SOFTWARE PROJECT MANAGEMENT

Module-3: RISK MANAGEMENT
Part-3

CSE4016

PRIYANKA SINGH

Estimation errors-

- Some tasks are harder to estimate than others because of the lack of experience of similar tasks or because of the nature of a task.
- Producing a set of user manuals is reasonably straightforward and, given that we have carried out similar tasks previously, we should be able to estimate with some degree of accuracy how long it will take and how much it will cost.
- On the other hand, the time required for program testing and debugging, might be difficult to predict with a similar degree of accuracy - even if we have written similar programs in the past.
- Estimation can be improved by analysing historic data for similar activities and for similar systems.
- Keeping records comparing our original estimates with the final methods of estimation, outcome will reveal the type of tasks that are difficult to estimate correctly.

Planning assumptions

- At every stage during planning, assumptions are made which, if not valid, may put the plan at risk.
- Our activity network, for example, is likely to be built on the assumption of using a particular design methodology - which may be subsequently changed.
- We generally assume that, following coding, a module will be tested and then integrated with others - we might not plan for module testing showing up the need for changes in the original design but, in the event, it might happen.
- At each stage in the planning process, it is important to list explicitly all of the assumptions that have been made and identify what effects they might have on the plan if they are inappropriate.

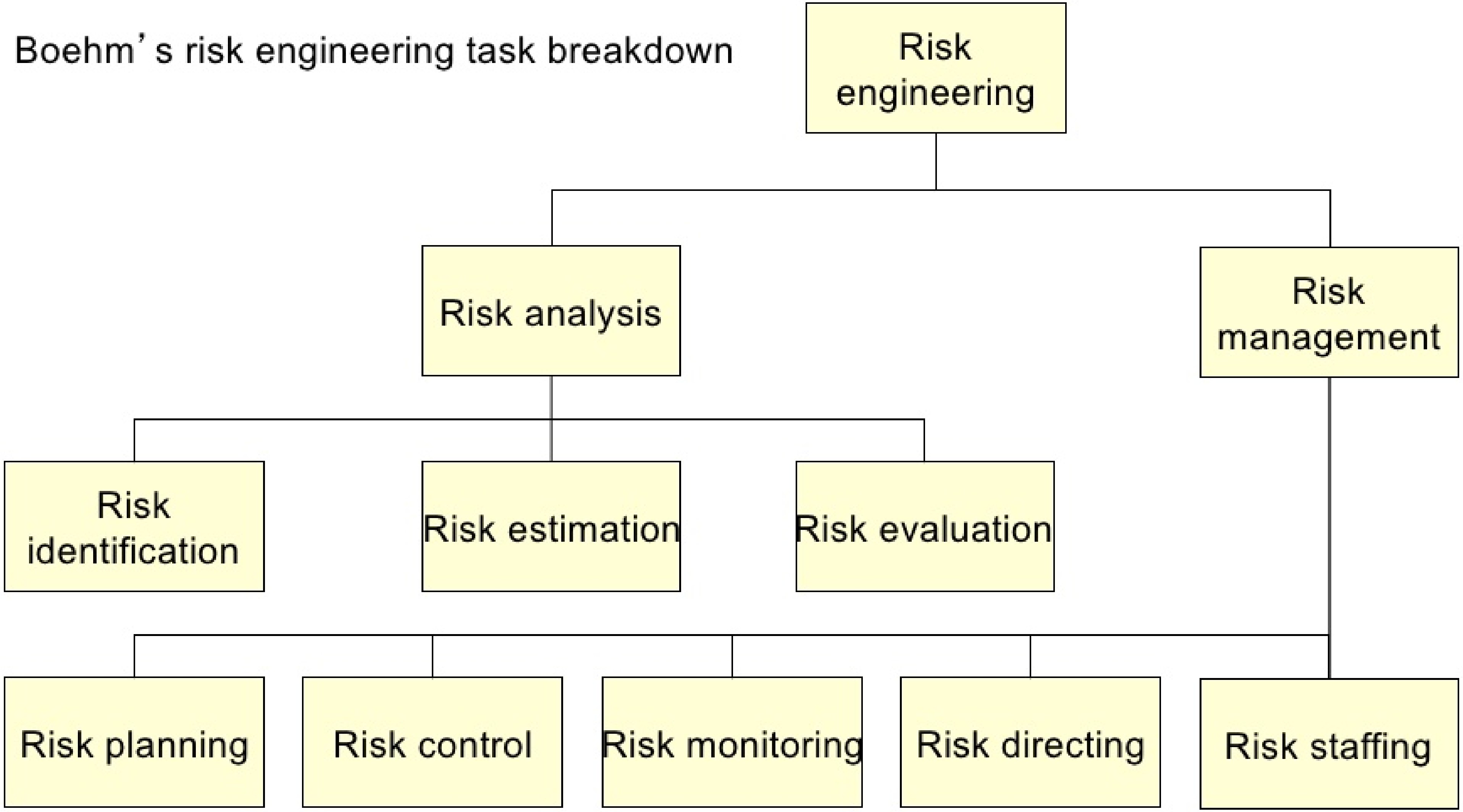
Eventualities

- Some eventualities might never be foreseen and we can only resign ourselves to the fact that unimaginable things do, sometimes, happen.
- They are, however, very rare. The majority of unexpected events can, in fact, be identified - the requirements specification might be altered after some of the modules have been coded, the senior programmer might take maternity leave, the required hardware might not be delivered on time.
- Such events do happen from time to time and, although the likelihood of any one of them happening during a particular project may be relatively low, they must be considered and planned for.

Managing risk

- The objective of risk management is to avoid or minimize the adverse effects of unforeseen events by avoiding the risks or drawing up contingency plans for dealing with them.
- There are a number of models for risk management, but most are similar, in that they identify two main components - risk identification and risk management.
- **Risk identification** consists of listing all of the risks that can adversely affect the successful execution of the project.
- **Risk estimation** consists of assessing the likelihood and impact of each hazard.
- **Risk evaluation** consists of ranking the risks and determining risk aversion strategies.
- **Risk planning** consists of drawing up contingency plans and, where appropriate, adding these to the project's task structure.

Boehm's risk engineering task breakdown



- **Risk control** concerns the main functions of the risk manager in minimising and reacting to problems throughout the project. This function will include aspects of quality control in addition to dealing with problems as they occur.
- **Risk monitoring** must be an ongoing activity, as the importance and likelihood of particular risks can change as the project proceeds.
- **Risk directing and risk staffing** are concerned with the day-to-day management of risk. Risk aversion and problem solving strategies frequently involve the use of additional staff and this must be planned for and directed.
- Whatever task model or whichever techniques are used, risk management will not be effective unless all project staff are risk-oriented and are provided with an environment where they can freely discuss the risks that might affect a project.

Risk Identification

- The first stage in any risk assessment exercise is to **identify the hazards** that might affect the duration or resource costs of the project.
- A hazard is an event that might occur and will, if it does occur, create a problem for the successful completion of the project.
- In identifying and analyzing risks, we can usefully distinguish between the cause (or hazard), its immediate effect (the problem that it creates) and the risk that it will pose to the project.
- For example, the illness of a team member is a hazard that might result in the problem of late delivery of a component. The late delivery of that component is likely have an effect on other activities and might, particularly if it is on the critical path, put the project completion date at risk.

- A common way of identifying hazards is to use a ***checklist listing all the possible hazards and factors that influence them***. Typical checklists list many, even hundreds, of factors and there are, today, a number of knowledge-based software products available to assist in this analysis.

- Some hazards are **generic risks** - that is, they are relevant to all software projects and standard checklists can be used and augmented from an analysis of past projects to identify them. These will i***nclude risks such as misunderstanding the requirements or key personnel being ill***.

The categories of factors that will need to be considered while identifying the risk-

- ***Application factors-*** The nature of the application of project - whether data used is simple while processing application-critical system or a large distributed system - is likely to be a critical factor. The expected size of the application is also important - the larger the system, the greater is the likelihood of errors and communication and management problems.
- ***Staff factors*** The experience and skills of the staff involved are clearly major. An experienced programmer is, one would hope, less likely to make errors experience was than one with little experience. We must, however, also consider appropriateness of the experience.

Such factors as the level of staff satisfaction and the staff turn-over rates are also important to the success of any project - demotivated staff or key personnel leaving unexpectedly have caused many a project to fail.

- ***Project factors-*** It is important that the project and its objectives are well defined and that they are absolutely clear to all members of the project team and all key stakeholders. Any possibility that this is not the case will pose a risk to the success of the project.
- ***Hardware/software factors -***A project that requires new hardware for development is likely to pose a higher risk than one where the software can be developed on existing (and familiar) hardware. Where a system is developed on one type of hardware or software platform to be used on another there might be additional (and high) risks at installation.
- **Changeover factors-** The need for an 'all-in-one' changeover to the new system poses particular risks. Incremental or gradual changeover minimizes the risks involved but is not always practical. Parallel running can provide a safety net but might be impossible or too costly.

- ***Supplier factors-*** The extent to which a project relies on external organizations that cannot be directly controlled often influences the project's success.
- ***Environment factors-*** Changes in the environment can affect a project's success. A significant change in the taxation regulations could, for example, have serious consequences for the development of a payroll application.
- ***Health and safety factors-*** While not generally a major issue for software projects (compared, say, to civil engineering projects), the possible effects of project activities on the health and safety of the participants and the environment should be considered.
- ***BS 6079 states that 'every project should include an audit of these specific risks before work starts' and that 'audit updates should be scheduled as part of the overall project plan'.***

Risk analysis

- Having identified the risks that might affect our project we need some way of assessing their importance.
- ***Some risks will be relatively unimportant*** (for example, the risk that some of the documentation is delivered a day late), ***whereas some will be of major significance*** (such as the risk that the software is delivered late).
- ***Some are quite likely to occur*** (it is quite likely, for example, that one of the software developers in a team will take a few days sick leave during a lengthy project), ***whereas others are relatively unlikely*** (hardware failure causing loss of completed code, perhaps).
- The ***probability of a hazard's occurring is known as the risk likelihood;*** the effect that the resulting problem will have on the project, if it occurs, is ***known as the risk impact*** and t***he importance of the risk is known as the risk value or risk exposure***.

- The risk value is calculated as:

risk exposure = risk likelihood x risk impact

- The risk exposures for various risks can then be compared with each other to assess the relative importance of each risk and they can be directly compared with the costs and likelihoods of success of various contingency plans.
- However, estimation of these costs and probabilities is likely to be d**ifficult, subjective, time-consuming and costly.** In spite of this, it is valuable to obtain some quantitative measure of risk likelihood and impact because, without these, it is difficult to compare or rank risks in a meaningful way.

- Popular approach is to score the likelihood and impact on a scale of, say, 1 to 10 where the hazard that is most likely to occur receives a score of 10 and the least likely a score of 1.

	Hazard	**Likelihood**	**Impact**	**Risk exposure**
R1	Changes to requirements specification during coding	1	8	8
R2	Specification takes longer than expected	3	7	21
R3	Staff sickness affecting critical path activities	5	7	35
R4	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	1	10	10

- Managing risk involves the use of two strategies:
  - reducing the risk exposure by reducing the likelihood or impact;
  - drawing up contingency plans to deal with the risk should it occur.

In practice, there are generally other factors, when prioritizing risks.

- **Confidence of the risk assessment** - Some of our risk exposure (RE) assessments will be relatively poor. Where this is the case, there is a need for further investigation before action can be planned.
- **Compound risks-** Some risks will be dependant on others. Where this is the case, they should be treated together as a single risk.
- **The number of risks-** There is a limit to the number of risks that can be effectively considered and acted on by a project manager. We might therefore wish to limit the size of the prioritized list.
- **Cost of action-** Some risks, once recognized, can be reduced or avoided immediately with very little cost or effort and it is sensible to take action on these regardless of their risk value. For other risks we need to compare the costs of taking action with the benefits of reducing the risk.

$$\textbf{\textit{Risk reduction leverage (RRL)}} = (RE_{after} - RE_{before}) \, / \, \textbf{\textit{risk reduction cost}}$$

Reducing the risks

Broadly, there are five strategies for risk reduction.

- ***Hazard prevention-*** Some hazards can be prevented from occurring or their likelihood reduced to insignificant levels. The risk of key staff being unavailable for meetings can be minimized by early scheduling.
- **Likelihood reduction-** Some risks, while they cannot be prevented, can have their likelihoods reduced by prior planning. The risk of late changes to a requirements specification can, be reduced by prototyping. Prototyping will not eliminate the risk of late changes and will need to be supplemented by contingency planning.
- **Risk avoidance-** A project can, for example, be protected from the risk of overrunning the schedule by increasing duration estimates or reducing functionality.

- **Risk transfer-** The impact of some risks can be transferred away from the project by, for example, contracting out or taking out insurance.

- **Contingency planning-** Some risks are not preventable and contingency plans will need to be drawn up to reduce the impact of the hazard occur. A project manager should draw up contingency plans for using agency programmers to minimize the impact of any unplanned absence of programming staff.

Evaluating risks to the schedule

- We have seen that not all risks can be eliminated - even those that are classified as avoidable or manageable can, in the event, still cause problems affecting activity durations.
- By identifying and categorizing those risks, and in particular, their likely effects on the duration of planned activities, we can assess what impact they are likely to have on our activity plan.

Using PERT to evaluate the effects of uncertainty

PERT (program evaluation and review technique) was published in the same year as CPM. Developed for the Fleet Ballistic Missiles Program it is said to have saved considerable time in development of the Polaris missile.

The method is very similar to the CPM technique but, instead of using a single estimate for the duration of each task, PERT requires three estimates.

- ***Most likely time(m)*** - the time we would expect the task to take under normal circumstances.
- ***Optimistic time (a)*** - the shortest time in which we could expect to complete the activity, barring outright miracles.
- ***Pessimistic time (b)*** - the worst possible time allowing for all reasonable eventualities but excluding 'acts of God and warfare'.

PERT then combines these three estimates to form a single expected duration, I_e, using the formula

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

Using expected durations

- The expected durations are used to carry out a forward pass through a network; using the same method as the CPM technique.
- In this case, however, the calculated event dates are not the earliest possible dates but are the dates by which we expect to achieve those events.

Activity		Duration (weeks)	Precedents
A	Hardware selection	6	
B	System configuration	4	
C	Install hardware	3	A
D	Data migration	4	B
E	Draft office procedures	3	B
F	Recruit staff	10	
G	User training	3	E, F
H	Install and test system	2	C, D

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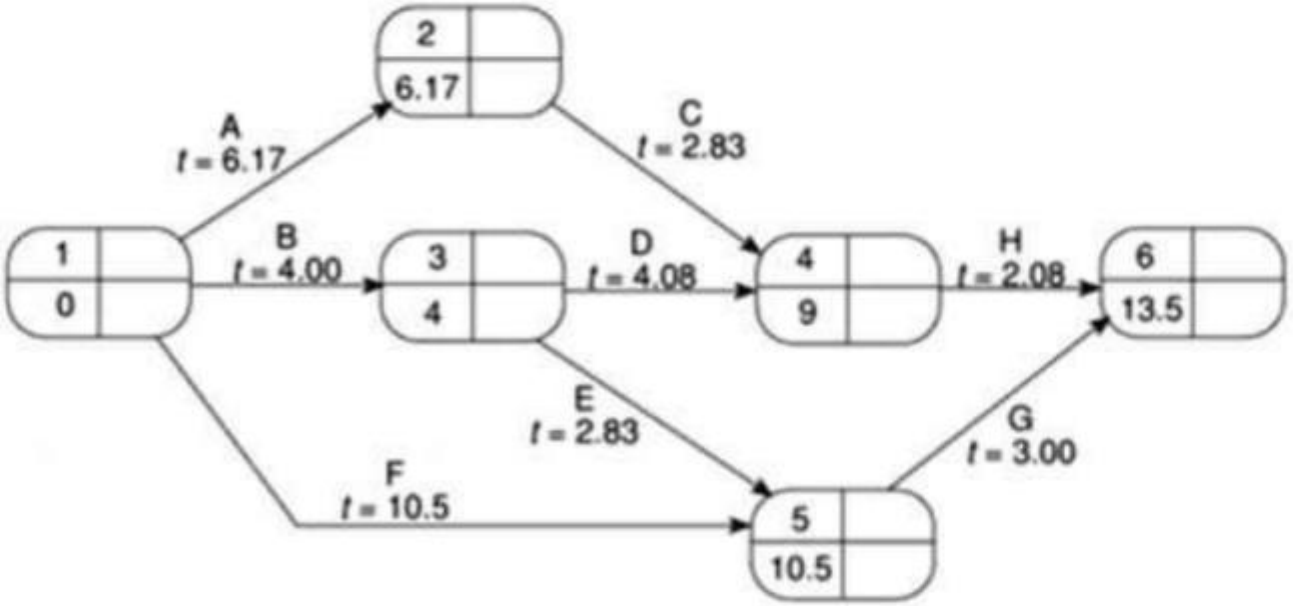
	Activity durations (weeks)		
Activity	Optimistic (a)	Most likely (m)	Pessimistic (b)
A	5	6	8
B	3	4	5
C	2	3	3
D	3.5	4	5
E	1	3	4
F	8	10	15
G	2	3	4
H	2	2	2.5

Pert labeling convention

The PERT network illustrated in Figure indicates that we expect the project to take13.5 weeks. An advantage of this approach is that it places an emphasis on the uncertainty of the real world.

Event Number	Target Date
Expected Date	Standard deviation



Activity standard deviations

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

$$\mathbf{s=(b-a)/6}$$

- 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.

Expected durations and standard deviations

Table Expected times and standard deviations

Activity duration (weeks)					
Activity	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

The likelihood of meeting targets

- The main advantage of the PERT technique is that it provides a method for estimating the probability of meeting or missing target dates. There might be only a single target date - the project completion - but we might wish to set additional intermediate targets.
- 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. These three target dates are shown on the PERT network in Figure 7.4.
- 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 standard deviation of each project event

- Standard deviations for the project events can be calculated by carrying out a forward pass using the activity standard deviations in a manner similar to that used with expected durations. There is, however, one small difference - to add two standard deviations we must add their squares and then find the square root of the sum.
- The square of the standard deviation is known as the variance. Standard deviations may not be added together but variances may.
- The standard deviation for event 3 depends solely on that of activity B. For event 5 there are two possible paths, B + E or F. The total standard deviation for path B + E is $\sqrt{(0.33^2 + 0.50^2)} = 0.6$ and that for path F is 1.17; the standard deviation for event 5 is therefore the greater of the two, 1.17.

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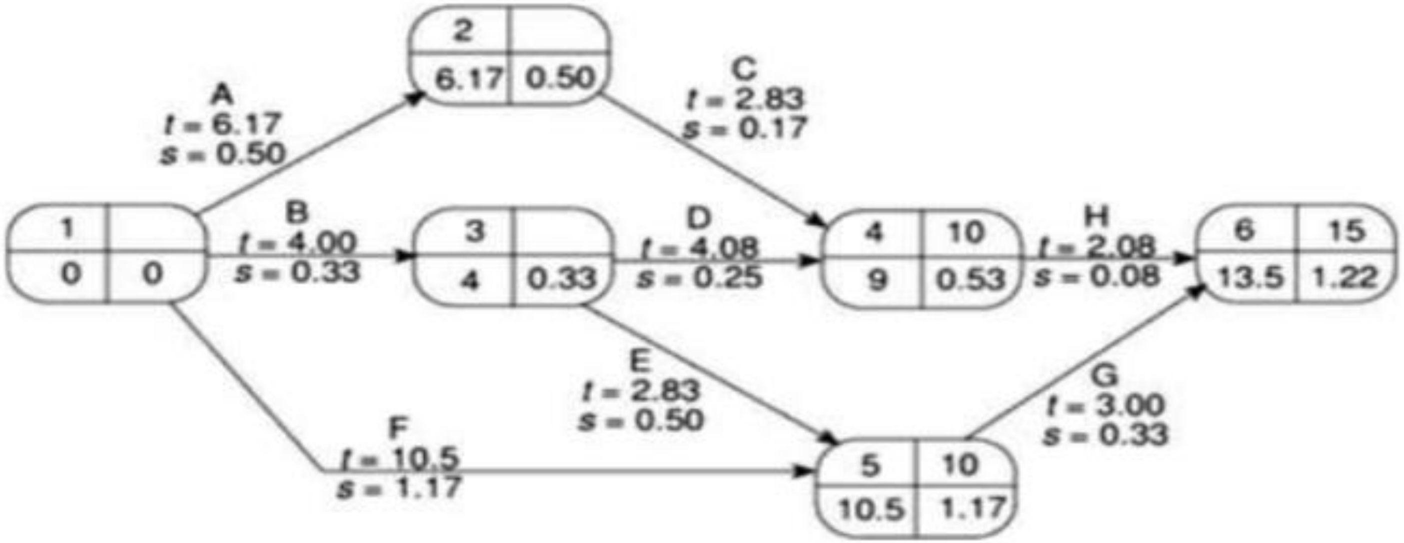
The PERT network with three target dates and calculated event standard deviations.



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 s where t_e is the expected date and T the target date.

$$\mathbf{z = (T - t_e)/s}$$

- The z value for event 4 is (10 - 9.00) / 0.53 = 1.8867.
- PERT focuses attention on the uncertainity of forecasting. PERT can be used to calculatethe standard deviation for each task and use this to rank them according to their degree of risk.

Monte Carlo simulation

- As an alternative to the PERT technique, and to provide a greater degree of flexibility in specifying likely activity durations, we can use Monte Carlo simulation techniques to evaluate the risks of not achieving deadlines.
- Monte Carlo Analysis is a risk management technique that is used for conducting a quantitative analysis of risks. It’s meant to be used to analyze the impact of risks on your project. For example, if this risk occurs, how will it affect our schedule and/or the cost of the project? Monte Carlo gives you a range of possible outcomes and probabilities to allow you to consider the likelihood of different scenarios.
- For example, let’s say you don’t know how long your project will take. You have a rough estimate of the duration of each project task. Using this, you also come up with a best-case scenario (optimistic) and worst case scenario (pessimistic) duration for each task.

- You can then use Monte Carlo to analyze all the potential combinations and give you probabilities on when the project will complete.
- The results would be something like this:
  - 2% chance of completing the project in 12 months.
  - 15% chance of completion within 13 months.
  - 55% chance of completion within 14 months.
  - 95% chance of completion within 15 months.
  - 100% chance of completion within 16 months. (If everything took as long as the pessimistic estimates.)
- Using this information, you can now better estimate your timeline and plan your project.

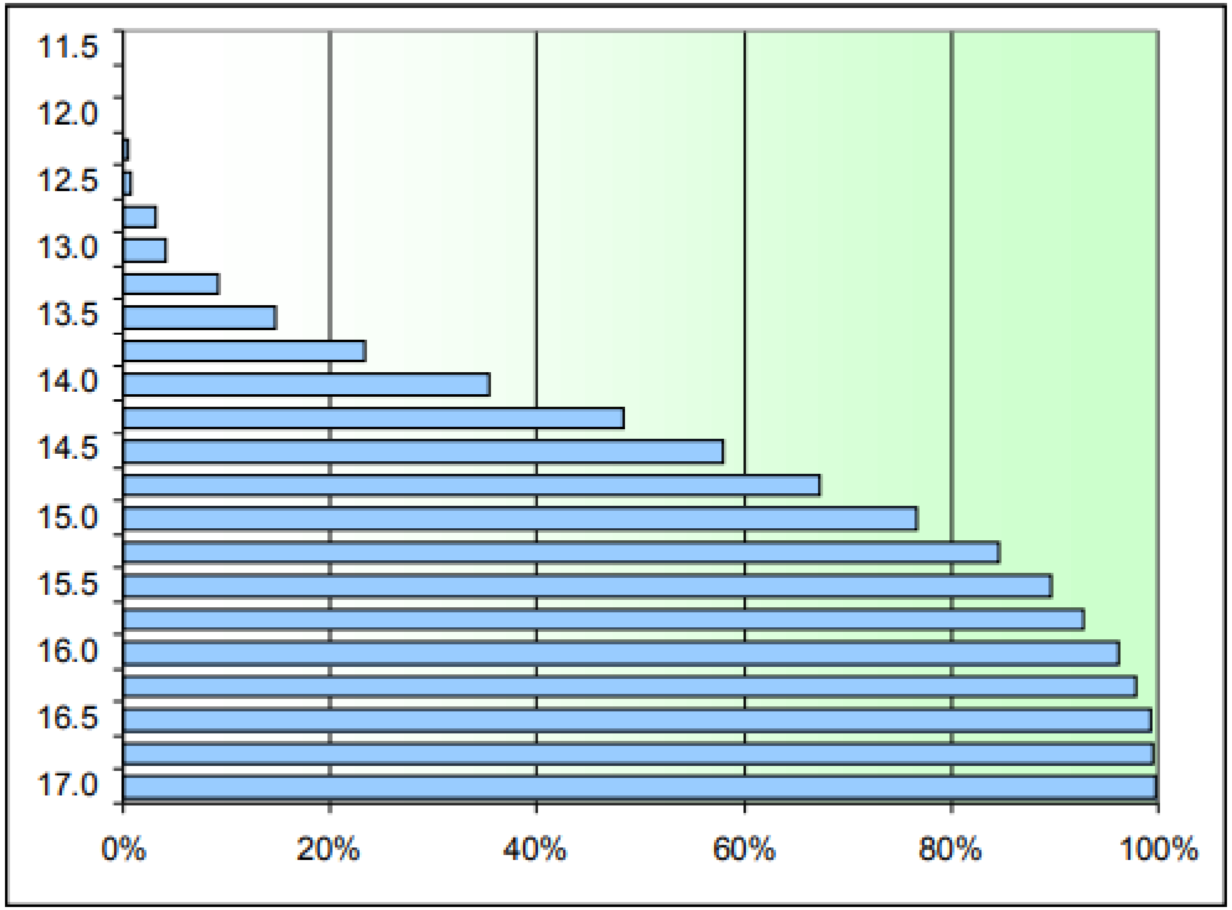


Figure 1: Probability of Completion Within Specified Time (Months)