Simulation of Business Systems
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Lecture – 08
How to build Simulation ? – Major Considerations

Good evening everyone, I welcome all of you to yet another lecture of Simulation of Business Systems course. And previously, we have seen quite a lot of new topics, we seen the definition of simulation, the importance of simulation, the type of simulations, the consideration when do we use simulation those kind of aspects. Then, we looked into the history of the simulation, how this tool came up as one of the most popular operation search tool and how to study complex systems or systems using simulation.

And, we also talked about some of the new techniques of simulation like, these with multiple models than Monte Carlo simulation etcetera, we worked a small example of a bank with hand and see how this simulation is working, when customers are coming to your bank. And we also worked a small model on Monte Carlo simulation on how to do Monte Carlo simulation, we also saw how we can do use excel Microsoft excel to do Monte Carlo simulation. And, how when you do large number of replications of the simulations, the output starts converging to a real value that kind of a thing ok.

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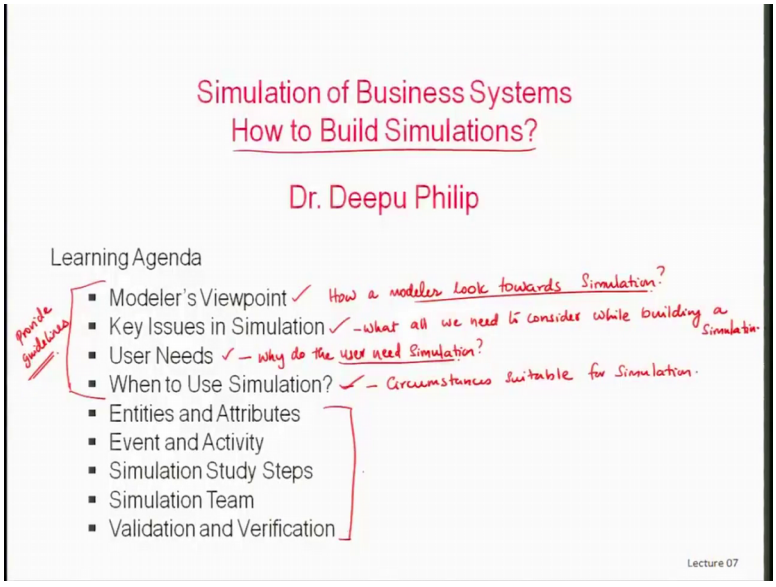

So, with this today what we are now going to do is we are now going to study the new topics on how to build simulations, when you are building a simulation what are the major aspects. And, under this topic the major topics that, we will be discussing as part of this particular section is what do you mean by a modulus view point, how does a modeler, how a modeler look towards simulation, or what we are more interested in it is how would the approach followed by the modular toured simulation, results in the or results in building the right simulation. Then the second part is the key issues of simulation, what all we need to consider while building the simulation, building a simulation ok.

So, that aspect is also taken care of here, then what are the user needs ok, why do the user need simulation, what are the user needs ok, what are the user needs we can satisfy using the simulation. And, then when to use simulation circumstances suitable for simulation, when do we use it that aspect, then we talk about. So, these things to a large extent well tell us you know the provide guidelines, guidelines on when to use the simulation kind of a thing. Then we talk about entities attributes even the activity then steps in the simulation these aspects will be the second part of the lecture ok.

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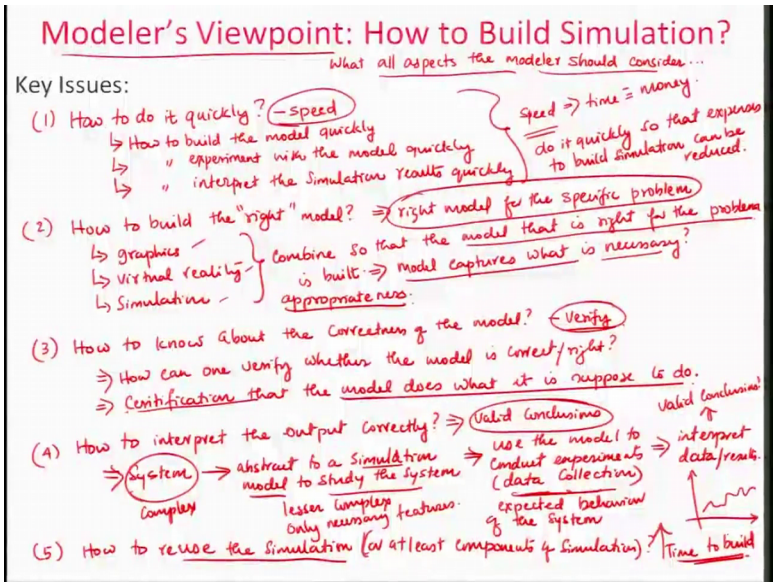

So, let us start with the first and most important aspect of it is what we call as the modulus viewpoint and or what should the what so, here what we are talking about what all aspects, the modeler should consider, should consider while building a simulation ok.

So, that is the main aspect that we are going to discuss here and so, what are the main aspect what role aspects the modular should consider when he or she is building the simulation. So, the first and foremost thing is the main key issue is how to do it quickly ok, or here the major consideration is speed, the sub questions under this category is how to build the model quickly. Then it is how to experiment with the model quickly ok, then another one there you can talk about is how to interpret the simulation results quickly.

So, all of these things they all focus on us we set the speed, because time equals or equivalent to money, more the time you spend in doing this more the money that you will be end up spending on running the simulation. So, here what you are trying to do is, you are trying to do it at a quicker space or a faster space ok. So, do it quickly so, that expenses to build simulation, simulation can be reduced ok.

So, this is the major consideration in how to do it quickly or we are considering here is the speed, now once the speed aspect is taken care of then the next question; obviously, is how to build the right model ok. You will use the word right model. So, the aspect here we are going to try is we are going to think about graphics, we are to going to think about virtual reality, then simulation etcetera all of these things you might want to combine. So, that the model that is right for the problem is built, this implies that model captures what is necessary ok.

So, what we are doing is we combine graphics, we combine virtual reality, we combine simulation all of this ok. So, that we can build a model that is right for the problem at hand, or whatever the problem that you are trying to simulate, or whatever be the simulation problem, then you want to build a model that is right to it and it ensures that the model captures what is necessary from the system so, that is building the right model. So, this means right model for the specific problem, this is what we need to think important here is the right model for this specific problem.

Whatever be the specific problem, we are interested in building the right model for it or the model that is appropriate ok, it is the appropriateness of the model that, we are talking about appropriateness alright. Then the third major consideration that we have here is how to know about the correctness of the model ok, this is more into what we are basically talking about is how do we verify ok, how can one verify whether the model is correct or model is right. How can one do that? What are the ways you can do this?

So, this concept of verification it is basically like kind of in a way certificate, certification that the model does what it is supposed to do, or supposed to do ok. So, what we are interested here is we are interested in to find out certify or assure people that the model is doing, what it is supposed to do. And how do we certify that how is this approval, or how does this tell people that yes this is the model that is supposed to be built and it does what it is supposed to do ok. Now, the fourth consideration out of this is how to interpret the output correctly. So, here means you have a system, then you say abstract to a model to study the system ok.

So, you have a system then you abstract to a model to study the system, use the model to conduct experiments, this implies data collection and from there you have is the interpret data or results ok. So, you have a system I have a complex thing ok, this is complex from here you abstract into a simulation model, to a simulation model. So, you abstract to a simulation model; so, that you can study the system.

So, this is lesser complex only necessary features, only whatever is necessary to be studied is abstracted to a model using the model, you conduct experiments he is very basically the model giving the output, or here is the expected behavior of the system, behavior of the system. And, from here once you collect use this experimentation it generates data, when the data is collected and then how do you interpret the data ok, when you put a graph or something like this, then what does this graph mean and how do you interpret this graph.

And so, that the conclusions that are made out of this data. So, this results in what we call as valid conclusions, how can you do that using this approach. So, that is the interpretation of the output correctly. So, here the importance is valid conclusions or you can say it does rational insights that is also one other way to say this ok. Then a fifth problem that is half done quite lately by people is people think about how to reuse the simulation, or at least components of simulation. The question here is how do we reuse the simulation or at least the comments of the simulation is the major aspect of this ok. So, there are multiple ways you can think about it, but the most important part of it is why do you want to reuse the simulation, because of the first thing ok.

Time to build: time to build the simulations are very high you need to spend a lot of time to build simulations. So, if you spend a lot of time building simulations, then if you once

build a simulation, you are more interested in reusing it, because more you reuse it then you can actually reduce the time to build the next simulation model. If you can reuse it then your problem of solving this actually becomes much more easy. So, from a modelers viewpoint these five are the major key issues, when it comes to building a simulation.

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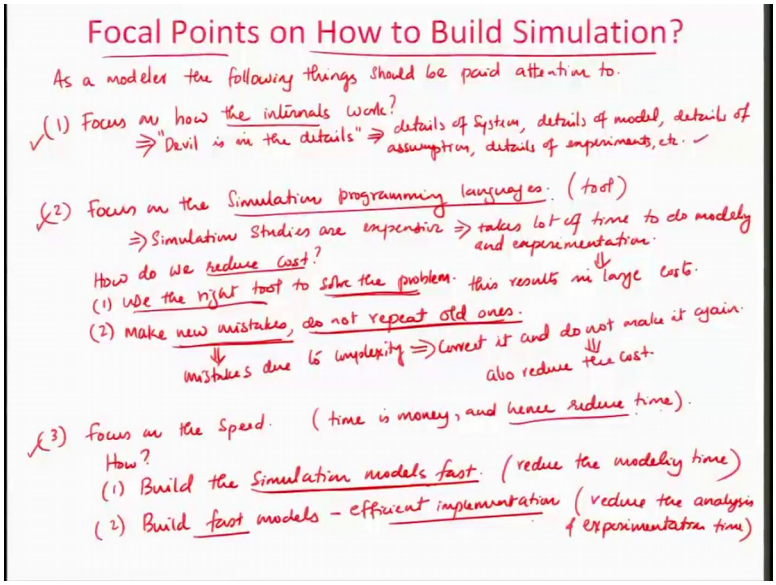

Now, with that let us see how do we do what are the focal points major focal points ok, what are the focal points on how do we build a simulation. So, these are the major considerations that we told earlier, now what are the focal points ok, as a modular. So, here is as a modular the following things should be paid attention to ok. What are the major things? Number 1, is focus on how the internal works, how the internals work internals of what so, the aspect here is devil is in the details. It is kind of a adage that people use ok; that means, details of system, details of model, details of assumption, details of experiments etcetera.

So, what we are saying here is that you should focus on the internals, how the details, how the different details of the system, how is the simulation model internal aspects of it. How does each sub module each aspects of the simulation is working that is the first part that we are for the focal point need to be of the modeler.

The second part is the focus on the simulation programming languages. So, because as I said earlier this is an important focus, because simulation studies are expensive, why

takes lot of time, lot of time to do modeling and experimentation. So, if you take a lot of time to model an experiment, then what happens these results in large cost ok. So, simulation studies are never cheap. So, then the way to so how do we reduce the cost, then how do we reduce cost, the first way to do it would be use the right tool to solve the problem. For studying a simple facility like a bank or something to do, you would not rather not build a custom built simulation stuff, you would rather we you say readily available simulation package. But let us say you are trying to study the law the launch of a nuclear bomb or something, then you would probably end up building a custom model.

So, how do you use which how can we use the right tool if you have the right tool to solve the problem, then that will result in reducing the cost; second one is make new mistakes, do not repeat old ones ok, when you are building a simulation model language simulation model, because the system is complex ok; the mistakes will be mistakes due to complexity ok. So, if you make a mistake then fine that is alright correct the mistake correct it and do not make it again, many a times you will keep on you will you know that how much of time is spent on solving the repeated old mistakes, it is crazy that and this trance this will also reduce the cost ok.

So, you use the right tool and to solve the problem and then if you want to make, if you are making mistakes make new mistakes never repeat the old mistakes to do this, these two will read you help in reducing the cost. Now, the third focal point for the modular in this regard is focus on the speed ok. The [FL] here is that time is money and hence, reduce time, reduce the time needed to build the model, reduce the time need to do the experimentation, reduce the time taken to interpret the results all these are part of the focus on the speed aspects.

So, the question here is how, how do we do this, the two ways you can do this number one is build the simulation models first. So, first thing is you do is you focus on building the simulation models quickly, fastly ok. If you can build this fast, then reduce the modelling time, that is what you are trying to do you are trying to reduce the modelling time. Second part is build fast models ok, or what we call as what we call as efficient implementation.

So, we are looking at you are focusing on building the simulation models first and then you are trying to build fast models ok, for simulation models or you are looking at the

efficient implementation of the simulation. Here, reduce the analysis time, analysis and experimentation time, that is what we are focusing in this particular aspect of how to build the simulation model.

So, these three points focus on the in how the internal works focus on which programming which tool to use ok. The tool aspect of it and focus on the speed, these three focus point will actually help we should be paid attention to by the modular, to realize very good simulation study ok, with that now we will get into what we call as the key issues in simulation.

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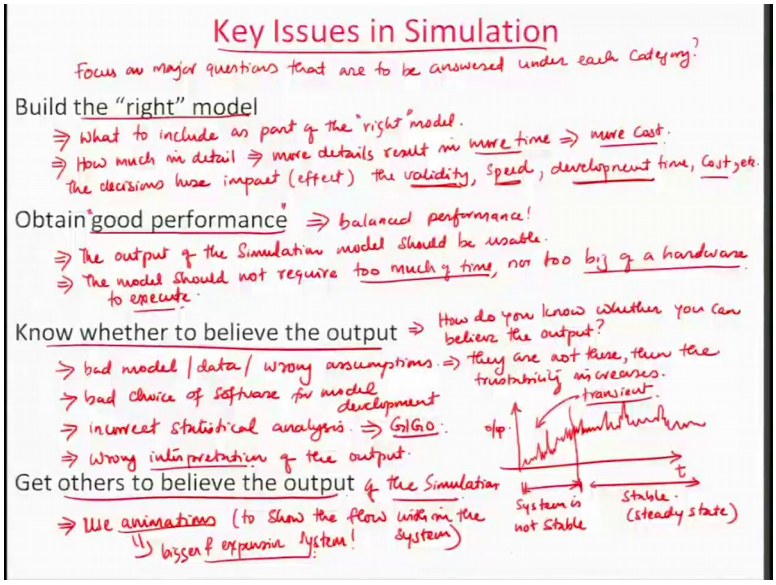

And as I said earlier with the focal points and some of the aspects are important and there are so, here what we say is we will focus on focus on major questions, that are to be answered to be answered, under each category, that is what we are trying to do. So, the first thing as I said earlier is build the right model, that is the first focal point you know. And the major questions that need to be answered in this point will be what to include, what to include as part of the right model ok. So, what do you want to include, what are to be included as part of the right model ok.

In a better way to think about these and then what are to be included on, how much in detail you want to include something fine go ahead and include, but then how much in detail you need to include this ok, because as I said more details implies result in more time, implies more cost ok. So, if you keep on including the more details yes, it will take

you more time and the time will translate to a bigger cost ok. The decisions here, the decisions here impact or influence or affect, affect the validity the validity of the simulation model the speed of the simulation model, then the development time and cost etcetera; so, all these aspects the validity of the model.

So, if you include sufficient details in the model become invalid, if you include too much of detail and the model might become valid, but then it will reduce the spirit of the model with which you can do experiment and the ready it will also read reduce the speed on the development time. And once the development time increases or goes through the roof then the cost will also go through, the roof and then the cost of the simulation become quite expensive. Second one is obtain good performance this is the second aspect of it obtain a good performance ok. So, which means the output of the simulation model should be usable ok, that is one part, that the model should not require too much of time nor too big of a hardware to execute ok.

So, you should not require too much of time to do the experimentation with the model, nor you should not require a too expensive of a hardware to execute the model. So, it should be a balanced performance. So, good performance or you can think about it as a balanced performance ok, that is what you are more interested in this aspect obtain a good performance once the model. Then the third aspect is you know whether to believe the output, or the question here is how do you know you can believe the output, how do you know whether you can believe the output, how can you figure out whether you can believe the output or not ok. So, the major things to focus here on are bad model or bad data or wrong assumptions ok.

So, these are the major aspects bad model or bad data or wrong assumptions is one aspect that you need to focus ok, if they are not there, then the trust ability increases. And this is true for other or some other things as well, they are bad choice of software for model development. So, if you did not make the right choice of the software for model development, then it will also help you in increasing the trust ability of the model, then the third part is incorrect statistical analysis. So, if you use the wrong statistical tool to analyze the data, then you know this will result in what we call as guy go garbage in garbage out if you use the garbage tool and the garbage wrong data to analyze the data analyze the data of the simulation experiment, then you will get that garbage output or the incorrect result will come to you ok.

Then what happens is the last one is wrong interpretation of the output of the output. So, like let us say if you see a scenario for example, many other time people study simulation this the system behavior how the simulation kind of looks like this, if you look at the system behavior it looks like this, sometimes it the system behaviors behaves typically like this. So, let us say this is the output of the system and up to this point you can see that we performance of the system, this much period ok, this time period. And the system performance is system is not stable and here is the system is stable ok, or steady state ok. So, if you take a small enough time window ok, small enough time aspect where the system has not reached a steady state, then you will never be able to do the steady state analysis. So, such kind of it so, this behavior of a system is called as transient ok.

So, you have to ensure make provisions for ensuring that the transient you are not analyzing just the transient to make about the steady state of the system. So, you are not interpreting the result in the wrong fashion ok. Now, once this is done the next question; obviously, is how do you get others to believe the output, how do you get others to believe the output of the simulation, how do you make others believe that there is this output coming from the simulation model is you know believable. And many a times use animations to show the flow, to show the flow within the system, but then animations means bigger and expensive system hardware.

So, you can make fancy animations to increase the believability of the system, or make others to believe the system, but then once you use animations, when you have fancy animations, then you how bigger an expensive hardware is also required to run the same animations. So, in a way having that animations will might increase the believability of your model with others, but that does not necessarily mean that it is not it will also increase the cost of your simulation study. So, the advantages and disadvantages of using the animation has to be strictly looked into ok.

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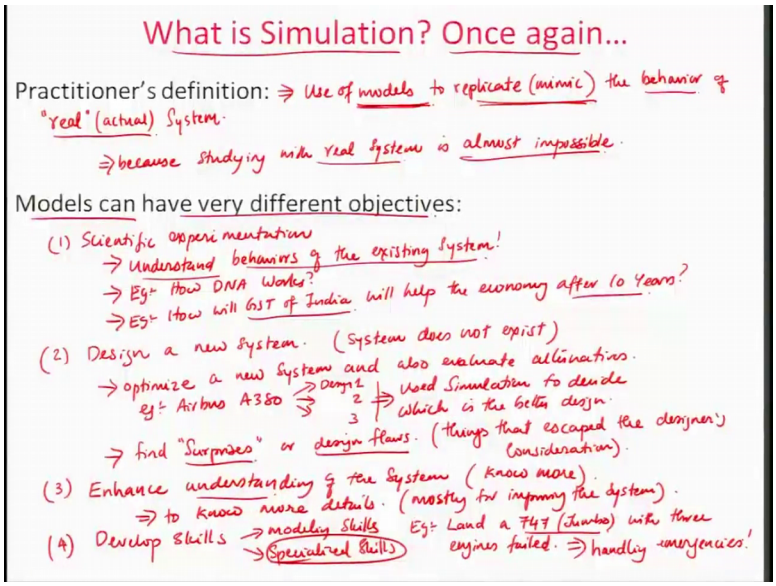

Now, we look into again you know once again we will look into the definitions of what is the simulation and given in the light of this key aspects of simulation, let us look into with these definitions once again. And here, I will focus more on the practitioners definition we use so, the practitioners definition sees simulation is the use of models use of models to replicate, or mimic, replicate or mimic the behavior of real system or we will call it as actual system ok.

So, that is in a way we are we are trying to do as a practitioners definition here, this class is we use models to replicate or mimic replicate or mimic, in a sense that we are basically trying to answer the question of you know how do the system behaves, how do the actual system behaves. And it is very expensive to study the behavior of the actual system with the help of the actual system. So, instead of you use a model to replicate, or mimic that behavior of the system ok.

Because studying with real system is almost impossible or cost prohibitive, or something like that, this in itself studying with the actual system the real system is an almost of an impossible task. And hence because of that reason you actually use models to mimic or replicate the behavior of the actual system and now; obviously, the problem is that the models can have very different objectives ok. So, the major objectives you can think in do multiple things ok.

So, the first set of objectives we can think about it as the scientific experimentation. So, the first objective is scientific experimentation what does this mean ok, this implies understand behavior or behaviors, behaviors of the existing system what we are focusing here, is we are focusing to understand the behaviors of the existing system ok, that is one aspect of the scientific experimentation.

An example of this is example how DNA works you may not be able to understand the behavior of the DNA, because it is very hard to really take the DNA out and put it in a room and then see how it behaves. So, you might want to build a model of that a particular model and, do the scientific experimentation of that right. Then another example of a second example would be how will GST goods and services tax GST of India, will help the economy after 10 years.

So, this question how the G goods and service tax of India will help the economy after 10 years you can actually study this by the real system. But it requires you waiting for 10 more long years which you do not have, if you want to find out what is it going to be the impact on the economy after 10 years. You have to build another option, but to build a simulation model put the values into it, try to mimic the behavior of the Indian economy and introduces in the GST into it. And run the simulation for a duration of 10 years and look at the result and then from the result make the conclusion. So, this is the scientific experimentation, where you are more focused on understanding the behaviors of the existing system. The second objective that we can talk about it is designing a new system design a new system ok.

So, in this case you the system does not exist the means most important thing is system does not exist. So, you cannot really play with an existing system, because it actually does not exist. So, here the idea is that optimize a new system and also evaluate alternatives ok. So, for example, in this case is you know airbus A 380 ok, they had at least three designs design 1 2 and 3 and then they simulated this use the simulation to decide, which is the better design. They were trying to optimize the design in this regard optimizing a new system.

Second part is find surprises or design flows, when you are designing a new system, there will be something that you might not have considered, there might be something that would not that have escaped the thought process of the designer or the design

process. Those are called design flows these are the things that escaped the designers consideration ok.

So, in this case these things had escaped the consideration of the designer. And hence those translates to what we call as design flows and or the surprises which will prevent the system from doing the expected behavior of the system. Then the third one is enhance understanding of the system ok. So, here it is called as know more you want to know more about the system, you want to understand much more about what is the system. So, here the system exists, but you want to know more details to it ok.

So, it is to know more details of the system, for something you might be interested in improving the system mostly for improving the system ok, that is the major consideration here, then the fourth part is the fourth objective that many people think about it is which is also I develop skills ok, or this can be one is modeling skills, other one is specialized skills. So, an example of it is example land 747 which is what we call as jumbo with three engines failed. So, nobody in the sane mind will actually take a jumbo jet a Boeing 747 fly up in the sky, we destroy three engines and try to land with the only one engine, but it is suicidal.

So, what people will try to do is you can actually create a simulation environment in which you a pilot can actually fly a virtual aircraft take it up to a particular altitude, and switch of the three engines similarly the scenario of three engine failure and, see whether the person can learn with a single engine. And in that process the pilot will learn what are the major aspects, what are the major considerations, how much should be the flaps b whether you should deploy the landing, gear it should be deployed landing, gear when it should be landing when it should be deployed should this last be deployed ok, what is rpm at with the engineers should be running all these aspects are considered.

So, this results in building the specialized skills for a pilot in handling emergency ok. So, this case is the case not, this specialized skill in this example is handling emergency emergencies ok. So, that is also considered as one aspect. So, development of skills in a very tough situations, or costly tricky situations is also one other objective of using the models to study a system ok.

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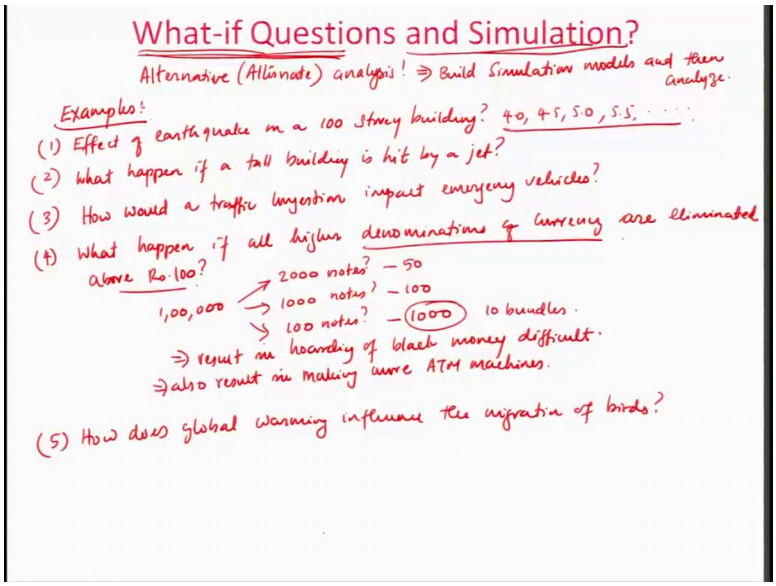

So, then the next part that we want to get into is what we call as the what if questions and simulation, what if analysis. What we are trying to say here is that the simulation always looks into what if analysis ok. What if analysis is were in a better way the word to use this is alternative, or alternate alternative, or alternate analysis. What are the alternatives that are available for the current system?

So, to do that the simplest and easiest way to do it is to build a simulation model and so, then alternative analysis, then you can say build simulation models and then analyze ok. So, this is one good aspect of simulation. So, what are the some of the examples let us talk about it quickly. So, it will give you an idea what it will be the effect of earthquake on a 100 storey building, what will happen if an earthquake happens on 100 storey building. So, you can take the richer scale of let us say again say its earthquake is on a 4 scale 4.5 scale 5 scale 5.5 scale like this.

What will happen the multiple earthquakes comes into picture or the earthquake of different magnitude comes into picture and, how did the 100 storey building will behave to this. So, that is an example of alternate or what if question, what happened if this earthquake comes into picture ok, what happen if a tall building is hit by a jet ok. So, like for example, what happened in World Trade Center, what happen if a big building is hit by the jet, what will be the outcome of it. Then another example is how would traffic congestion impact emergency vehicles.

So, if there is a huge traffic congestion how would it impact the movement of the emergency vehicles ok, what happen if all higher denominations of currency are eliminated higher denominations eliminated above rupees 100. What would happen, if all higher denominations of currencies eliminated above rupees 100; what would be the what will happen to that. So, for example, of this is if you eliminate all the currency above 100, then they if you have 1,00,000 rupees; so, in the case of 2,000 notes how many do you require ok.

If you have what how much how much you if you have 50 notes 50 200 note 10 200 notes will be 20000 50 of them ok. So, if you have a 1000 notes so, how many it would be? 100 notes, you have only 100 rupee notes, then how many you will end up having 1000 of them so, this will be 10 bundles. So, it will result in hoarding of black money difficult, but it will also result in making more ATM machines, because the number of currencies that can be dispensed by an ATM machine will be in less. So, you require more ATM machines for people to for to dispense that much amount of money ok.

So, similarly there are many questions you know, how does global warming influence the migration of birds? What happen is the temperature of the globe increased by 2 degree Celsius? How would it influence the migration of the birds? These kind of things, these kind of what if questions can be quite well analyzed by using a simulation ok.

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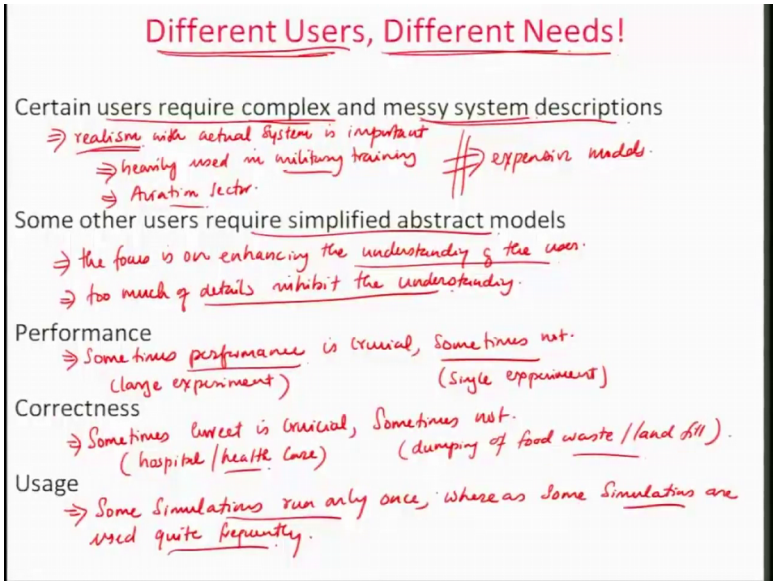

With this we get into what we call as the different needs, different user needs and different uses of different needs, you know and how do we manage these different user needs and that aspects of the simulation. So, the first point is certain uses how complex they require complex and messy system descriptions ok. So, here the most important thing is realism with actual system is important, you want the system to be as realistic as possible with that of the actual system ok heavily used in, heavily used in military training aviation sector.

So, the simulations that are used in military and aviation sector are quite complex and messy system descriptions, because you want to have it as close to as reality as possible. So, these are typically what we call as the expensive models ok, more realistic the model is more expensive it actually becomes ok. Sometimes other uses they do require simplified abstract models. Here, the focus is on enhancing the understanding of the user ok, that is the first thing if the user is focused on enhancing the understanding of the system ok. Then too much of details, inhibit the understanding of the user. If you put too much of details into the system it will inhibit the understanding of the user, then sometimes performance is critical or is crucial sometimes not.

So, if you want to do a large experiment, then the performance is crucial, because if the model is not fast then your experimentation will take a long time. Sometimes you only do single experiment, only once you will do the experiment and that is it. In those case you might not require the model to run that quickly it can take a little bit of time, because you are really doing it for once. So, correctness ok, sometimes correctness is crucial sometimes not, like for example is that you want to probably estimate the so, in the case of a hospital or healthcare business the correctness is quite crucial.

Where, you are talking about dumping of a food waste, or landfill you might not be interested in that much of a correctness such that in the case of a healthcare simulation model. So, depending upon the model that you are doing you might wanna highly correct model, or you might not want a highly correct model. The last part is the usage ok. So, some simulations run only once whereas, some simulations are used quite frequently ok.

So, some of them are only used once and some of them are used quite frequently. So, depending upon the usage also you will end up different. So, the different type of users,

the type of user varies the same way are the needs of the simulation also varies in this regard.

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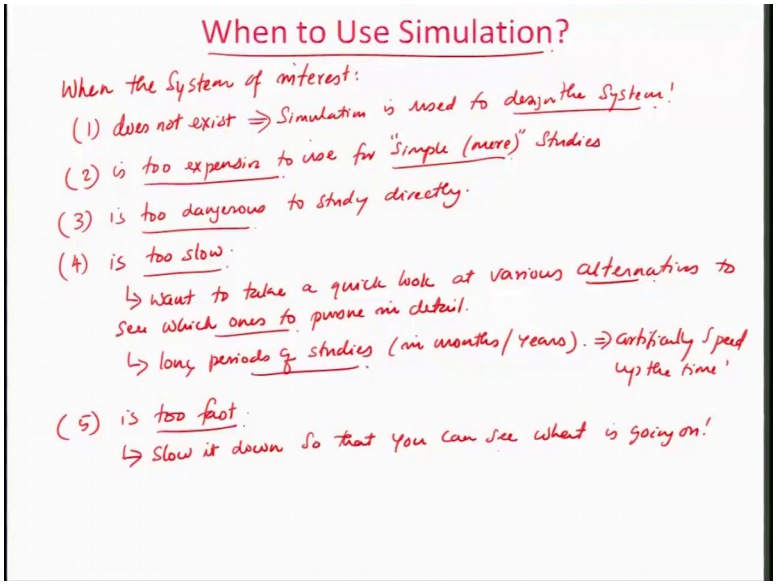

So, then; obviously, the question is you know when to use the simulation, or what is the appropriate time to use the simulation ok. So, the major time that you will use the simulation includes, these are the major points that you should remember. When the system of interest, it is all about the system that you are interested in studying when the system of interest number 1 does not exist ok.

So, if the system does not exist then simulation is used to design the system. So, if the system does not exist then you cannot study using the real system. So, you use simulation mostly to design the new system ok. Second one is when the system of interest is too expensive, to use for simple ok, or we call it as mere studies. Let us say you want to find out what is the average queue length in a factory; a factory is an expensive system and you do not want such a too expensive system to use for two simple studies. If that is the case then we use simulation number 3, when the system of interest is too dangerous to study directly.

So, you want to find out what is the impact of dropping of an atom bomb in a big city, it is pretty dangerous to actually take the atom bomb and drop it in the big city, instead what you would do is you build a simulation model of the city, you build a model of this atom bomb and drop it. And, then try to study it using different propagation shockwaves

and other things and try to figure out how it actually happens ok. Then the fourth part is the system of interest is too slow ok, what is the impact of the GST on the country in 10 years or something like that ok. The system takes 10 years to do it; you cannot do anything about it. So, when the system is too slow what you want to do is you want to take a quick look, at various alternatives to see which ones to pursue in detail.

If the system is too big and it is too slow, you want to look at some alternatives and to see which one to pursue in detail, that is when you use simulation ok. Also it is like long periods of studies in months or years ok, if your time period is too long to study, then it is also important to use a simulation. So, you can speed up the time artificially speed up the time ok, then the fifth consideration is when the system of interest is too fast, it is running too fast then what it down then slow it down; so, that you can see what is going on ok. So, that is the last aspect if the system is too fast you want to actually find a way to slow it down; so, that you can actually see what is going on within the internals of the system ok.

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So, what we will do now is we will stop here today and, what we our main aim would be to take the rest of the terms in the next rest of the parts in the next presentation. And, we will go in detail from there, thank you for your patience listening. And, also please ensure that you go through the notes and as well as the assigned reading; we will see you soon.

Thank you very much.