo simulation approach.
- Monte Carlo simulation are a class of general analysis techniques that are valuable to solve any problem that is complex, nonlinear, or involves more than just a couple of uncertain parameters.
- When Monte Carlo simulation is used to analyse the risk of not meeting the project deadline, the project completion time is first modelled as a mathematical expression involving the probability distributions of the completion times of various project activities and their precedence relationships.
- Monte Carlo simulation essentially evaluates a range of input values generated from the specified probability distributions of the activity durations. It then calculates the results repeatedly; each time using a different set of random values generated from the given probability functions.

- The main steps involved in carrying out Monte Carlo simulation for a project consisting of n activities are as follows:

Step 1: Express the project completion time in terms of the duration of the n activities (x_i, $i=1, n$ and their dependences as a precedence graph, $d = f(x1, x2, \ldots, x_n)$.

Step 2: Generate a set of random inputs, $x_{i1}, x_{i2}, \ldots, x_{in}$ using specified probability distributions.

Step 3: Evaluate the project completion time expression and store the result in *di*.

Step 4: Repeat Steps 2 and 3 for the specified number of times.

Step 5: Analyze the results d_i, $i=1,n$; summarize and display using a histogram as the one shown in figure below

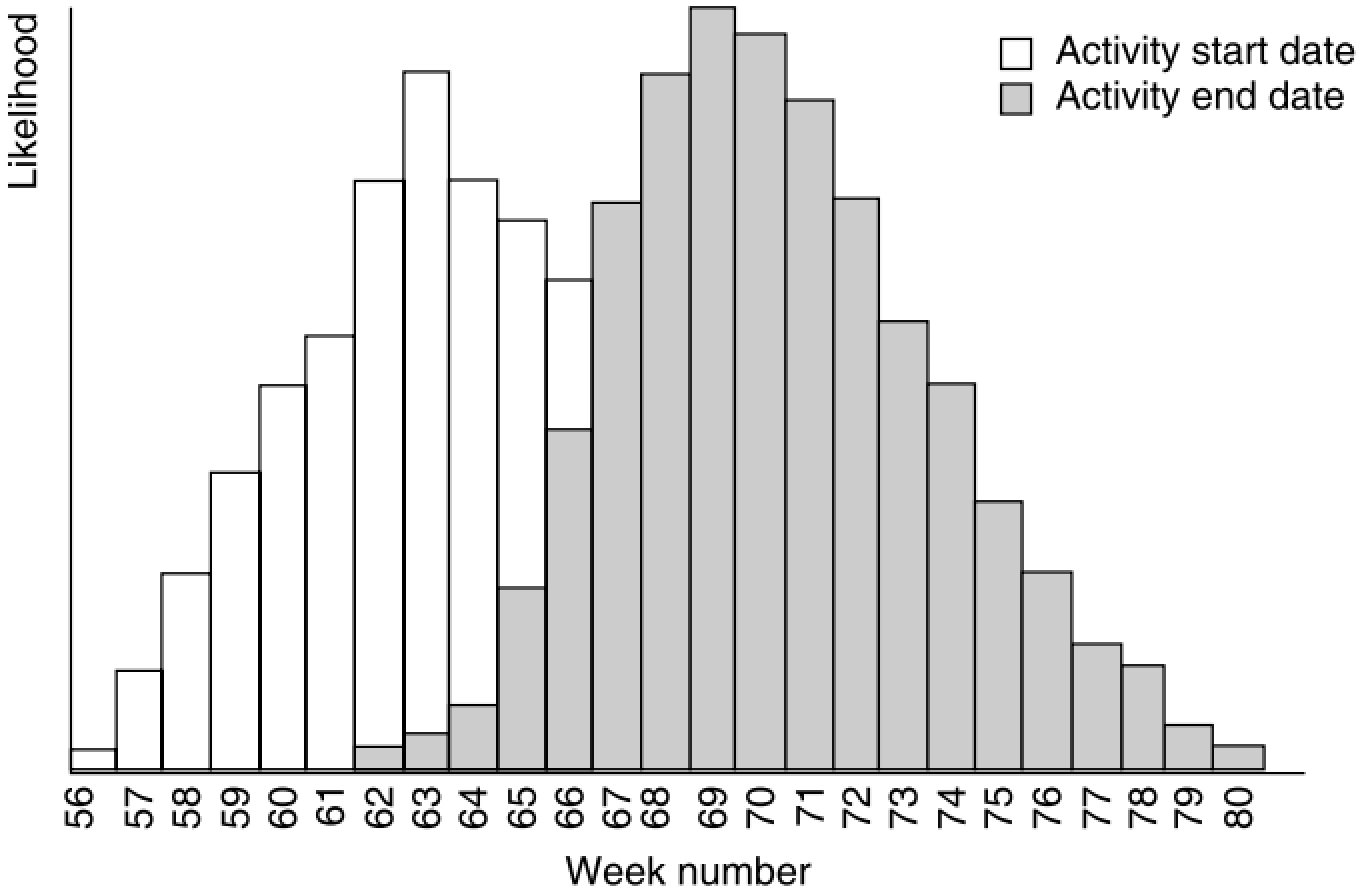


Figure: Risk profile for an activity generated using Monte Carlo simulation