Principles of Engineering System Design
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Lecture - 04
Six Functions of Design Process

Hello friends. Welcome back to this lectures on Engineering System Design. In the last few lectures, we discussed about the importance of system engineering and in the previous lecture, we discussed about the life cycle of engineering systems and some of system design processes like engineering systems vee stage, gate process and spiral process. Today, we will start the system design process. We will go through the different steps one by one on the design of engineering systems.

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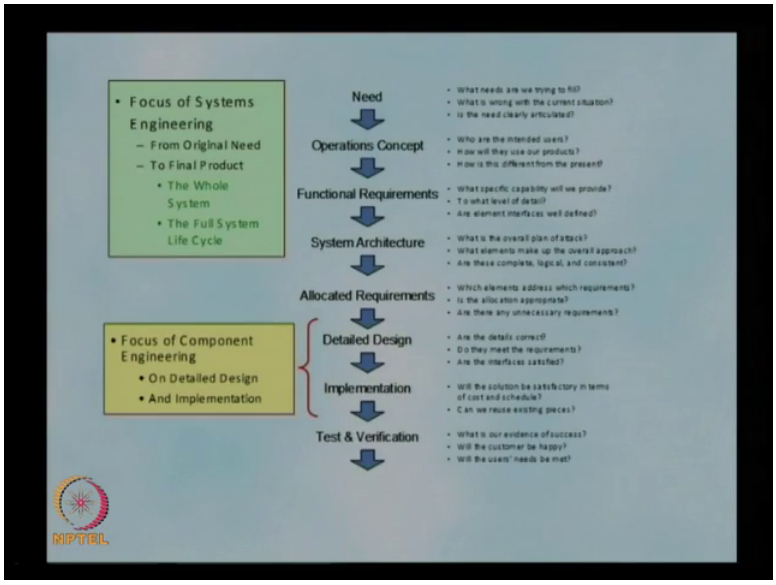

As explained in the previous lectures, we start with the system design process with the identification of needs. So, the focus here is mainly on finding out the original needs.

And then based on this needs we go to the operational concept functional requirements system architecture and then allocated requirement for these systems once we identify these requirement for various subsystems then we go for the detailed design and then implementation. And finally, we go for the test and verification. So, this is the flow of steps involved in the design. So, we start with the need identification.

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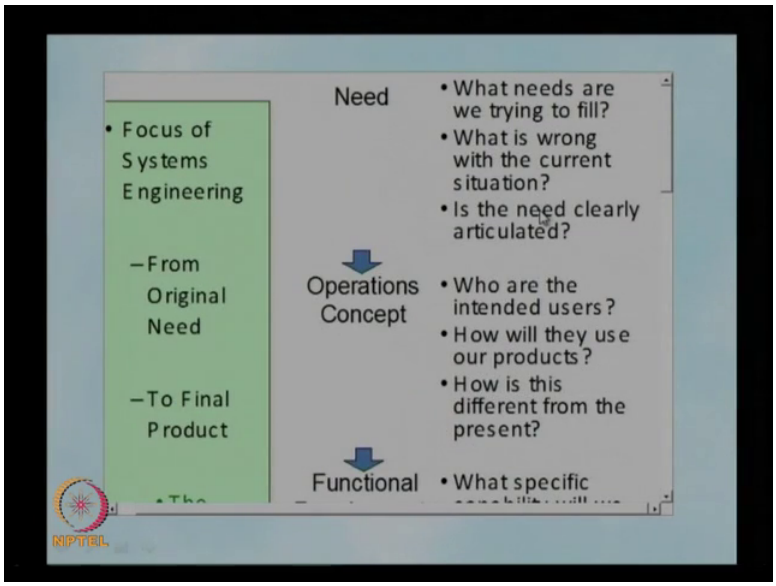

So, we will try to see; what are the needs we are trying to identify or what are the needs we are trying to filled using this system design and what is wrong with the current situation and why do we need this particular situation, so that will tell us; what are the needs to be addressed in this particular design. And, another important part is that whether the need is clearly articulated or clearly understood clearly mentioned or clearly recorded the requirements and the needs of the customer.

So, once we have this needs identified we will go for the operations concept for the system; since it is a new design, we need to identify some kind of a Friesian concept which will actually help us to develop the system based on these concepts. So, in order to do that what we tried to do is to find out; who are the intended user for this system: how they use the products or how they actually use these products and how is this different from the present system.

So, if we know these things about the users and their preferences and what should be different from the existing we can develop an operations concept, once we have these operations concept we will go to the next level of functional requirements.

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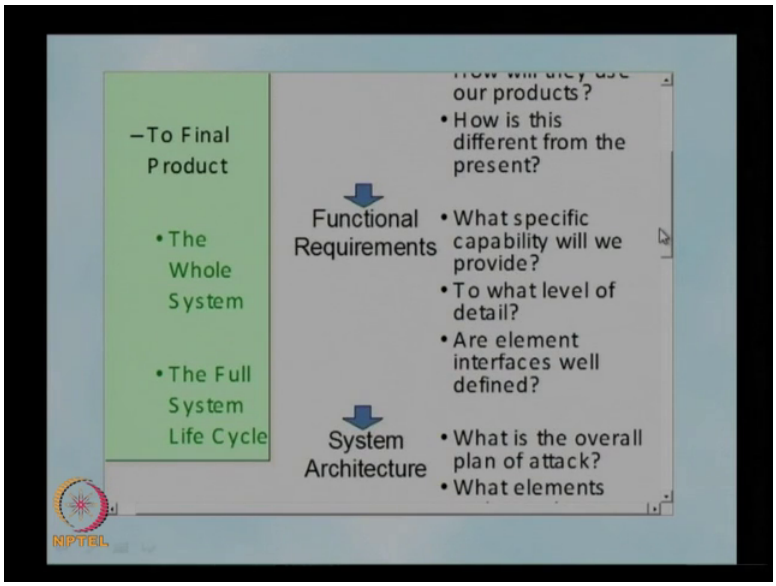

So, what specific capability will be provided in this particular system to satisfy the customer requirement and to what level of detail we need to provide these requirements and whether all the element interfaces are well defined within the requirements. So, once we have these answers to this question we are actually having our functional requirements ready based on that we will go for the design of the system architecture.

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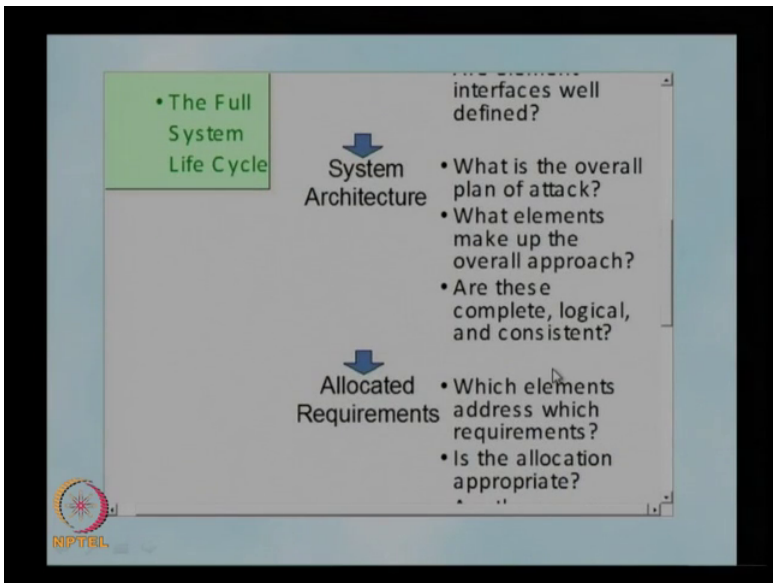

So, here we will try to address what is the overall plan of attack what elements make up the overall approach and are these complete logical or consistent. So, whether the overall

plan of attack is consistent whether it actually satisfy the requirement and whether their complete and logical will be identified and verified in the system architecture stage. And then we go for the allocated requirements since we have many requirements and many systems.

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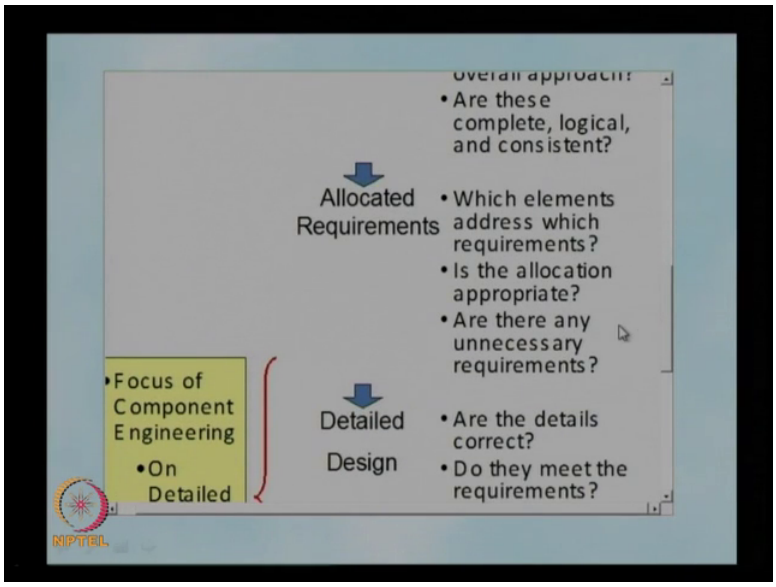

So, we have to allocate this requirement amongst the system components. So, we will try to see which elements address which requirement.

So, we do a mapping of the requirements with the components or the physical structure. So, there we do a mapping to identify which are the elements which actually address a particular requirement identified by the customer. And then we see whether the allocation is appropriate whether the allocation is appropriate or we have did an over allocation or an under allocation. So, this will be analyzed and then there any unnecessary requirements.

So, we have to go through the requirements and all the requirements are genuine and there are no unnecessary requirements which warn an edition of additional elements into the system. So, all this will be analyzed in this stage and once we are comfortable with these requirements and allocation of the requirements we will go for the detailed design.

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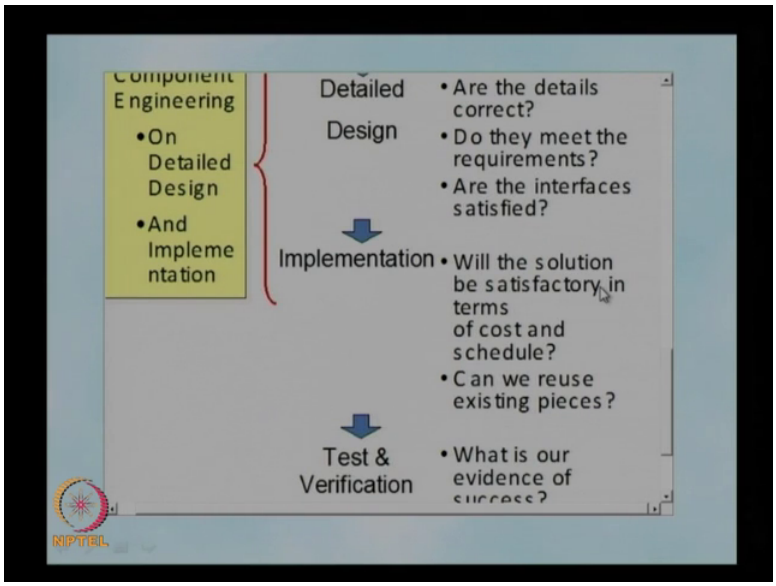

Which again is not part of the system engineering which is more of a component engineering focus and this that the details are correct do they meet the requirements are the interfaces are satisfied all these are done by the design engineers or component engineers and once the components are ready and it is ready for integration again, the system engineer will take it over and then start the assembly. And then do the implementation then basically we will do a testing of the implementation will be tested basically to understand the solution be satisfactory in terms of cost and schedule.

And can we reuse the existing pieces. So, this will be analyzed in the implementation of stage and once this is completed we will go for a test and verification.

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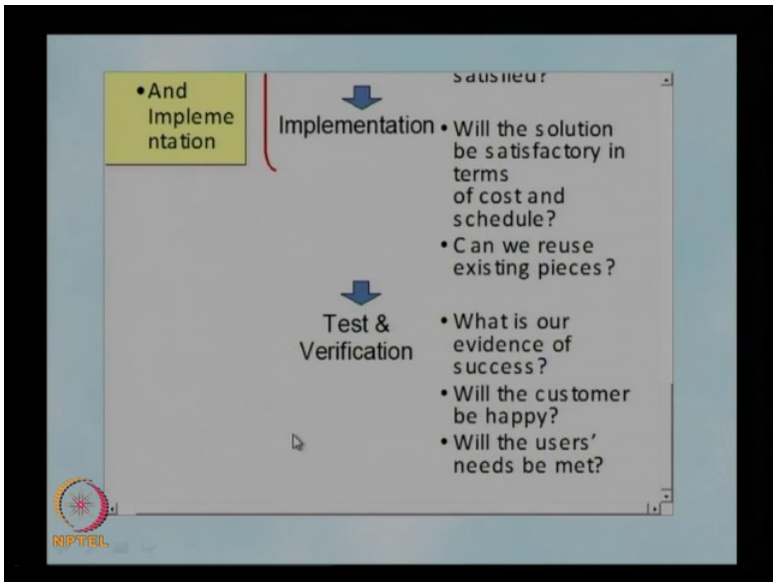

Basically, we are try to understand or identify what is our evidence of success and will the customer be happy with this particular system or will the users need; whether the all the needs of the users are matched. So, we will do a test and verification the end of the design process to ensure that it actually satisfy the customer requirements. So, these are the various steps involved in the design of the system.

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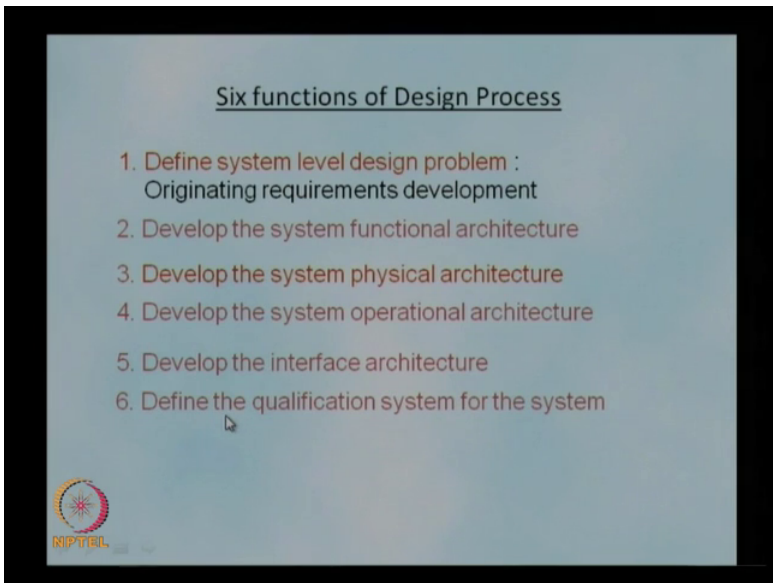

So, in order to achieve this we have divided this whole process of the system design in to 6 process or the 6 functions of design process. So, these 6 functions are applicable across

life cycle and the first one is define system level design problem. So, here we try to understand the whole problem from the customer's point of view or the stakeholder's point of view; try to develop concepts for the system and try to identify the system boundaries try to identify the requirements and then prepare a originating requirement document.

So, the purpose of the first level of a design process or the first function of design process is basically to define the system level design problem let second function is basically to develop the system functional architecture. So, here once we have these are the requirements identify; we try to identify their functions to be provided in the system. And then provide a hierarchical structure for the functions and identify all the functions and make sure that this functions are sufficient to meet the customer requirements the third one is to develop the system physical architecture. So, once the functions are identified, we try to identify the components or the physical systems which actually will provide these functions in the system this stage is the physical architecture development stage and the fourth one is the system operation architecture.

So, once we have the system the physical system in place we need to find out how the system will be operated what are the operational requirements for the system and then we develop an operation architecture which will satisfy the customer requirements then we development an interface architecture since we have many sub systems in place. So, we go for an interface architecture which will try to identify are the interfaces needed for the sub system as well as to the external system, and ensure that there is compatibility with the standards. And other requirements identified in the system and make sure that there is no loss of data or no loss of data in the communication systems.

And finally, once the system is ready developer qualification system for the system where we ensure that the developed system is qualified to meet the requirements of the customer. So, in this process this course what will try to do is to go through all these steps in details try to identify; what are the tasks involved in each stage or the each function. And then finally, we will develop the qualification system for the main system which will actually satisfy requirements as I mentioned earlier this is applicable throughout the lifecycle of the system.

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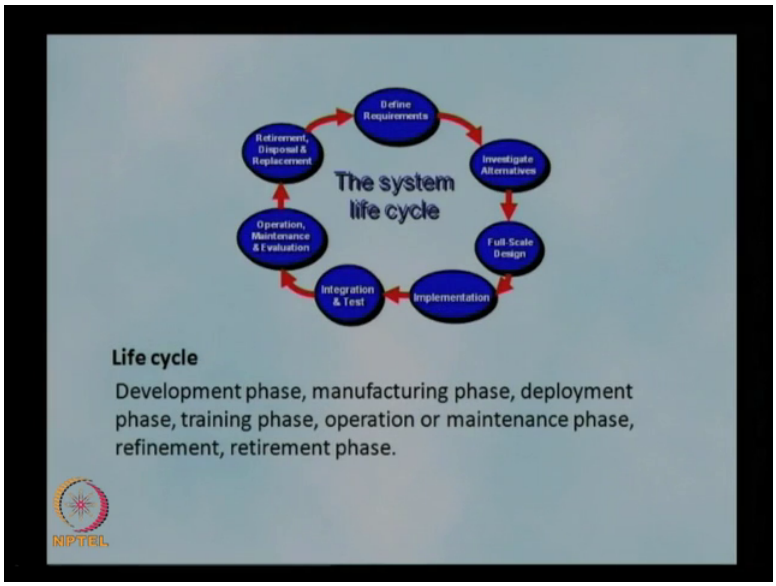

So, for any life cycle of the system these 6 functions are applicable. So, if you take the development phase or the manufacturing phase or deployment phase we need to identify the requirement we have to define the problem we need to define the functional architecture we need to define the physical architecture we need to identify the interfaces we need to identify the qualification system. So, across the life cycle these processes are applicable. So, we will develop these 6 functions for each life cycle separately and then identify the requirement for each life cycle and the function and the architecture for each life cycle.

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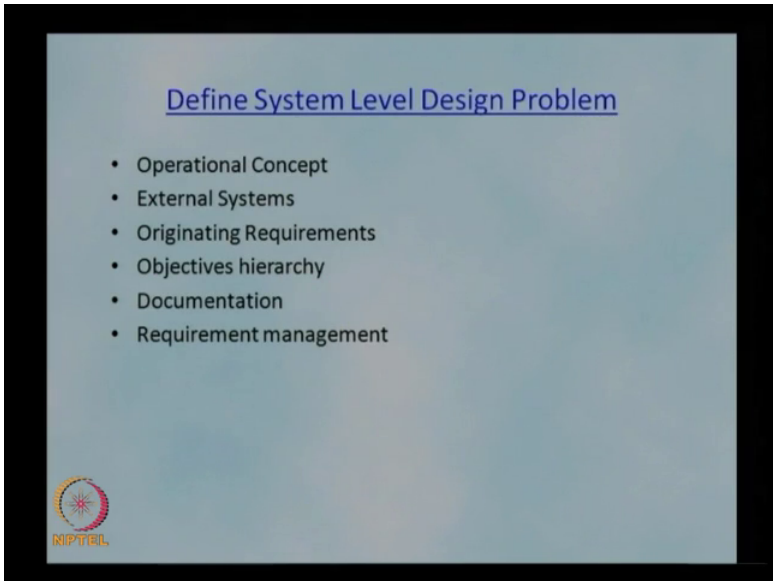

So, to come to the first process which is the define system level design problem which is the out of the 6 function this is the first one; so here in this stage.

We try to develop the operation concept for the system we try to identify the external systems which are external to the system being developed. And will try to identify the originating requirements we try to identify what are the objectives of the system and how do we develop the objectives hierarchy and then how to we how to make the documentation for the requirements, and then how do we manage the requirements. So, this are the steps involved in defining the system level design problem, we will go through one by one what are the steps and how do we actually do all these stages in to achieve the system level design problem.

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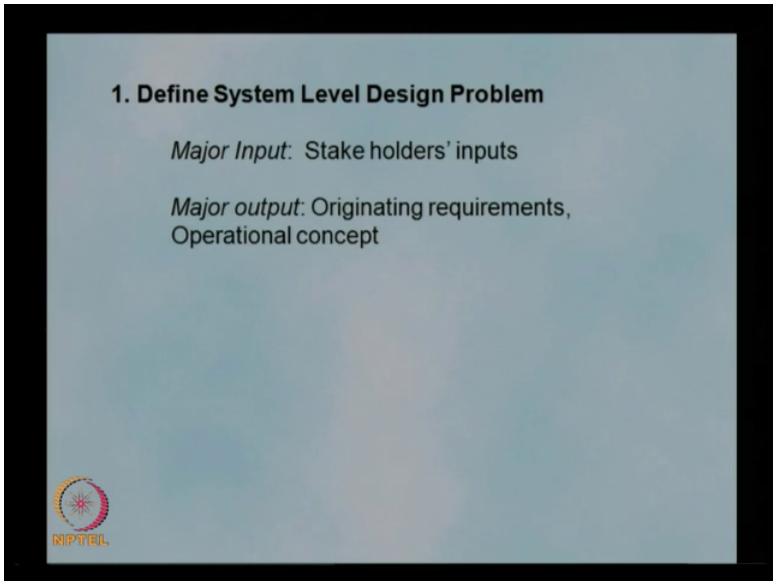

So, as you can see here the system level design problem the major input is stakeholders input. So, we have stakeholders it can be the customer it can be the purchaser or who are this using it. So, there this input is the major input for the system level design problem they states the requirements their application their expectation from the system based on that the output will be coming as originating requirements and operational concepts.

So, the major input is the stakeholders input and then the major output from this particular stage is the originating requirements we make a document which is called originating requirements document or ORD. And we have few operational concepts which can be developed further to satisfy the stakeholders requirements.

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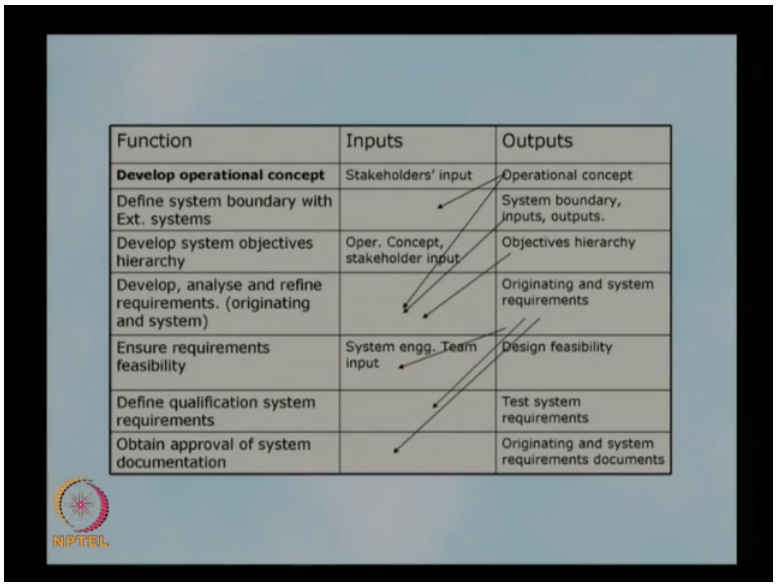

So, this chart actually explains the various stages and what are the inputs and outputs for the each stage in the first function. Thus, you can see here develop operational concept this is the first stage where we have the stakeholders input as the major input and we have an output from this particular stage as the operational concept. So, we develop operational concept very top level operational concept very abstract and without any much details. So, this will be the output from the first stage of develop operational concept and once we have this we use this as an input operational concepts as an input and defend the system boundary.

With external systems since every system is interacting with the external system we need to identify what is our focus. So, which one we are trying to focus here. So, that becomes our main focus and that becomes our system of interest and everything which is interacting with the system will define as external system help us to make boundary within which we need to design the system. So, the second stage of defining the system boundary will help the external system diagram, it help you identify the system boundary the inputs and outputs. So, the main output from this particular stage is the definition of the system boundary the inputs to the system and what the outputs going out of the system then we use the operational concept as well as the system boundary inputs and outputs and this operation concept and stakeholders input will be used to develop the system objectives hierarchy. So, every system will be having some object used to be met

which is defined by the customer something like the operational cost or the operational efficiency.

So, these things need to be given a particular hierarchy. So, we cannot have same importance to all these objectives. So, based on the operational concept and the stakeholder input an object is hierarchy will be developed which will help us to have some trade off at a later stage in the design. So, the output from this stage is the object is hierarchy which is the input for operational concept and the stakeholder input now using all these output from the previous stags we develop analyze and refined requirements.

So, this is an important stage where we need to develop all the requirements and analyze and refined the requirement for the customer now we have an operational concept we have the stakeholder input. And we have an objective hierarchy based on this we will identify all the requirements needed for the system and then prepare the originating and system requirements. So, there are 2 types of requirement one is the originating requirement the other one is the system requirements we will see what are this requirements at a later stage. So, this will be the output from this particular stage.

Then we go for analysis of this requirement to ensure that they are feasible and they meet the requirements. So, that stage is the ensure requirements feasibility. So, here the system engineering team input will be important because that system engineers know what actually the system requirements really meet the customer needs. So, the system engineering team input as well as the originating and the system requirements become the an input here and when do a design feasibility analysis once this satisfied we go further qualification system requirement because every system has to be qualified to satisfy the requirement.

So, we define the qualification system requirements and the output will be the test system requirement document and once this is done we will get obtain the approval of this system documentation from the higher ups and at the end of this we will be getting the originating and system requirements documents. So, this process function of system level design problem we start with the stakeholder's inputs and within originating and system requirements document.

So, this is the final output of this particular stage of development this is important because the requirements need to be clearly defined and understood by the stakeholders

as well as the developed the system engineers any constraining requirement will be a problem at the latest stage of design. So, we should make sure that the requirements are flexible. So, that we can have some freedom at the later stage to make sure that that proper trade of can be carried out and the system designers are not too much constraint in development of the operational concept as well as the functional and their physical architecture of the system.

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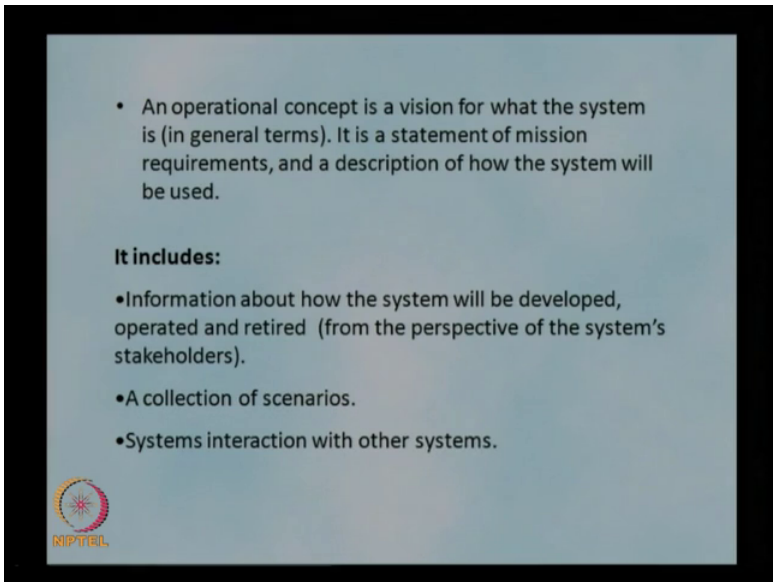

So, as I mentioned the first stage is operational concept development. So, in operational concept is a vision for what the system is it is a statement of mission requirements and description of how the system will be used. So, that is a very preliminary or very abstract level of concept where we just define a vision.

For what the system is and it is a very simple description of how the system will be used it will include the information about how the system will be developed operated and retired from the perspective of the system stakeholders and collection of scenarios and systems interaction with other system. So, in order to develop an operational concept we need to have to develop preliminary analysis or preliminary concept how the system will be operated and used and try to identify different scenarios of operation. So, what are the scenarios under which the system will be operated? So, that that will give us some input on the requirements different various kinds of requirements and their systems interaction

with the other system which is basically an external system diagram. So, these are the things to be included in the operational concept.

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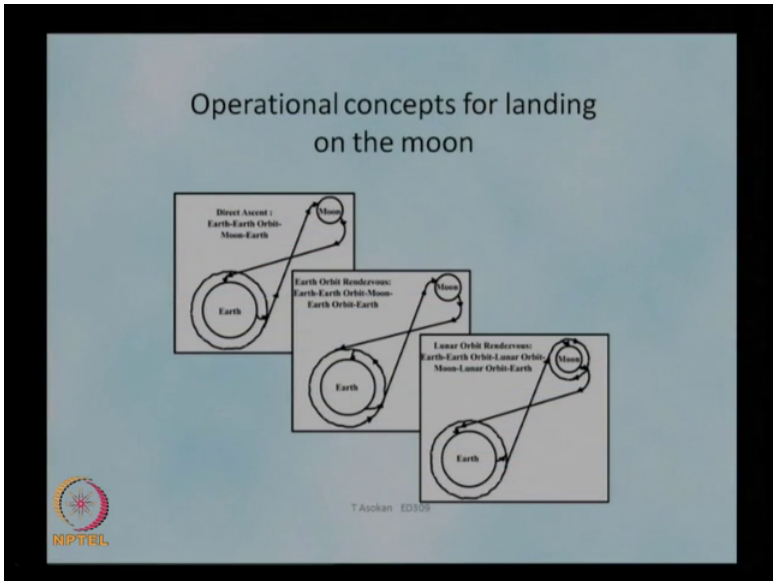

For example, if you take the operational concept for landing on the moon it is again at a very top level concept you can have different concepts to do this.

You can have a direct ascent where the vision will start from the earth and it will go on around the earth and then again will take off to the moon directly from the orbit and land directly on the moon and then take off from the moon and then again come directly and come to the earth. So, this is one way of doing it is a director ascent or you can have an earth orbits and print out where the earth orbit will be the first stage and then it go directly to the moon and then land on the moon.

And then come back from the moon directly take off from the moon, go one round around the earth and then land on the earth. So, this is the another possibility another concept which can be employed or the other one is lunar orbit; orbit round out where the along with the earth orbit it will go one round around the moon and moons orbit and then come back to the land on the moon then take off from the moon and then come back to the earth.

So, this are the different operational concepts for landing on the moon this is the way how we start with the system design because we do not have any concepts to follow it is

a totally new mission the we need to identify what are the possible options for the possible concepts we can employee then take one of these concepts. And then, develop the next level were we try to develop the operational scenarios based on which we can identify the requirements to be provided or the functions to be provided in the system.

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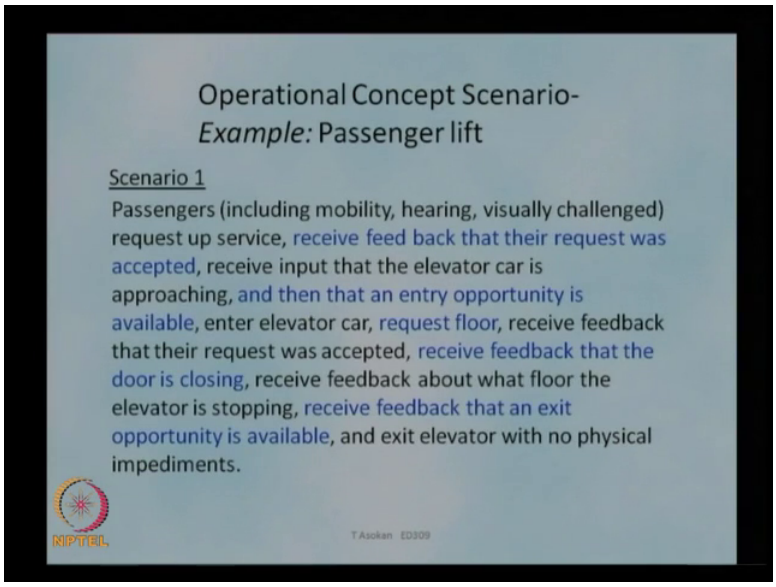

So, in order to develop operational concept scenarios we will try to identify various operational scansions which we can think of for example, if you take the case of an elevator which is very common in most of our buildings if you want to develop a system for elevator system for a particular building with multiple elevators or a single elevator we will try to make a simple concepts scenario, where we will say that we have 2 elevators in 2 sides of the building or 2 different locations and then this will be serving 2 different floors at particular frequency is a particular efficiencies or the performance characteristics.

And once we have this then we will try to identify what are the different scenarios under which this lift will be operated. So, we will try to define this scenarios in detail as much as detail as possible. So, that it will include almost all the details what we need to know about the requirements to be provided in the system for example, we take the scenario of a elevator passenger lift. So, we try to define the scenario in detail. So, we will try to explain it that the passengers including mobility hearing and visually challenged request up service. So, we are trying to include the disabled or the differently abled people also

into this so that the requirements to be met in the elevator will be different if we are not providing this particular requirement. So, we are including that also here we are providing the passengers including the differently abled people they request the up service and the down service they receive a feedback that their request was accepted. So, unless they receive a feedback they will not be knowing whether the elevator is working or not.

So, it is necessary to provide a feedback to the passenger saying that yes your request has been accepted and we will give a feedback that request was accepted and then receive an input that elevator car is approach. So, not only that the request was accepted it will also give an input that the elevator car is approaching and then that an entry opportunities available, so it should be informed to the passengers that an entry opportunity is already made available this is important especially because of visually challenged people they may not be knowing that has it has reached at the door is open. So, we need to ensure that in entry opportunities available and then the passenger will enter the elevator car and then request the floor and once the passenger requests for the floor the they should get the feedback that their request was accepted and then receive feedback that the door is closing receive feedback about what floor the elevator is toping we receive the feedback that an.

Accent opportunities available and exit elevator with no physical impediments. So, it clearly explains the whole scenario of using an elevator by a passenger from the moment he requests for a service to the action where he actually comes out of the elevator without any physical impediments it is important to say all these words like including mobility hearing visually challenged as well as exit elevator with no physical impairments all this will define the actual requirements to be provided in the elevator. So, this is just one scenario there will be multiple scenarios like this which will help us to identify various requirements for example.

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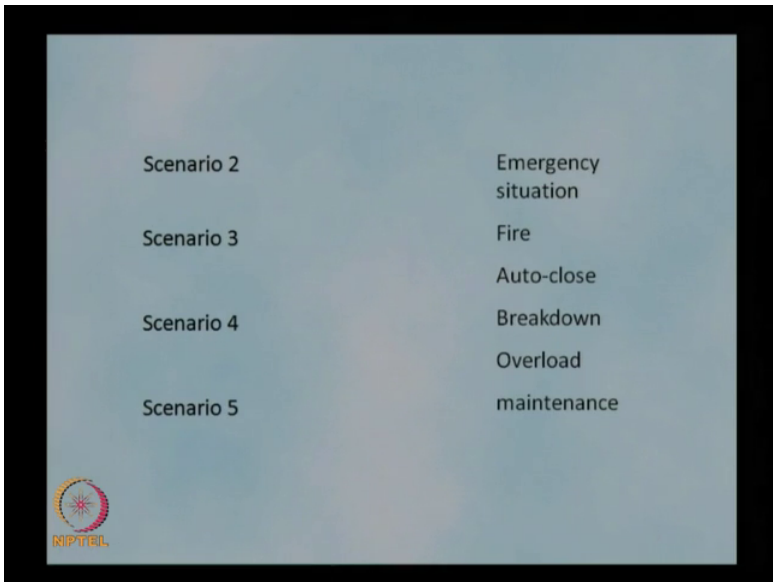

We can define different scenarios like emergency situation. So, what will happen if there is emergency in the lift that inside the lift door outside the lift? So, what are the things to be taken care of under this situation and that is a fire in the building. So, if there is a fire what will be the way in which the elevator should function whether it should provide the service or it should stop at the point where it is point inside the lift what should be the action to be taken. So, for that what are the other requirements to be needed what kind of communication system to be provided between the elevator and the building between the elevator and the emergency response team.

So, all those things will be identified in this scenario description similarly auto close breakdown overload maintenance all this scenarios can be clearly explained using the scenarios then we can identify those requirements for to meet such requirements. So, this will ensure that we are taking care of all the requirements all the scenarios and ensuring that the lift which is being this designed we meets the requirements of the customer to meet the various requirement under various operating scenarios.

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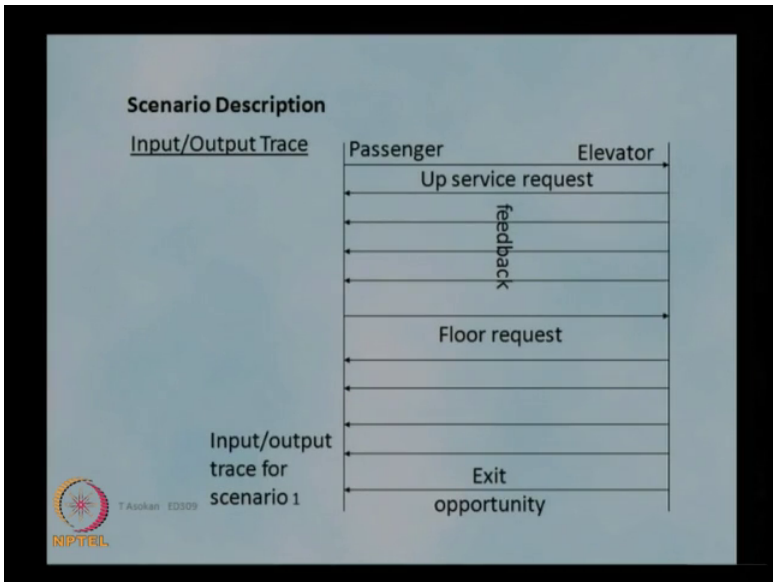

So, to describe the scenario we can actually use method called input output trace. So, here the input output trace.

Basically gives a picture will representation of the scenarios here we the vertical lines represents the interacting people the passenger and the elevator or the system components the system or the external system and the horizontal represents the communication between system and the external system. So, here the passenger is an external system and the elevator system is the main system which we are interested. So, we can identify what are the request going from the passenger what kind of feedback is coming back to the passenger and then what information is being sent from the passenger to the elevator based on the feedback given by the elevator.

So, all this can be represented in a pictorial way. So, that it is easy to understand for others especially the design engineers. So, anyone going through this will understand that the kind of interaction taking place between the system and its sub system or the external systems. So, this is the input output trace for the scenario one which we discussed we explained in the previous slide.

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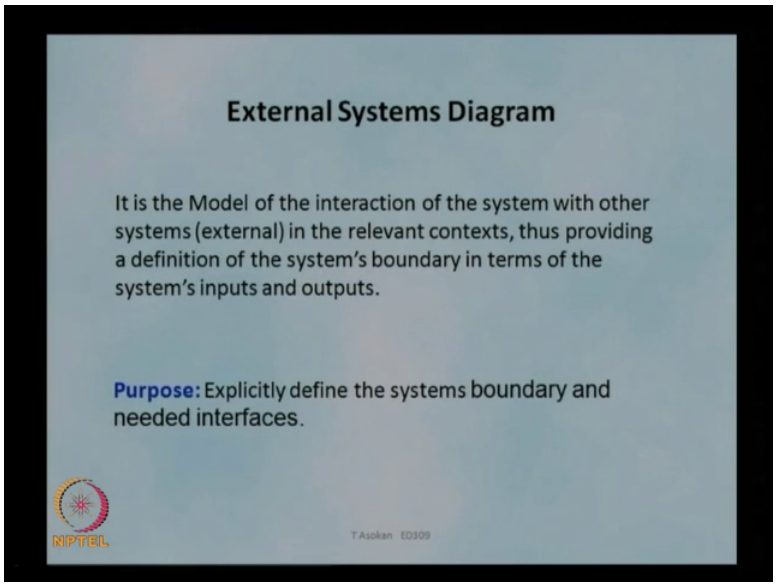

So, that was the about the input output trace for identifying the requirements for operational concept and another factor we need to take care is the external system diagram. So, as I mentioned the system interacts with the environment and another system. So, we need to identify the boundary in which the where we need to concentrate our design efforts for that we need to have the external systems diagram which is the model of the interaction of the system with other systems in the relevant context; thus providing a definition of the systems boundary in terms of the system inputs and outputs.

So, here we are define the system boundary in terms of the systems inputs and outputs the purpose of this one is basically to explicitly define the system boundary and needed interfaces. So, using this external system diagram will be able to define the boundary and the defined interfaces for the type of interface needed between the system and the external system.

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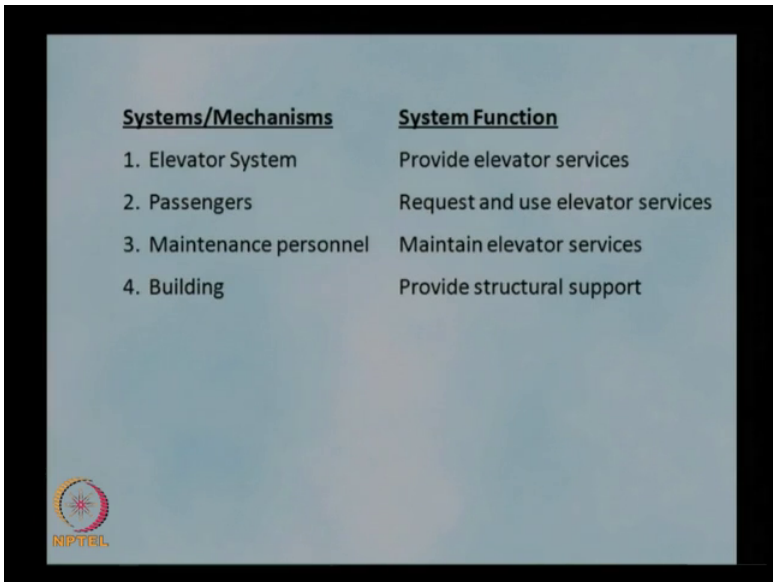

For example, we take the same elevator system we can see the elevator system is the main system provides the elevator services and there are other system external systems like passengers they request and use elevators service maintains service will be maintaining the elevator whenever there is a problem they will be attending to the elevator there is a breakdown or any other service requirements.

So, they are the people again will be interacting with the system then there is the building on which the system is the main system is installed, so that also influences the design of the system. So, this provide the structural support in provides the necessary safety features in provide necessary power connection. So, this also is interacting with the main system. So, we need to find out what kind of interactions are taking place between the system and the external systems.

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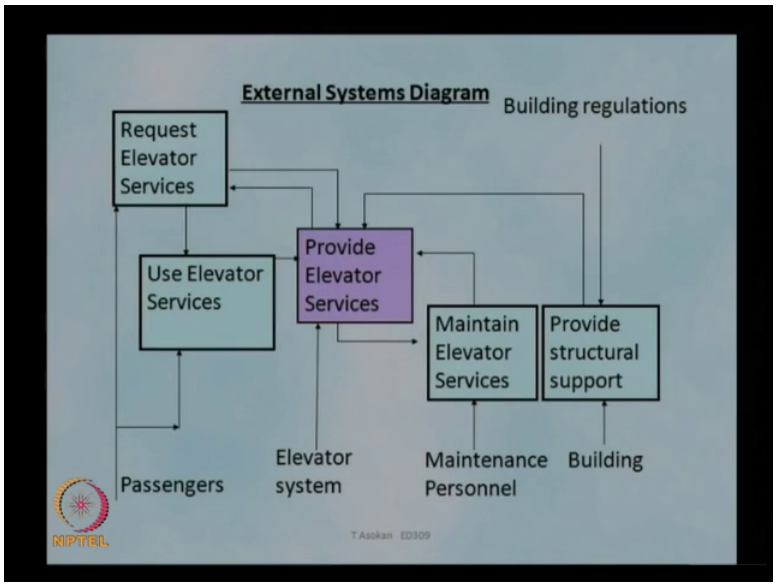

For that we will develop an external system diagram. So, this actually shows the systems diagram where the main function or the main system is here given as the function which provides the elevator services. So, the elevator system is the main system and others are the external system we can actually identify other external systems depending on the type of system there may be much more many more external systems, but in this case we are considered the passengers as one external system and maintains person as other external system and the building as external system and then building regulations which actually coming through the buildings and again interacting with the main system.

So, we can see here the passenger request elevator services that is one kind of interaction taking place and then they use the elevator and then will be giving input to the elevator only taking output from the elevator there is another kind of interaction taking place similarly the maintenance person will be maintaining the elevator. So, there will be some inputs and outputs going and coming to the; this particular external system similar the building also this is how we actually define the external system. So, what we need to look at here is this main system where we tried to provide the; we are developing this main system.

So, we need to provide the interfaces between this system and other systems at the design level itself we need to ensure that we are providing necessary interfaces with the external systems we identify all the kinds of inputs coming into this main system. So,

that the interfaces are capable of providing these communication between the system and the external systems.

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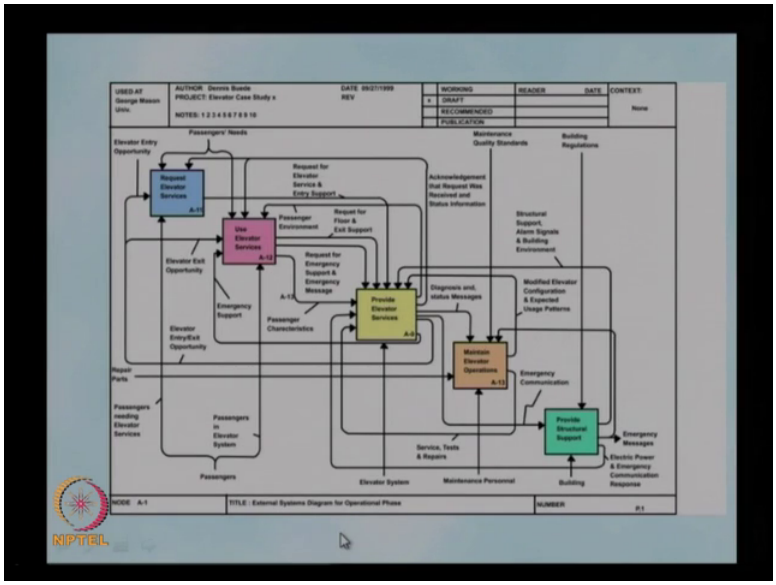

This is the standard way of representing the external system diagram this is known as an I dash 0 diagram, we will be going through this method of developing the system diagram latest stage which is modeling of the system using graphical tools. So, I will not going to the details of this at present what we try to do is to identify the functions.

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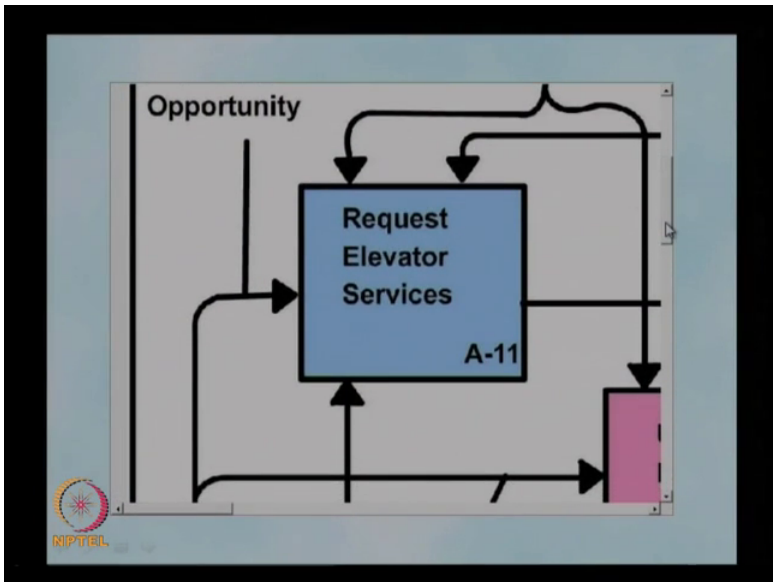

The requested elevator services is a function which actually is done by the customer. So, there is an external system function. So, we will try to identify what are the inputs coming into this particular block.

And then what are the outputs going from this blog; so which one this particular function is interacting with particular output is there an output going from the system you can see that there is an output going from here to the external system. And similarly the use elevator service is another function.

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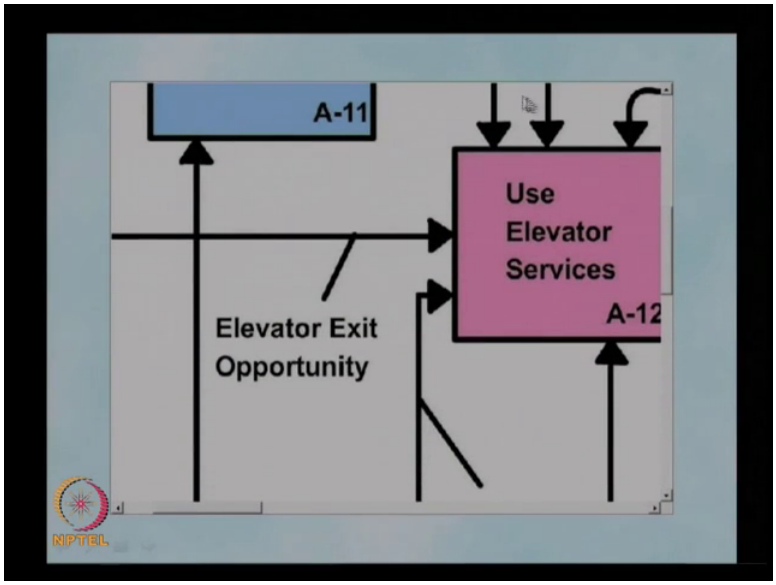

So, what was the output coming from here will be coming to here as a digital input. And then it will be going to the elevator services and then there will be passenger environment.

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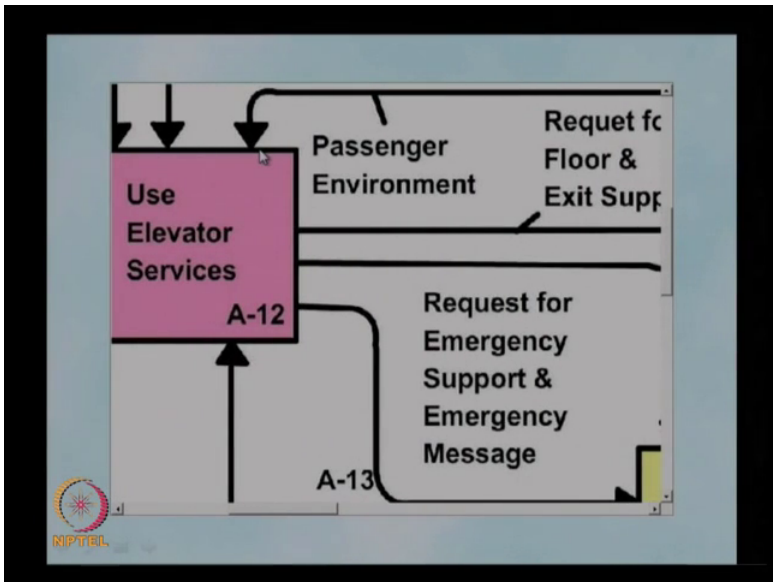

Coming as an external input to this and then the request emergency support and emergency message will be another output from here. So, all these inputs and outputs and the inter action will be properly recorded in a pictorial way basically to get a better understanding of the interaction between the system and the external system. So, these kinds of diagrams are used for a external system diagram, but again for the functional decomposition and then the functional structure and their physical structure of the system.

We will learn more about developing this kind of diagram at a later stage, but I just want to explain that you can use this kind of diagram I dash 0 diagrams to represent the external systems in the design stage.

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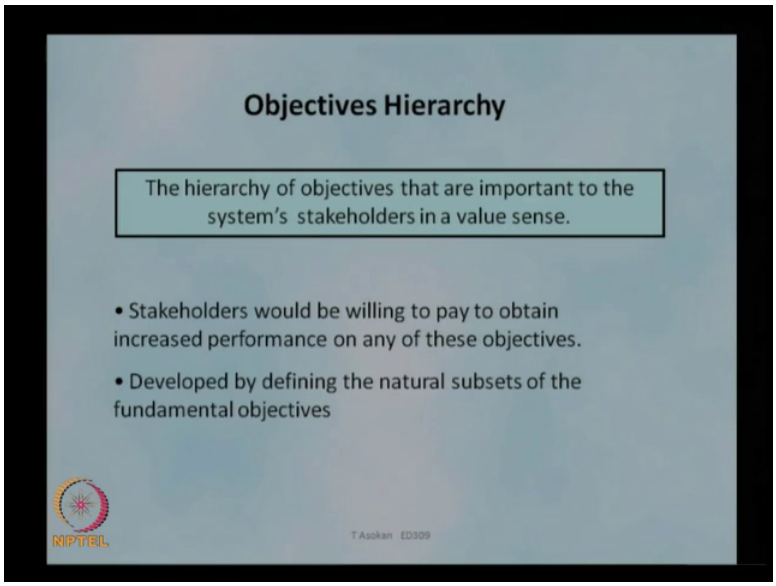

So, the next stage is the basically it would develop the objectives hierarchy of the system as I mentioned earlier the stakeholders will be having some objectives which actually they will explain to the designers that this system should meet the particular performance requirement particular operational cost limitations are there or particular operational efficiencies are to be maintained. So, this are the hierarchies this are the objectives given by the stakeholder to the designers, but since the there are many such objectives it is impossible to have equal weightage for all those requirements all those objectives what we need to do is to have a proper hierarchy of the objectives and identify which are the sub functions which actually contribute to the main objective and then give a particular hierarchy or weightage to each objectives.

So, that at a later stage if you want to make a tradeoff between the cost and the efficiency or the power requirement or the weight or the other physical requirements, then we can actually use this as a reference to make sure that we really meet the objectives without compromising on the customers requirement to the hierarchy of objectives that are important to the system stakeholders in a value sense are developed in the objectives hierarchy. So, what we do here is to understand what the customer is willing to pay. So, sometimes the stakeholders would be willing to pay to obtain increase performance on any of these objectives. So, the stakeholders will tell you if I can improve that particular feature the performance or the response time or the cost if you can reduce the cost I will be ready to spend more money to for the development stage the operation cost can be

reduced even if the development cost is slightly higher the customer would be ready to pay for that.

So, designer should understand what are the willingness of this other stakeholders in this regards and then this is developed by defining the natural subsets of the fundamental objectives for the fundamental objectives we can identify some natural subset. And, then we give different values to these objectives, and make sure that we have a proper objectives hierarchy which actually meets the stakeholder's requirements and their willingness to pay extra to obtain this particular requirement.

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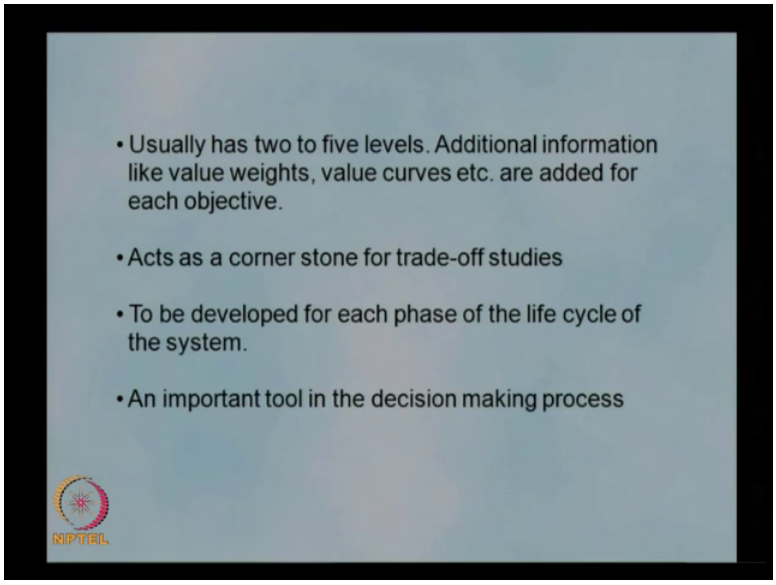

So, this hierarchy will be having 2 to 5 levels normally additional information like value weights value curves extra added for each objective its acts as a corner stone for trade off studies as I mentioned earlier if you want to make some trade of. So, we can be used as a corner stone and based on this we can decide whether to go for a trade off or not this is to be developed for each phase of the life cycle of the system. So, that is important for each phase of the life cycle we develop this kind of an objectives hierarchy this is an important tool in the decision making process.

Because at later stage if you want to make some decisions about trade off or any other decisions under uncertainty then this will become a important tool for the designer.

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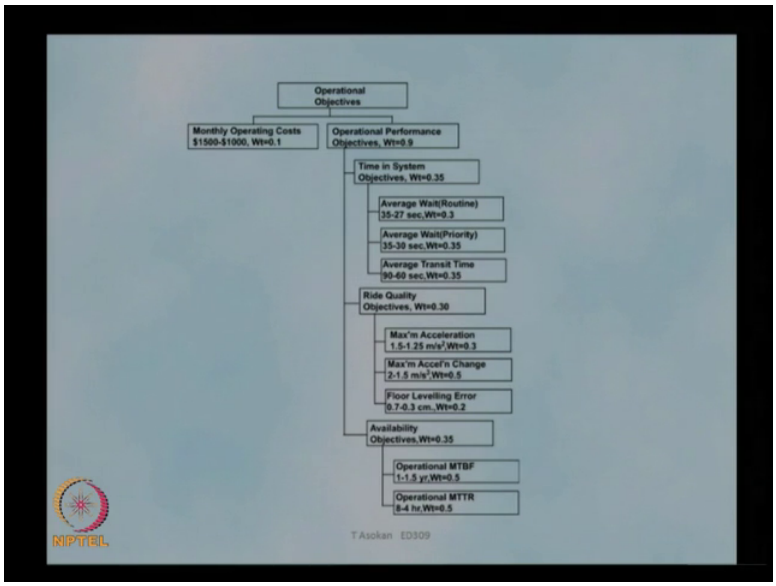

So, this diagram shows basically a objectives hierarchy. So, as you can see here will be an operational objectives which are defined by the stakeholder like the monthly operating cost would be 1500 dollar to 1000 dollar or the operational performance objective like that the elevator should the response to the customer is the passengers request within 1 seconds or 5 second. So, this are the operational performance objectives and this are the operating cost objectives. So, when you have an operating cost objective and operation performance objective we need to define we have to decide. So, what should be the weightage for this? So, here you can see that operation cost weightage is only 0.1 for more weightage us given for the performance objective. So, even if the operating cost is slightly higher the customer or the stakeholder is willing to pay more for operation performance objective.

That is why this given a higher weightage of 0.9. Now if we want to make the operational performance objectives we need to identify what are the other sub objective or the other functions or objectives is actually contribute to this main objective. So, we identify all these objectives and then give weightage to each one like the time in system the ride quality or availability of the elevator.

So, in the case of an elevator you can find out how much time is taken by the elevator to move from one floor to other floor which is represent in terms of a time in system similarly the ride quality how comfortable is the ride inside the elevator and availability

how much it is available to the passenger whenever it is needed. So, whether the availability is good availability is there or not. So, this are the 3 things which are actually decides about the operation performance objective. So, again these 3 we need to give weightages. So, depending on the again based on various analysis there are various analysis tools which can be actually be used for this weightage.

So, based on this those analysis we will be doing the weightage the time in system objective by 0.35, 0.3 and 0.35 again; this depends on the designer based on his own understanding and some analysis you will decide what should be the weightage to be given for each one and again we can find out the other sub objectives or the which actually form to this main one. So, the time in system we can see that average weight average weight for priority and routine and average transit time.

So, these are the 3 which actually decides about the time in system again we can give weightage for these 3 and in the case of ride quality we can see the maximum acceleration change and floor leveling error. So, these are the 3 things which actually decides at the ride quality. So, based on this we can give the weightage for this 3 and similarly for availability are. So, we can give a weightage meantime between failure and mean time between replacements. So, this weightage is also can be given.

So, once we give this that actually shows that for this particular operation performance objectives this are the sub objectives which are actually contribute to the main one and then we give weightage for each one and then later on when the design staged if you want to make some tradeoff between the MTBF and MTTR, we can find out these are equal weightage. So, we can make a trade off in any one of these, but in the case of here you can see that maximum acceleration as got a 0.3 and leveling average weightage of 0.2. So, solve based on that we can decide which one we should give priority to achieve. So, this objectives hierarchy helps the designer to understand or to make a decision at a later stage for trade off analysis.

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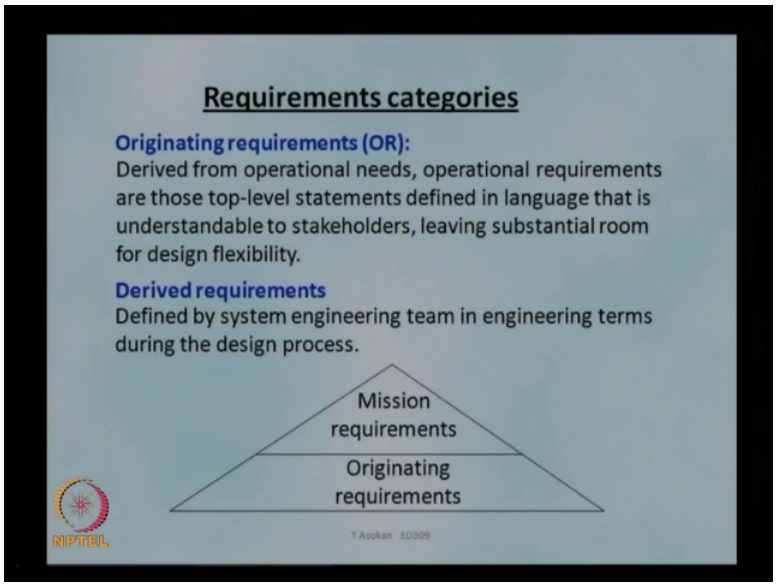

So, that was the first level were we developed the operational concept for the system and once we have this operational concept we need to develop the requirements for the system for the requirement analysis, we can divide this requirements in to different categories like originating requirements.

And derived requirements the originating requirements are basically derived from operational needs. So, the operational needs are identified in the concept level. So, we know that do that particular concept implement that particular concept there are some operational needs and this this actually defines the operational requirements there the top level statements defined in a language that is understandable to stakeholders leaving substantial room for design flexibility.

So, these are actually understood by the stakeholders because stakeholders are the people who really tell what is; what are the operational needs. So, the requirements also should be understood by them clearly. So, we should define any language that is understandable to stakeholders leaving substantial room for design flexibility. So, this is one important aspect we should not be we should not make it to reject the requirements because then there will not be much freedom for the designer or much flexibility for the designer at a later stage. So, we should give substantial room for design flexibility and there are derived the requirements which are defined by system engineering team in engineering times during the design process.

So, derived requirements are basically which the requirements which are identified by the system design is which are we needed to satisfy the originating requirements. So, originating requirements alone may not be satisfied because there are many other requirements like there external systems there are regulations. So, in order to meet all those requirements the design team will identify some requirement they are the derived requirements.

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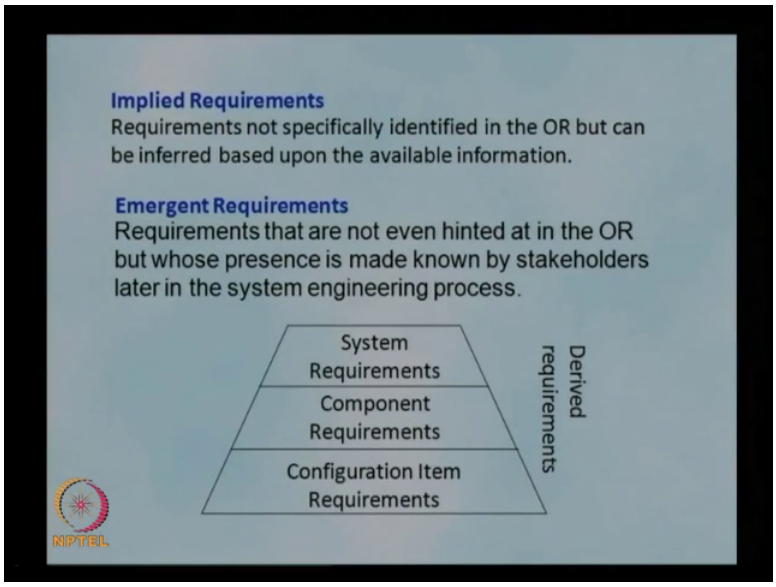

Then we have this implied requirements the requirements not specifically identified in the originating requirement, but can be inferred based on upon available information. So, these are the implied requirements which are applicable depending on the system context and the environment in which the system is operating. So, this requirements are very implied and they need to be included in the system requirements analysis and then we will be having some urgent requirements the requirement that are not even hinted in the originating requirements, but whose presence is made non by stakeholders later in the system engineering process.

So, once we start the system engineering process the stake holders may come up with the new requirements saying that we identified some other requirements. So, we need to incorporate these requirements also into the system. So, these kinds of requirements are known as emergent requirements the design process we should have the flexibility to incorporate such requirements to the maximum extent possible so that the customer will

be happy with the system that is designed and developed for them. So, the requirements as we mentioned the originating requirements derived requirement and implied requirements and emergent requirements are important in the analysis of the system requirements as you can see here in the slide.

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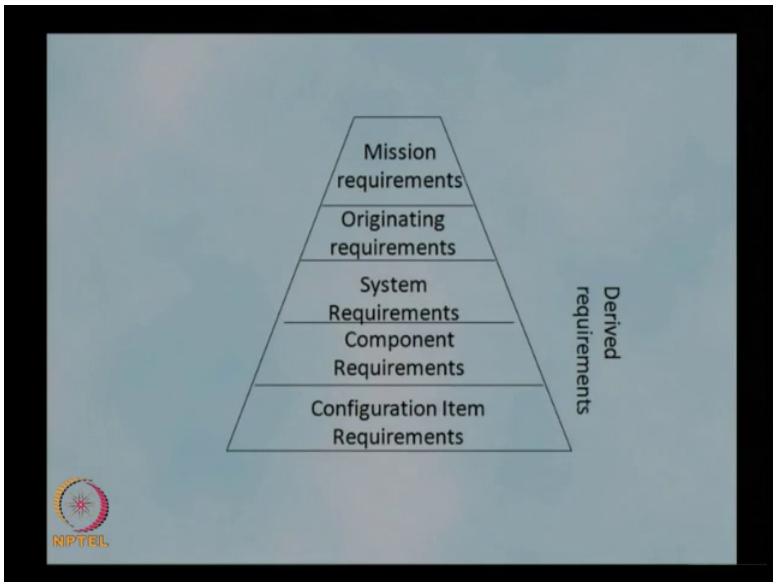

So, this is the hierarchy of the requirements as we can see the top level is the machine requirement which are identified by the stakeholders and then based on this machine requirements, the originating requirements are identified by the system designers which can actually be understood by the stakeholders. So, the stakeholders will accept yes this is what we want from this particular mission.

So, these are the originating requirements then based on this originating requirement the system requirements will be developed by the developers and the system designers basically you need to address in we will be knowing where to go and how to from where this requirement came and can have a close look at that particular scenario and then decide whether to really have that requirement or not. So, this is basically about the development of requirement. So, we need to actually go to the next level were we develop the originating requirements document. So, there are some procedures and some standard formats to provide this particular requirement.

So, we will stop this lecture today at this point in the next class. We will look at the writing of originating requirements document and what are the specific issues, we need to address when we write the originating requirements document, till then bye.