Project Planning & Control

Prof. Koshy Varghese

Department of Civil Engineering

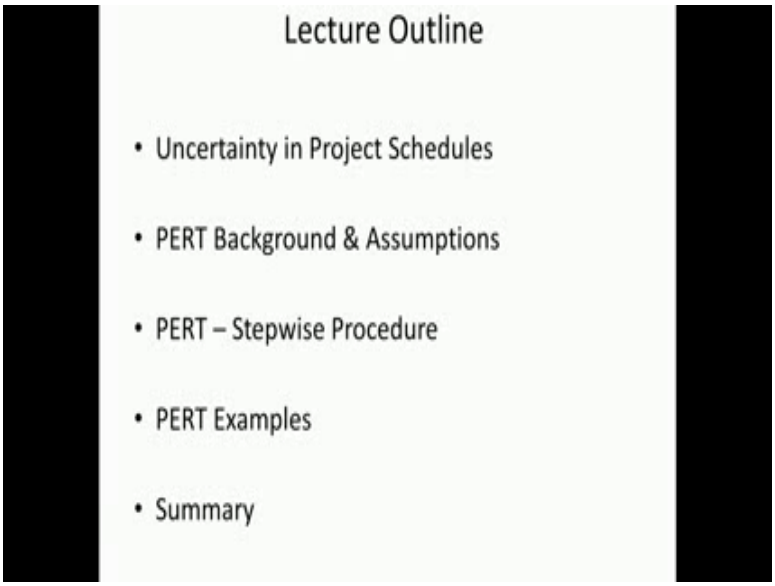
Indian Institute of Technology, Madras

Lecture – 51

Uncertainty in Project Schedules

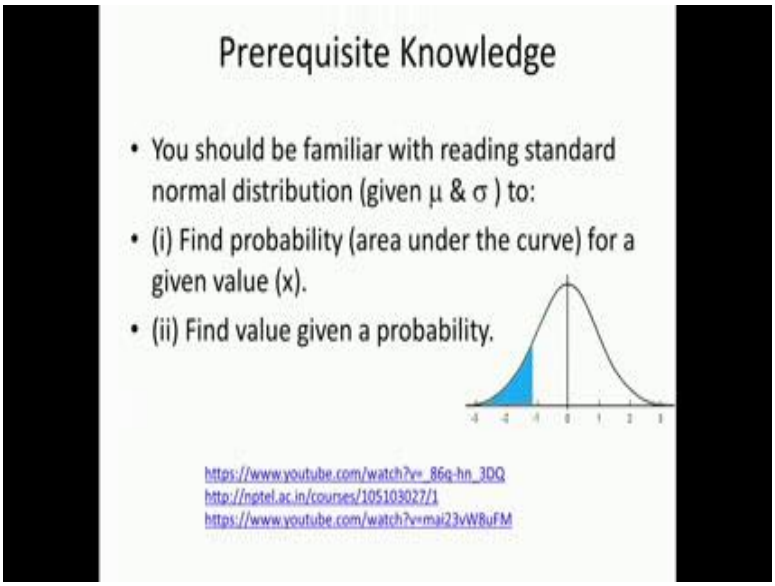
In this lecture, we are going to look a probabilistic scheduling. We will be primarily looking a PERT as a method of probabilistic scheduling. But, we will also cover some a broader aspects of how do you include probability and uncertainty into schedules.

(Refer Slide Time: 00:32)



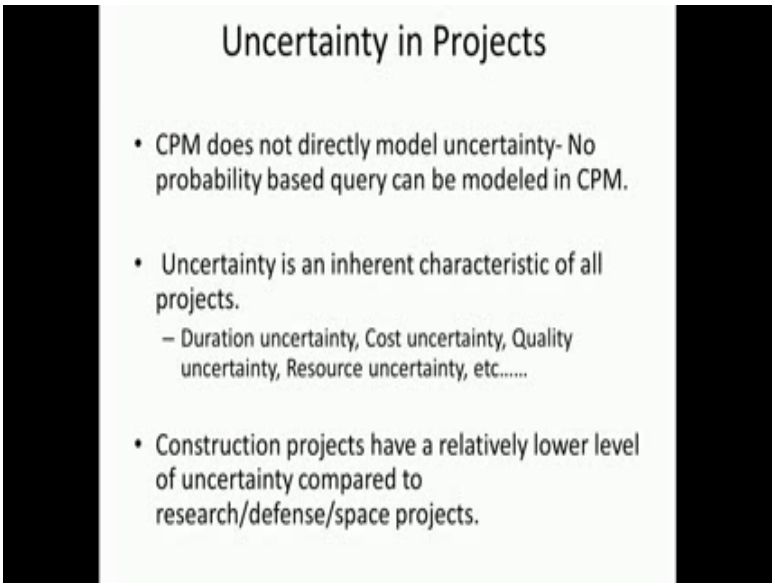
The outline of the lecture is as follows. We will first look at uncertainty in general and in project schedules; then, go to the PERT, the background and assumptions for PERT. We will go through a stepwise procedure to do PERT. And then go on to some – an example; and then, we finally, summarize.

(Refer Slide Time: 00:42)



So, when we start dealing with uncertainty in projects, it is quite an issue. Now, to be able to know this lecture, one of the prerequisites we are assuming that you are aware of will be as to how to use a normal curve; the probability of an area for a given value as well as find a value of a given probability. So, these exercises with a normal curve you should be able to do. Now, if you are not familiar with this, I would recommend that, there are several sources on the web; I have listed a few sources here. But, this is something which you should be familiar with because a lot of these operations are required in PERT.

(Refer Slide Time: 01:27)

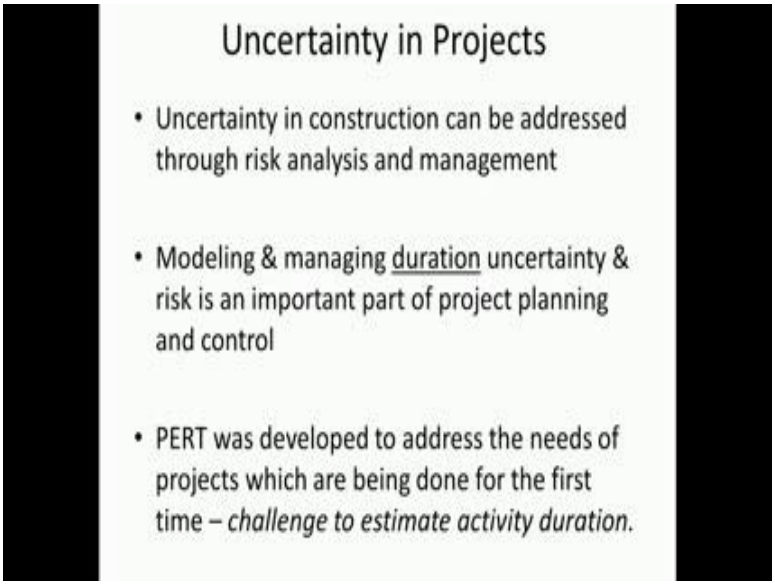


Now, if we take uncertainty in projects, we have so far covered the critical path method;

and, as we are aware, it cannot actually model any probabilistic events. We do everything assuming that it is deterministic, the values for the duration is there is no uncertainty involved; we are assuming that is a duration that is going to happen and we go ahead with the plans. But, we certainly realize that, in our control, that, that is not what is happening. And, we certainly take care of uncertainty more in the monitoring and control part of CPM. But, there is no direct way in which we can model uncertainty. But, we know that uncertainty is an inherent characteristic of all projects. Not only do we have duration uncertainty, but there is cost, quality, everything. So, a challenge of project management is that we have to face uncertainty.

And, when we take construction projects, we generally say that construction projects have less uncertainty compared to projects like research, defence, space, which are novel projects. The first time somebody is doing something; it is much more difficult to manage the uncertainty on these open-ended projects as in construction. So, techniques like.. for uncertainty modeling are much more prevalent in these research or defence projects rather than construction. But, of late, tools for modeling uncertainty have started coming into construction management practice. And, we will talk a little bit about this in the introductory slides.

(Refer Slide Time: 03:01)

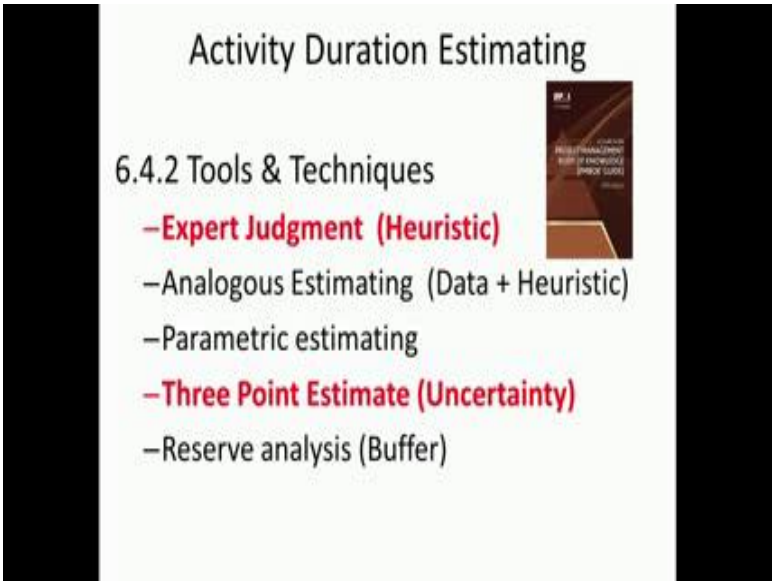


So, when we look at uncertainty in construction, there is certainly – there is a whole area of risk analysis and management. So, this is now a core area in construction project management. And, any good construction project has a risk analysis approach, risk management approach and people will quantify and try to manage the risks at all phases

of the project. So, this is something, which is a science on its own and it is the practices becoming very popular; but, it is beyond the scope of this particular lecture to cover this aspect. We will certainly look at risk from what PERT can associate it with. And, when we then go into this from the broader perspective of risk analysis and management, when we talk about just duration uncertainty, this itself is one of the biggest risk in our project- the fact that it can exceed the plan duration or the fact that an activity takes more time than it supposed to or, how do we actually handle this.

So, the whole aspect of duration – planning for duration uncertainty is also a very very critical part of project planning and control. And, PERT was actually developed to handle this. Primarily, they talk about cost and duration uncertainty as the objective of PERT. And, PERT explicitly models the uncertainty due to duration. Now, when we are going to estimate uncertainty on duration, we certainly have to first estimate the activity duration itself. And then, how do we actually… We covered this in the earlier lecture as to how we estimate the activity duration. But, now, it is not just a duration we have to estimate, but the uncertainty associated with the duration also. This certainly turns out to be a challenge.

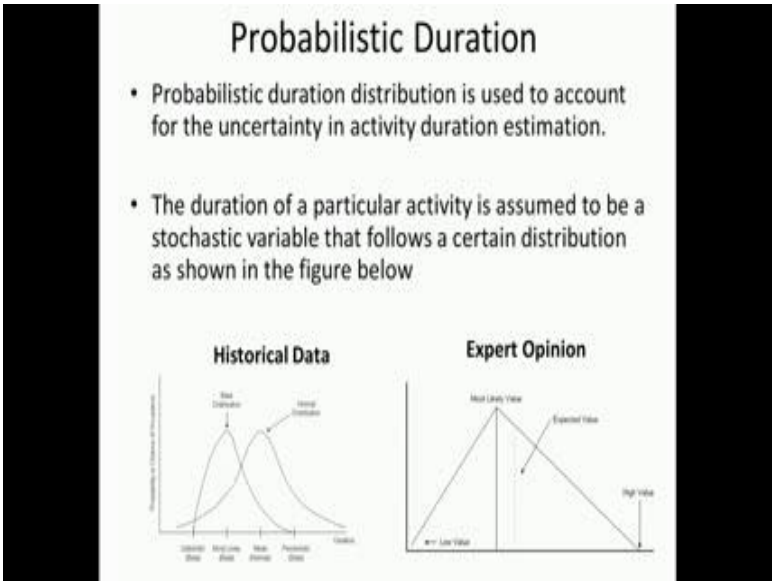
(Refer Slide Time: 04:47)



When we go back… You might be familiar with this slide; we did this in the initial lectures, we took activity duration estimation and we had several tools and techniques as specified by the project management institute and the project management body of knowledge. So, two, which have highlighted here are an expert judgment or Heuristic and the three point estimate. We actually covered a parametric estimate as the part of the

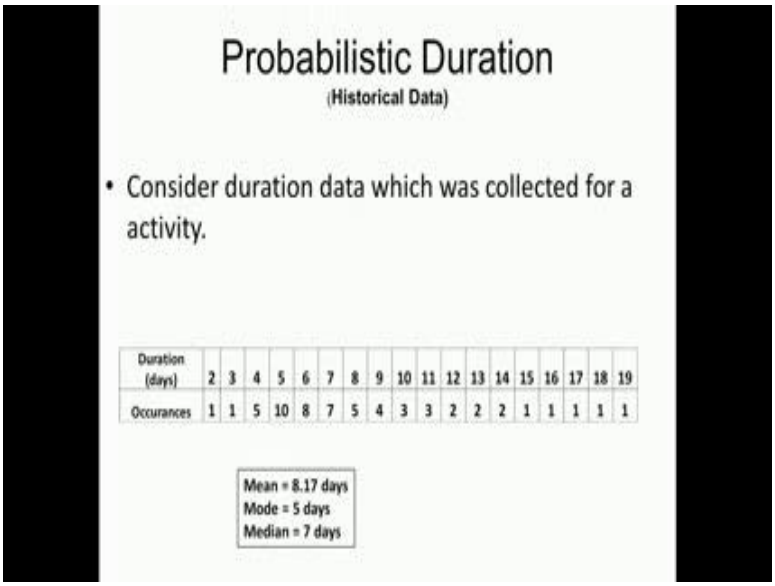
lecture series earlier. But, these tools and techniques have been identified formally. And, when we start coming into uncertainty, we certainly have more challenges as we discussed; and, expert judgment is one of the key ways. The other key way is actually to use data.

(Refer Slide Time: 05:31)



So, when we look at a probabilistic duration, we need actually a distribution. We need a probabilistic distribution and this is how we account for uncertainty in the activity. Now, duration of an activity can be assumed to follow a stochastic variable. And, if you look at… If I have historical data, I could fit into some of the distributions you see below. A lot of times, construction follows the beta distribution; you will be hearing more about this. We are all familiar with the normal distribution here; but, we will have to play a quite a bit of role in the normal distribution also in PERT. And, we will see this at a later stage. So, I can get historical data and fit it into a distribution or I can get an opinion from an expert and also try to generate the distribution from it. So, obviously, when I get an expert opinion, I will have more limited data, but I still should be able to make a reasonable distribution out of it which suits that purpose for which I am applying it to.

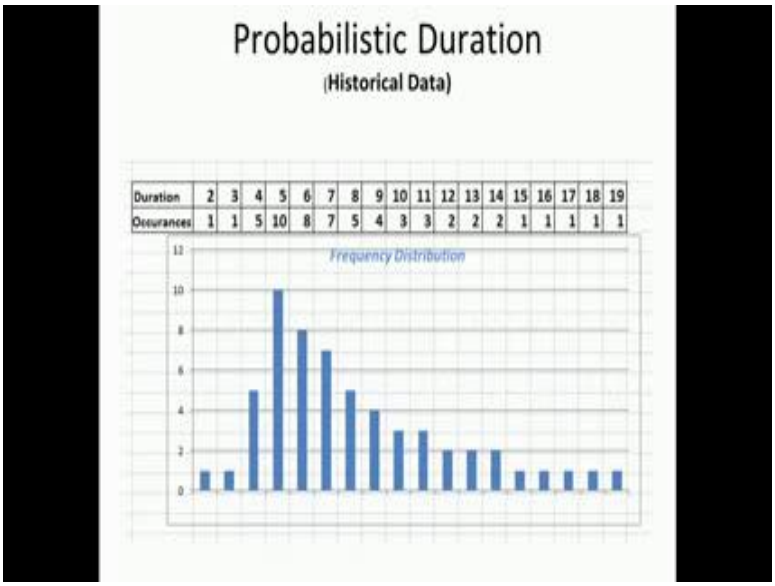
(Refer Slide Time: 06:35)



If we take historical data, given here is a table. How would I collect historical data? Actually, what we would take is let us say an activity and you can see the number of occurrences of a particular duration that activity has undergone. So, the activity has been done in as short as 2 days and as long as 19 days. And, this is really the frequency of occurrence of the various days. So, you can see that, in one instance, it was done in 2 days and one instance, 3 days; on 5 instances, 4 days; 10 instances, 5 days; in 8 instances, it took 6 days and so on. Now, This is basically my historical data.

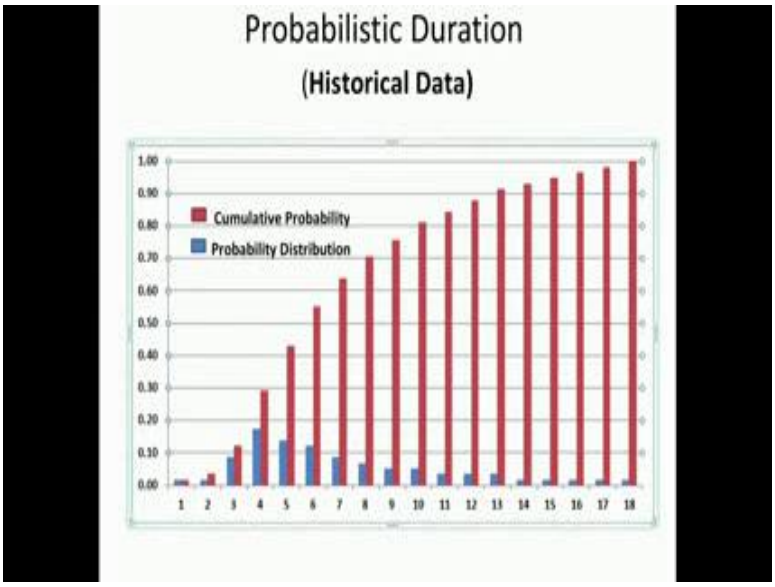
Now I can do my statistics, my basic central tendency statistic on this and I get their mean of this is 8.17 days; the mode is 5 days and the median is 7 days. Now, if I was going to use this as a critical path method, I wanted a single deterministic duration. The mean I might take the mean duration; or, we might say no, the mode is also a possible duration I could use. So, this is something which has to be discussed and might be finally, you need an expert judgment to be able to bring this into it if I am going to use a single duration. But, how do we take this and try to fit a distribution to this?

(Refer Slide Time: 08:06)



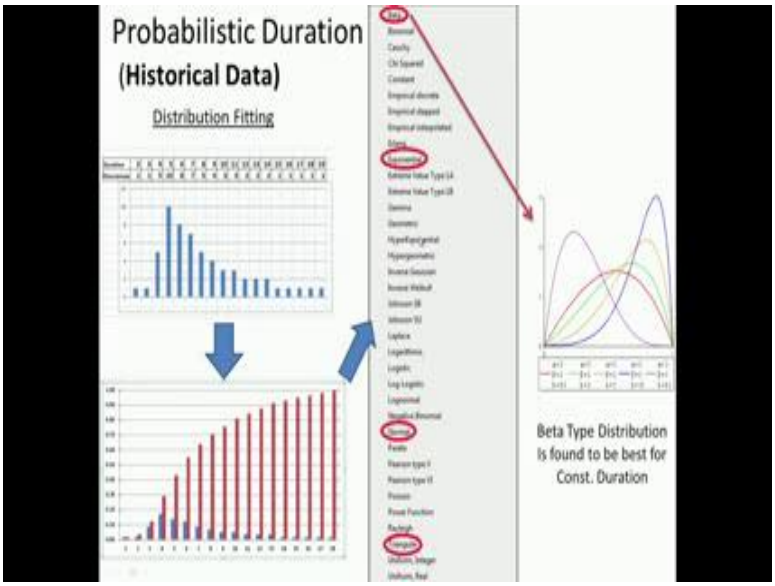
This is what we would ideally want to do if historical data was available. So, I could make a frequency plot of this.

(Refer Slide Time: 08:11)



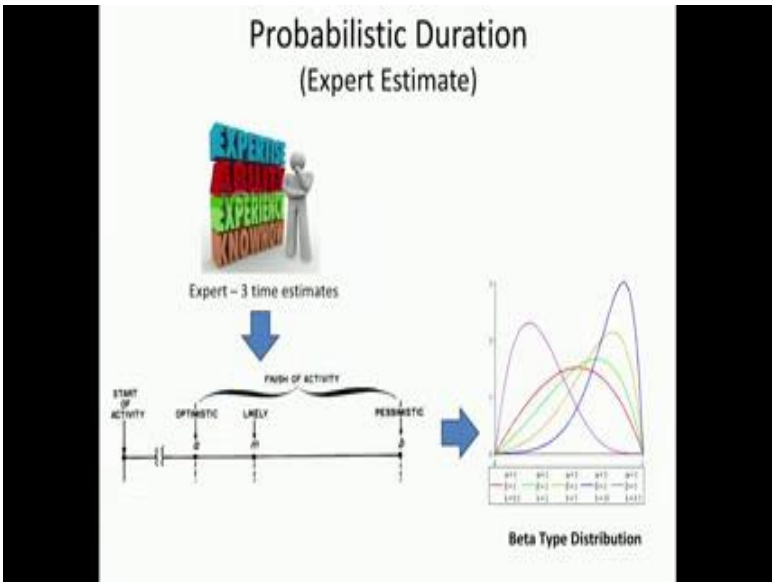
And then, convert the frequency plot into a probability distribution or a cumulative probability distribution as shown here. And, from this, basically I would need to do some statistical data fitting and a distribution fit should be found.

(Refer Slide Time: 08:23)



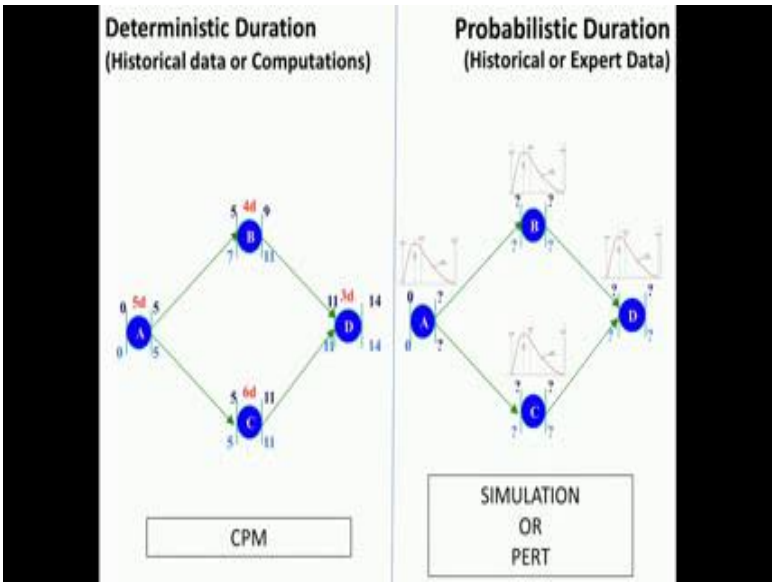
So, here you can see the steps I am going through. I get my frequency, I get my probabilistic fit; and, I have a range of distributions I could possibly fit this profile into. And, the challenge of distribution fitting is to find which of these distributions models my data appropriately. And, people have done this for a construction project and generally found that the beta type distribution is best for construction. So, you can see some familiar distributions here, there is beta, the exponential, the normal, triangular. So, there are all of these. But, actually, what I need to do is to be able to fit, take my data and try to do the distribution fit and find which distribution fits my data. And, basically, like I said, beta is what people have found to be good for construction activity duration.

(Refer Slide Time: 09:28)



Now, it should be nice to be able to do this, but certainly, there is an overhead when we try to do it from a data perspective. So, the other option is to go with an expert estimate. So, in this particular case, I get an expert and I cannot get this level of data from an expert; I cannot get this level of data from an expert. But, I will be able to at least get three times- saying what is an optimistic time, what is a likely time, what is a pessimistic time; and, based on this, again there are other several distributions; I mean I could use a triangular distribution here too. But, again what we will find is that a beta distribution has been used to model this kind of expert estimate also. So, we are able to now either get data to make the estimate or an expert to make the estimate. And, in both cases, we ideally need a distribution to be able to model the uncertainty of that information.

(Refer Slide Time: 10:26)

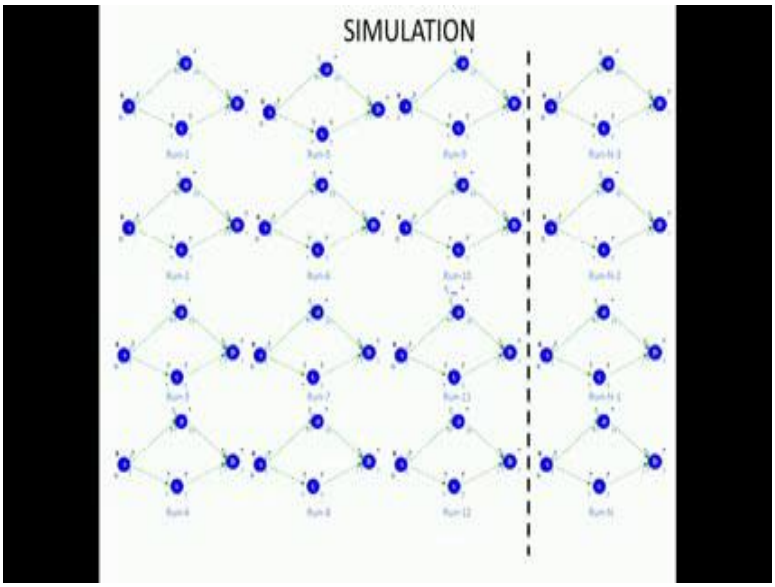


So, if I compare what a deterministic duration was a probabilistic duration; here I have my network. In a critical path method, you will recall that I had deterministic values. So, this was A was 5 days, B was 4, C was 6, D was 3, and we have fixed it in that. Whereas, when we come to the probabilistic approach, A now does not have a value of 5, but it has a distribution that is going to define its duration. Similarly, B has another distribution that will define as duration. Here I have basically shown a symbol of a duration; this does not mean that A, B, C, D – all have the same distribution; I have just shown an icon for a distribution to say that, A, B, C, D will all have a distribution to model the duration.

So, there is no particular value, A can take a range of values based on the distribution it specifies. And, sampling the distribution at each instance might be giving a different value for the duration of A; which is what actually happens a reality. Every time I repeat

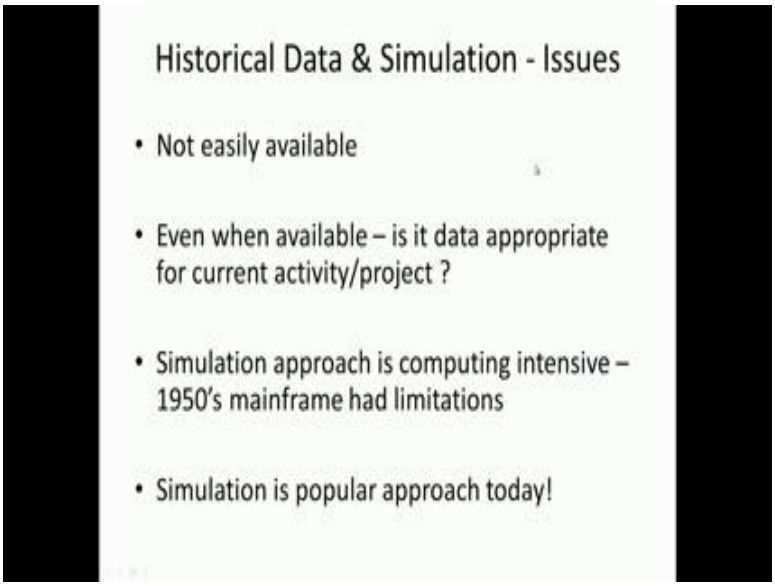
A, it will not exactly the same time as 5 days; but, it will change based on some conditions. And, if I am able to capture the distribution characteristic and represent the distribution correctly, I have actually captured the uncertainty of the duration of A and represented it appropriately. Now, once I have this kind of a representation for my activity durations, there are two approaches, which are typically used: one is either a simulation approach or a PERT approach. Let us briefly cover the simulation approach because it is getting more and more important today.

(Refer Slide Time: 12:04)



In a simulation approach, what we would do is we would take those durations and we would run, we would take – we would run the networks several times; I have to run to 1, 2, 3 as I have shown. Each time I will take a different sample of value from the distribution. So, I will not get a single value; for every run, will have a different value. So, you will see that I will do several runs in my simulation. It will be like doing a project 'n' number of times. Each time, my sample value for each duration will be different. So, my project duration is different. And finally, if I take the samples of all the project durations, I will get a distribution of project duration itself. So, that then defines what my project duration characteristics are and the variability in the project duration characteristics. So, this is an important area, which is becoming more relevant today.

(Refer Slide Time: 13:04)



After this introduction, I am not going to take too much of time, but we are not able to do this because sometimes historical data is not easily available. And, this is a problem. If I want to do a fit and a simulation, I am not able to get historical data for it. But, even when historical data is available, I might not be able to map my specific project to that kind of data. So, might be I have excavation data for several projects, but the project I am working on there is a lot of excavation; but, that data does not suit my type of projects. So, going through a fit will not make it any better. Now, in the 50s when PERT was developed, people knew about simulation; they would like to use simulation, but the simulation is computing intensive. And, the main frame of the 1950s had its limitations in being able to compute so many possibilities as we saw here. So, they really wanted to go following for a much more closed form kind of an approach, which PERT is.

But, now, today, computing has come out of the limitations what we had in the 50s. And, more and more simulations becoming a very popular approach, most of the tools – the popular scheduling tools we use; whereas MS project or Primavera will have a simulation engine also to be able to model uncertainty in risk. But, it is not widely practised; only some of the leading companies are starting to use simulation-based schedules for uncertainty modeling and risk analysis, primarily because getting data is challenging. You could go with the expert data and simulation also; but, again the simulation technique was also quite a bit more complex than the CPM. And, as we discussed, CPM itself, people are finding it a challenge to use it properly. So, it is going to take sometime before simulation becomes main stream in our construction projects.