Principles of Engineering System Design
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Lecture – 02
Engineering Systems Classification & Examples

Hello friends, welcome back. In the last lecture we introduce the concept of system engineering and the basic principles of system, what is the basic definition of system, how the system engineering evolved over a period of time, what is the importance of using system engineering in various applications and what are the complexities involved in designing system for various complex systems.

So, today we will discuss little bit more about system engineering some of the basic principles before we really get into the actual design of engineering systems.

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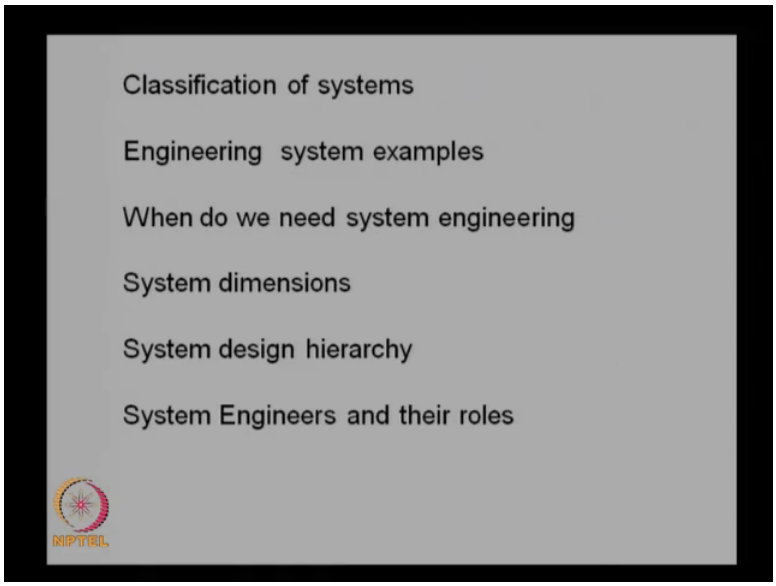

So, this lecture is divided into two parts in the first part and I will be talking about the classification of a systems basically the natural systems and artificial or manmade systems and we will talk about the engineering system examples, when do we need really to use system engineering and what are the system dimensions basically what kind of social and technical dimensions are there for the engineering systems. And then we will talk about the system design hierarchy and then the role of system engineers, how system engineers play a vital role in design development and execution of engineering systems.

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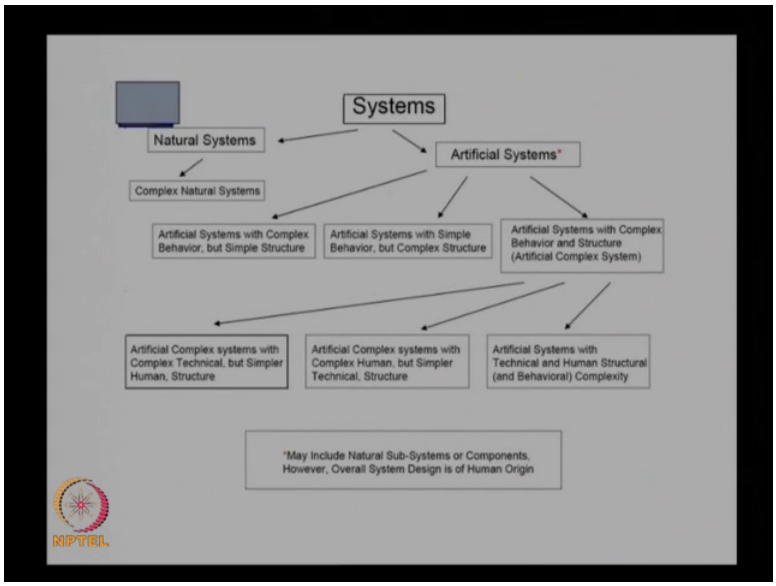

So, let just look at the classification of systems as we explained in the last class we found that the there are various kinds of system there are a manmade systems and there are natural systems. So, we can basically divide these systems into two classes, one is the natural systems and the other one is the artificial systems.

As you know naturally systems is the existing in the nature. So, human body is a system ecosystem is there then we have the systems of planets and other celestial bodies. So, these are the natural systems and there are complex natural system which is a human body is an assembled where the complexity of the system is still not understood fully. So, that those are the examples for a natural system where some of them are very simple, but some of them are very very complex which is beyond our analysis at this stage. Then we have the artificial systems which are basically man made. So, in manmade system we can classify them into many classes depending on the complexity and human involvement.

As you can see in this picture there are artificial systems with the complex behavior, but very simple structure and we have artificial system with complex behavior and structure. So, there may be complex behaviour as well as the complex structure for the artificial systems. But then we have systems with the human intervention or human behavior like artificial complex system with the complex technical, but the simpler human structure then we have artificial complex systems with complex human, but simpler technical

structure and artificial system with technical and human structural complexity. So, there are depending on the system type we can actually find whether this and actually classify them whether they are complex in human behaviour or complex in technology or the technical behavior.

For example, if you take operation of a missile system it is more of a human complex human behaviour and when you take the design of a missile system it is more of complex technical behaviour. So, depending on the context in which we use the system engineering we can actually divide them into human behavior, system with the complex human behaviour or complex technical behaviour. So, manmade natural system or components also may include in this systems because there maybe some natural subsystem which is part of the manmade systems. This is the basic classification of the systems.

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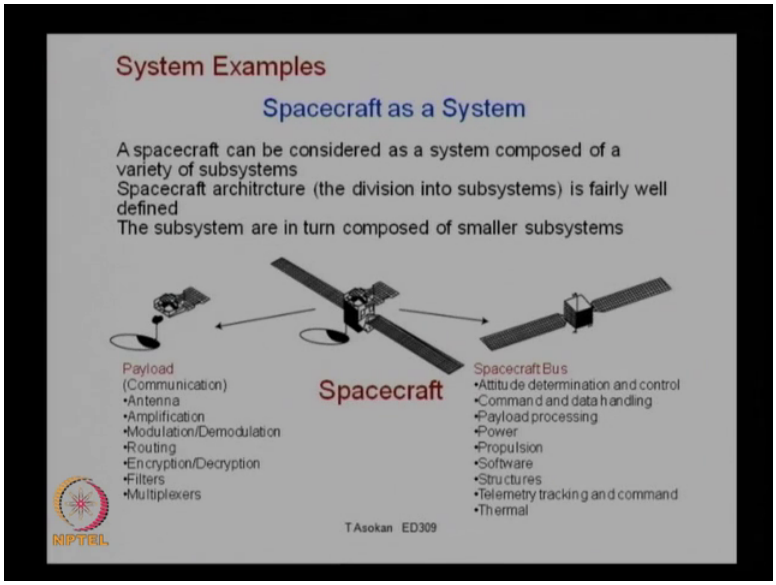

Let us just take few examples for these systems and then try to understand what are the subsystems involved and how they have become part of a larger system or a subsystem or some other system. Take them for example, spacecraft as a system as all of you know it can be considered as a system composed of a variety of subsystems so every spacecraft has got many subsystems and this spacecraft architecture it is well defined because if there is a well defined structure for the aircraft architecture and the subsystem are in turn composed of very smaller subsystems.

For example, you take the communication subsystem or the payload subsystem of a spacecraft as you can see communication is payload in a space craft and we can consider this as a subsystem of the spacecraft. So, you can see here there are many other system part of the a payload, you can see that antenna is a part of the communication payload, amplification, modulation, demodulation, routing and encryption, decryption, filters multiplexers these are all becomes part of the subsystem of the spacecraft.

Similarly, you have the spacecraft where attitude determination and control is there, command and data handling is the payload processing is there, then power, propulsion, software, structures, telemetry, thermal systems. So, these are all becomes part of the main system. So, if you take spacecraft as a system then you can find these are as the subsystem of the spacecraft.

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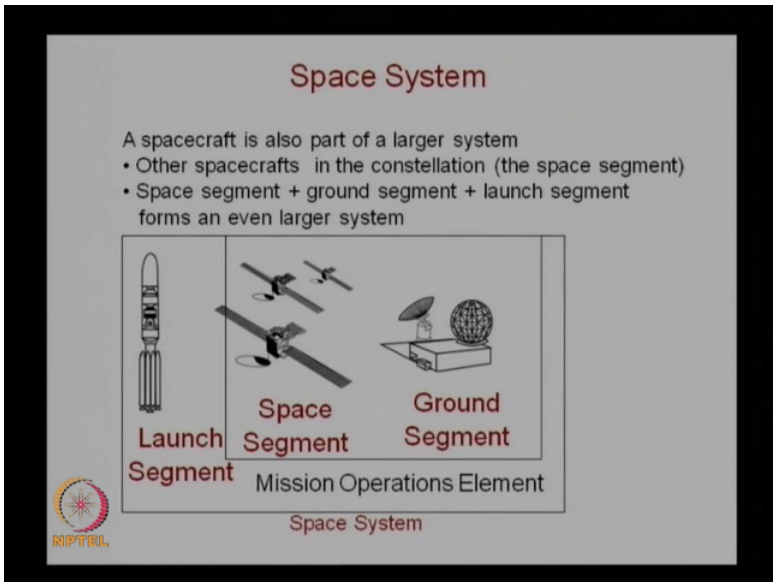

But if you take the space system as a whole system then you will find that the spacecraft is a part of a largest system which is the space system. We will have many spacecraft in the space system which is the other spacecraft in the constellation, then you have different segments for the space system like you have the ground segment, then you have the space segment, then you have the launch segment. So, this all becomes a subsystem main system of the space system.

Though spacecraft can be considered as a system by itself when we define the space system then the spacecraft becomes a subsystem of the main space system. Thus any

system can be considered as a subsystem of a larger system or can be considered as a system by its own merits. So, it depends on how you actually define the system and what actually are going to design. So, depending on that we need to define what is that particular system and what are the subsystems of the main system and then how do you define the boundary of the system and the subsystems. As you can see here these are the this actually shows the space system where there is a launch segment, there is a space segment and there is a ground segment which are all part of the main space system.

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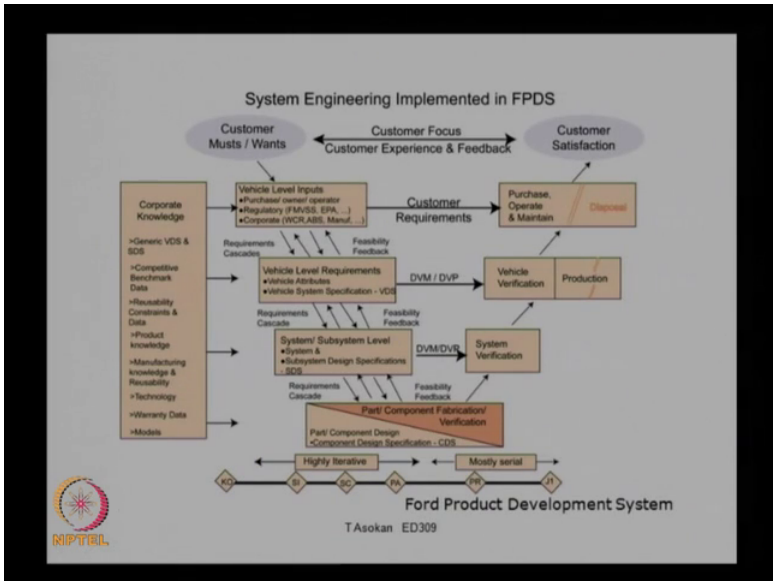

This figure again shows another diagram which actually shows the product development system for ford motor company. We will not go into the details of this figure as we will be discussing it in the later stage when we discuss about the product development process or the system development process, we will discuss about in detail. But it shows that how from the initial customer requirements the customer satisfaction is achieved through various processes and how it passes through different stages of design fabrication, testing, integration and then validation and then to reach the customer.

So, this again the development it becomes a part of a major system or the product development system. We will discuss this detail at a later stage.

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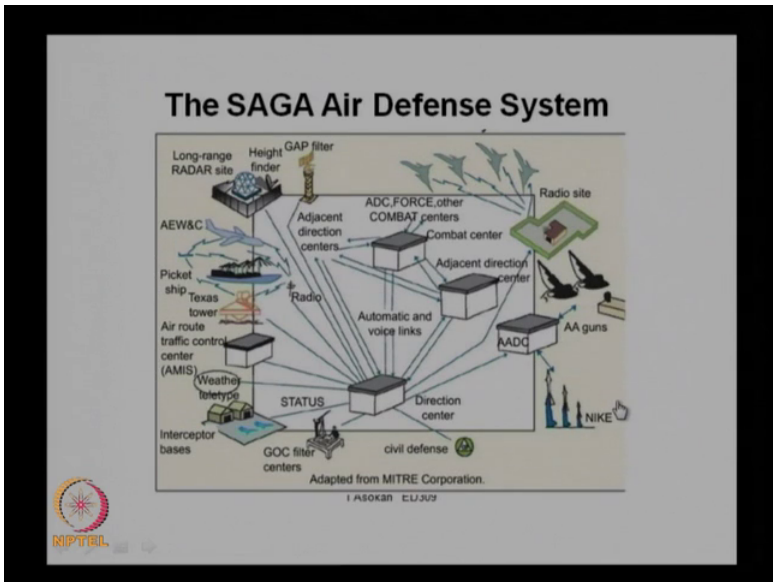

This is another example for the system complex system manmade system which is the air defence system. As you can see that air defence system as got various subsystems something can be in the air or something can be on the ground and something can be completely controlled by the man or completely automated with the different sensors and signal processors kept at different locations.

As you can see they are radar sites which actually used to find out the locations of the aircrafts then there are early warning, and control systems which actually consists of many aircraft and other sensor suits. Then we have the traffic control air traffic control centre which actually controls the movement of air traffic then you have this interceptor bases where the air defence systems are placed from where they actually take off and then carry out the missions.

Then there are civil defense applications for this particular system. So, civil defense senders will be sending information to the main database center or the control centre then we have the amination systems with various location, there are radio sites for transmission of signals. And then we have all those base centers which actually coordinates them in activities of various centers in pass part of this system.

So, to as you can see it is a fairly complex system with the various subsystems and lot of interaction between these systems and therefore, the system engineering concept is well suited for this kind of a complex man made system.

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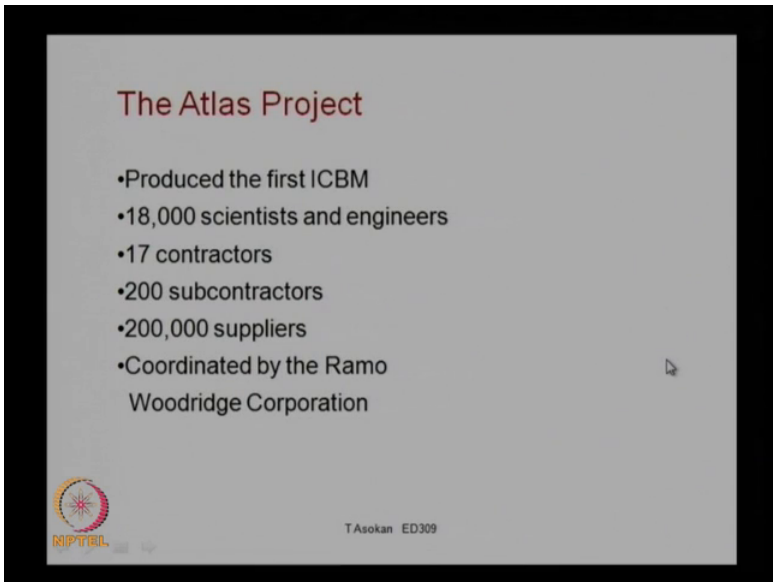

This one we discussed in the previous class about atlas project as you can see there were 18,000 scientists and seventeen contractors with 200 subcontractors and 200,000 suppliers and the whole process coordinated by Ramo Woodridge Corporation.

So, again you can see that there were 200,000 supplier. So, you can see the complexity of human involvement in this particular project apart from the technical complexity of designing the missile there were it is actually a larger complex human behaviour involved in this system and therefore, we need to look at the human interaction and human behaviour aspects in the design of systems.

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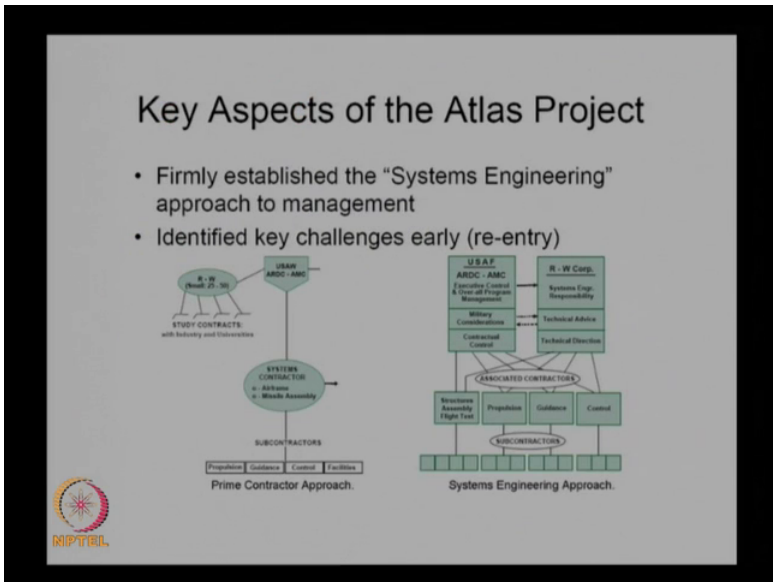

These are the key aspects of the atlas project. So, this actually was the one of the project which firmly established the systems engineering approach to management. It identified the key challenge early in the system that are what are the key challenges in its reentering the atmosphere what are the challenges, so all those things were analyzed initially itself and then the system design process are preceded. As you can see here this figure shows the interaction between various entities in this particular project as you can see there is air force one agency which is most of the customer in this case and the RW corporation is the agency which actually coordinated the whole design process. Frequently there were a lot of interaction between the customer and the contractor at different stages and this military considerations and a contractual control were actually coordinated by the RW corporation with what are the requirements of army and how do they actually include those requirements into the system design.

And then there were many other subsystems like propulsion system, guidance system and control system and then there were many sub contractors which are designing developing and supplying some of the components and the systems for this. So, you can see there is a very good hierarchy of information flow as well as the assignment of task and responsibilities and this actually calls for the principles of system engineering and that is why this was one of the project which firmly established the principles of system engineering approach to management of a large scale engineering systems.

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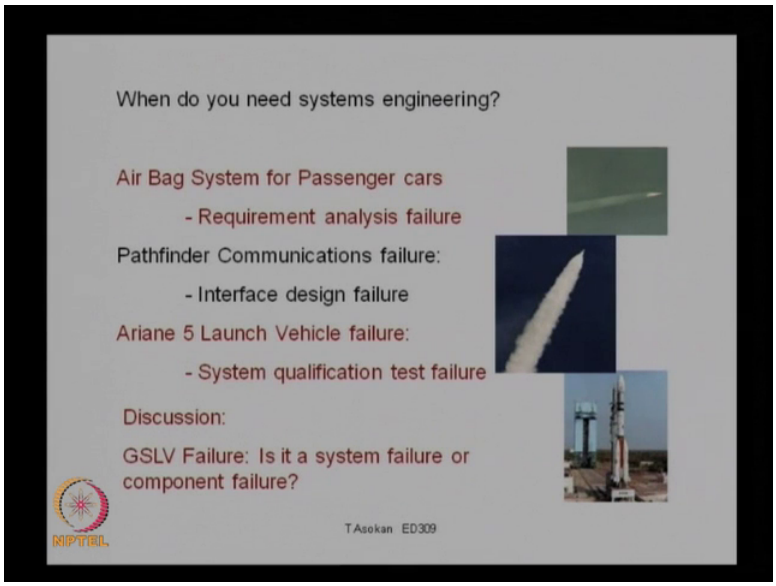

So, that there are different kinds of a systems and there are different kinds of complexities in the system. But then we need to find out when do you need to really apply the system engineering concepts where are the projects are good candidates for a system engineering or there are projects which does not warrant the need for a system engineering concept. So, how do we decide this based on our approach to the project or based on understanding of the project?

We discussed about some of the failures in the previous class system engineering failures in the previous class where actually we discussed about the air bag system failure for passenger cars and we have found that there was a failure in the requirement analysis of the project. There was a failure in pathfinder which is again a space system where the communication failed in the pathfinder this was because of the interface design failure and then Ariane 5 launched vehicle failure we discussed these are all various example for system failure and whether there are the candidates for the application of engineering system design. If you look at we need to find out the real causes of system failures to see what actually really happened in the system or what actually caused the failure of the system.

Now, this discussion point for you can actually find out from the literature or through discussion with your friends or your colleagues what actually happened in our GSLV failure. So, we know that our geo synchronous launch vehicle have failed recently and

there were many icons for the failure of the system. So, probably you can identify that there was a system failure or it was a component failure.

So, probably we will be able to distinguish between these two what actually happened whether it is a there was a failure in the whole system or the process of a development of a system or there was a component failure which actually more of a an engineering failure which actually the fail to meet the desired design requirements of the that particular component. When you analyze these kind of these kind of a failures then we will know that whether it was a problem with the technical design of the system or it was a problem with the whole system design.

So, based on that we will be able to tell, oh this was a failure in the system engineering and therefore, we need to look at the process and procedures we followed for engineering the system and accordingly we need to go ahead with the design of the system or apply the principles of a system design.

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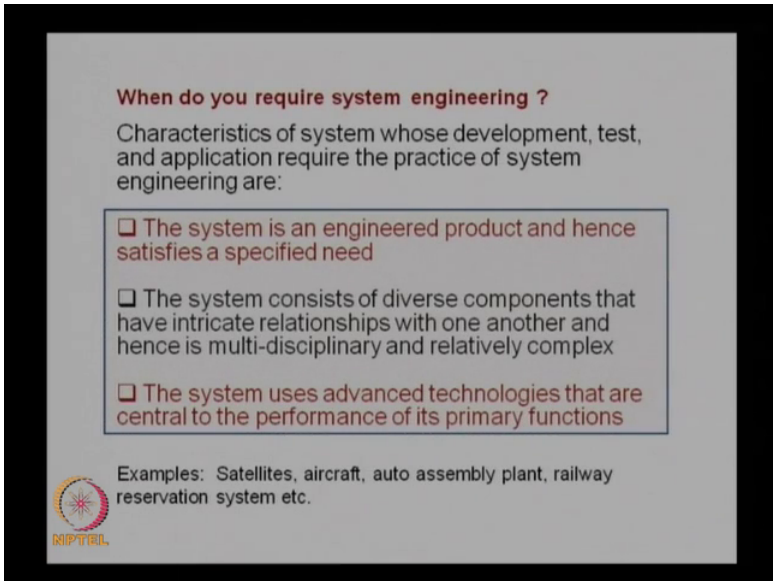

So, let us just look at what are the criteria went for when we decide to take the system engineering principal for a particular project. The characteristics of a system whose development test and the application required the practice of system engineering that the system is an engineered product and hence that specifies a specified need. So, that is one of the basic requirement it is an engineered product and hence satisfies a specific need most of the systems actually satisfy this requirement.

The system consists of diverse components that integrates relationships with one another and hence it is multidisciplinary and relatively complex. This is one of the important aspect we need to look at what are the different components and different systems or subsystems which comes as part of this one, what are the discipline or the technology domains we need to have to achieve the target or the achieve the function of the system. So, once we know that there are people who domain expertise requirement and multiple technology requirements and there are lot of interaction between these different domains then it will be a very good candidate for system engineering because multi system or multi domain interactions cannot be normally captured in the normal design process and therefore, we need to try to incorporate these factors into the design or we have to take in to the count these factors when we consider the system design and then we need to make sure that we apply the system design principles to such designs.

Then another factory that the system uses advanced technologies that are central to the performance of its primary functions and there are advanced technologies which are not well proven at this stage or it is still in the development stage the advanced technologies then probably that it is a very good case for system development because system development actually system development principle basically takes care of the modeling simulation verification and validation of different technologies before we are really implement those technologies into the system.

So, if any system which actually satisfies these three conditions, but the system is an engineered product and have a particular specified need and it actually warrants the use of multiple disciplines as well as technologies and there are newer or advanced technologies which are being used in many system then such systems are a good candidate for application of engineering system principles. Some of the examples for such systems are the satellites man made satellites aircraft auto assembly plant railway reservation system. So, these are all some of the system or an engineering system manmade systems where we can really use the principles of a engineering system design to achieve the desired goals from the system. Because they are all satisfy these conditions their multi domain expertise needed there were lot of interactions between different domains and different subsystems and there are advanced technologies used.

So, for example, if you take the railway reservation system which is one of the best online systems we have for rebooking of a railway tickets you know that there are

multiple subsystem, there are customers, there are booking agents, there are railway station booking facilities, there are centralized servers and there are payment agencies. All these are interacting with the main system and they are using the latest technologies of communication and networking as well as data analysis and data processing.

So, that becomes a very good candidate for applying the principles of system engineering when we developed systems like this systems of complexity like this.

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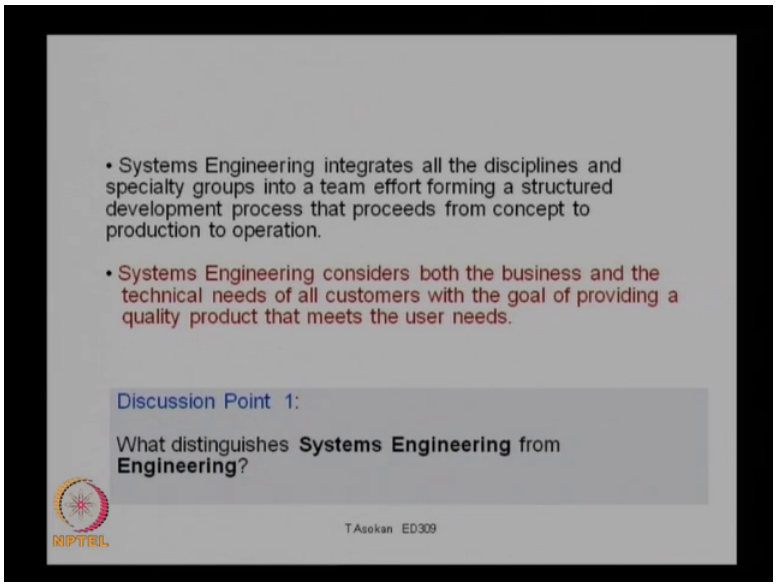

So, in the previous class the system engineering which actually integrates all the disciplines and speciality groups forming into a team effort forming a structure development process that proceeds from concept to production to operation. So, if you apply these principles of a system engineering we can actually have a structured design process its actually we will start with the development process and proceeds from concept to production to operation of the system. And it considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs.

So this is again a discussion point for you we discussed about the system engineering in detail, so what actually system engineering in when do we in order to use the system engineering principles what are the basic requirement of applying system engineering. So, probably you can have a discussion what distinguishes system engineering from the normal or the conventional engineering, what are the factors which actually distinguishes

from a system engineer, how a system engineer is different from a conventional engineer or a domain expert. So, this will actually help you to understand the system engineering concept in a better way and appreciate the importance of system engineering in developing complex engineering systems.

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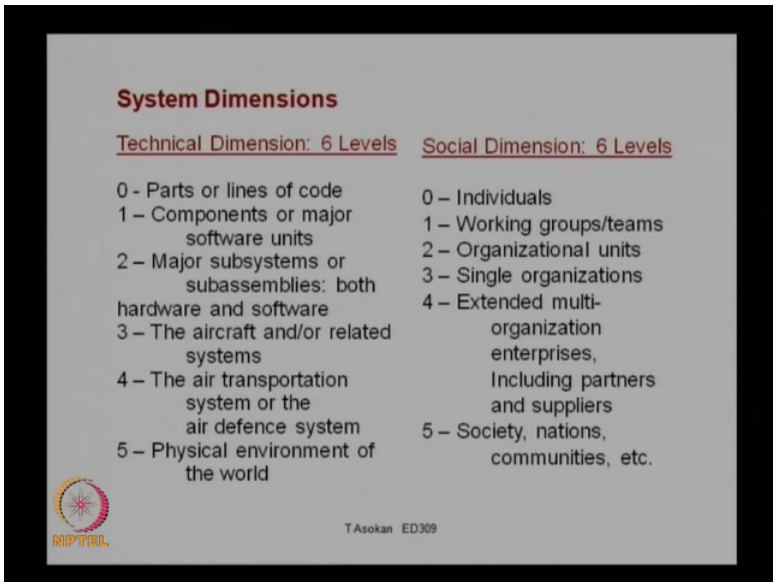

We discussed about the system and then as I mentioned this system has got a technical component as well as a human component because there are complex human systems and complex technical systems.

So, let us just look at what are the technical dimensions of the system as you can see there are 6 levels of technical dimension for any engineering system. So, you will start from the highest level it is basically the physical environment of the world were actually the system operates. So, we call it as the system context. So, every system will be operating in a particular environment so that environment becomes the dimensions of the system because all these dimensions are important in system development because all these dimensions have impact on the system or the system can be impacted by those factors.

So, if you look at the highest one then it can be a physical environment of the world and then we can have different levels if I start from the lowest level at that is zero that becomes the parts or lines of code of a system. So, you will be having many small components which are of the cell for which does not require any specific design, like you

have nuts bolts and other kinds of screws and small fascinates becomes parts or a small parts or the zeroth dimension of an engineering system. So, if you take the software then the lines or code becomes the zeroth dimension of this technical dimension.

The next level is the components or majors of their units. So, if you have main components of the system that becomes the first level dimension or the major software units in the case of software. The third level is the major subsystems or sub assemblies. So, you will be having subsystems or sub assemblies in a system that becomes the third level of system, but in the case of a software then the software becomes the next level where you have subgroups or the sub particular group a software which actually carry out a specific task.

Then the next level is the larger system which is an aircraft if you take the space system or air transportation as a main systems then aircraft becomes the next level of component or next level dimension here or anywhere system related to that. Then the higher level is the air transportation system or the air defence system. So, if you consider that as a whole system then air transportation or air defence becomes a major system and the highest level is the as I mentioned it is the physical environment or the world in which it operates. So, these are the 6 technical dimensions of an engineering system and all these technical dimension has got impact on the system developments. So, every system can be in begged by these dimensions and therefore, we need to make sure that we take into account all these parameters into consideration when we design our system. So, that is about the technical dimensions.

Let us look at the social dimensions. So, every system has got because it is some social impact where as the human is involved and it is mainly designed for human use and therefore, there is a human intervention or human impact on the system and that is why we have a social dimension for the system. Again we can have 6 levels of social dimensions, so the highest level again it is a society nations or communities where the system is being used. So, depending on the country or depending for the society where it is being implemented we can say that it becomes the highest level of a social dimension for the engineering system.

Then the lowest level is of course, the individuals who actually directly interact into the system or directly involved in the recent development used or maintenance whatever

way he interacts with the system that becomes the zeroth dimension of the engineering system. Then there are working groups or teams either development teams or the operation teams or maintenance team they are becomes the next level of social dimension. Then the organization units where the particular organization where they are developing they will be design team there will be a fabrication team, there will be machine maintenance team. So, there becomes a third level of dimension which is the organizational units.

Then single organization or the next level where the larger organization like drdo becomes a single organization with many labs across the country. So, each lab becomes a single organization which is the fourth dimension level dimension. Then there are extended multi organization enterprises including partners and suppliers. So, this actually is a group of supplies consumers and subcontractors they are become the fifth level of extended multi organization. So, if a company is developing a particular system then there are many suppliers quality assurance teams there are organization which monitor the quality of the system, there are organization which actually is going to finally, use it they are also part of the system. So, like that there are extended multi organizations which actually becomes part of the fifth level of social dimension and the last one is the society as I mentioned where actually we are going to use the system that becomes the fifth level of the society as a social dimension.

So, as you can see there are technical and social dimensions for an engineering system and therefore, we need to look into the aspect of the social aspect as well as the technical aspect of the system design when we start the design and development of an engineering system which is finally, going to be used by the customers where there are a lot of human interaction as well as there are technical complexities.

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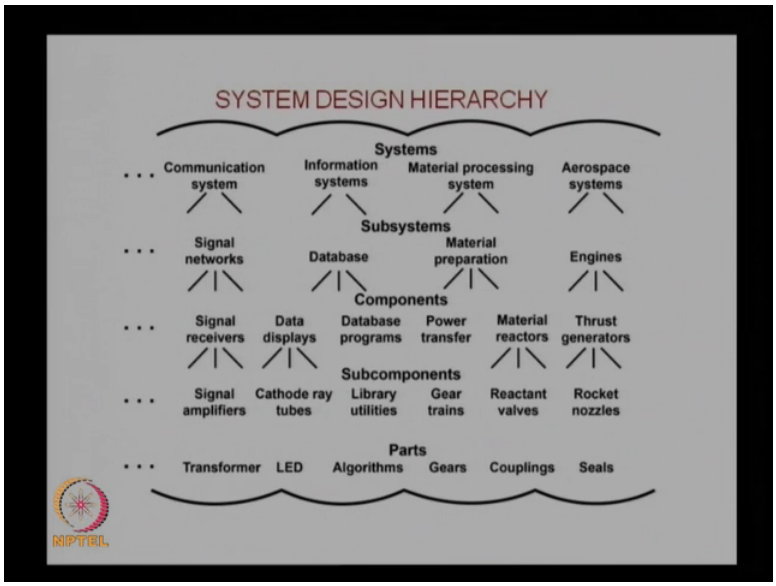

So, we discussed about the different dimensions of the system and I told you that there are different technical dimensions for the system. So, you can see that as I mentioned there are lower level parts or components which actually becomes the zeroth level system dimension. Then there are sub components were actually the signal amplifier cathode ray tubes or gear trains or walls or nozzles becomes the sub components.

Then we have the components like a signal receivers data displays power transfer material, reactors, thrust, generators and etcetera, then we have the subsystems where as signal networks database material preparation engines etcetera are being used for developing the final system and you can say these are the communication system can be a system on its own merits. And then there are information systems material processing system aerospace systems. So, these are all the a top level and of course, when you use these systems for another system then these becomes sub systems of the another major system like air diffence system if you take as a system then this communication information which will processing all these becomes the subsystem of the main system. So, that was about the system in general.

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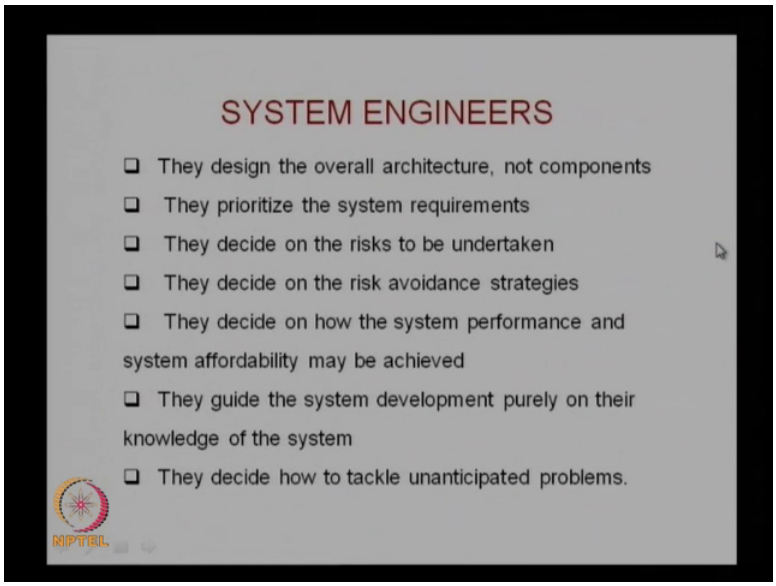

Then we need to see who are the people who design it and what they actually they do. So, these people who are actually responsible for a design development and integration and verification validation of a engineering systems are known as system engineers, they are different from the engineers or the domain experts like mechanical engineer or electrical engineer or an electronics engineer system engineers are not the exactly the domain experts, but they are more like a people who actually see the big pictures and try to integrate many things into a single piece. So, they will be having the larger picture of the system and they know what can go wrong what are the issues coming up.

So, they will actually do the troubleshooting and then make sure that the system development process goes takes place in a structured manner without any problems. So, the system engineers are those who design the overall architecture, but they are not the people who really design the components the component design is basically done by the domain experts or the engineers or mechanical engineers or electrical engineers. They prioritize the system requirements, there are different requirements for the system those who are designing the component may not be knowing what are the actual requirements of the original system which the component is a part.

So, the system engineers are the people who actually prioritize the system requirements and design the components or identify the components or the requirements of the components and then pass it to the design engineers and the system engineer's people

who decide on the risk to be undertaken. Then there may be many inherent risk in developing a system because every system means a totally a new system and there are different technologies employed and therefore, there are risks involved in designing the system or using a particular technology.

For the system and they try to understand the risk involved they try to understand the risky involved they try to ensure that the risk what they are taking is a calculated risk or it is a risk understood by the designed team. So, that they are prepared to make the changes whenever it is necessary and they are they decide on the risk award and strategies also. So, when they identify a risk they will try to see the risk can be avoided and so they have built in functions and procedures to avoid the risk and then they decide on how the system performance and system affordability may be achieved. So, affordability is another important aspect. So, then you do they are the people who can actually look at the performance requirement from the customer and the business aspect of the system.

They need to have a proper balance between these two. So, they will analyze the system performance and system affordability and then go ahead with the choosing particle technology or components. They guide the system development purely on their knowledge of the system. So, there the people who really know the complete system they know what actually is expected from the system what are the subsystem going to come in the picture and what are the types of interaction going to happen between the system. So, they guide the system development based on this the knowledge what they have for the particular system and they decide how to tackle unanticipated problems.

So, it is very common that there will be a lot of problems coming up in the development process. So, they are the people who actually tackle the all these unanticipated problems and then take the design forward or the system development forward to ensure that it is delivered in time and with the decide performance requirements.

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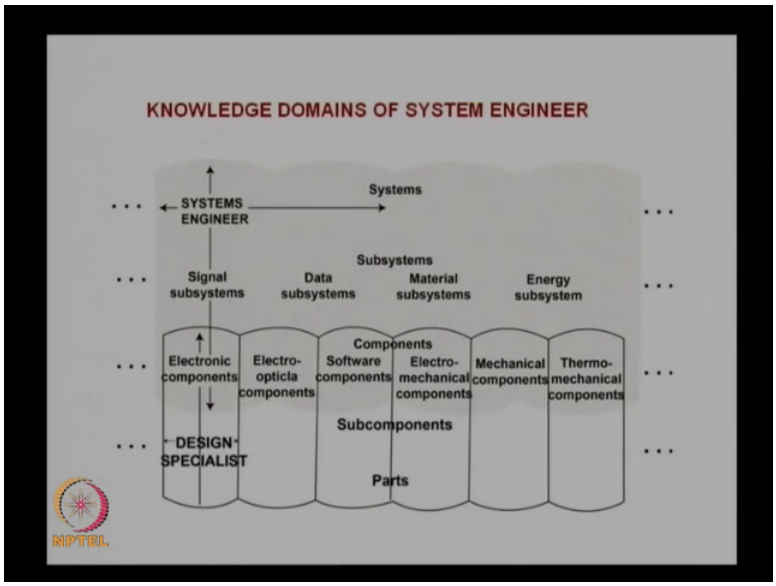

So, what are knowledge domains where the system engineer operates? As you know as I mentioned previous slide that they are the responsibilities are much more than the design of components. So, they are the people who actually manage a whole design process, so what are the domain knowledge or domain areas where the system engineers operate. As you can see in this picture the parts and some components are the beauty of a design specialist. So, the system engineers will not come into the design of parts or subcomponents. So, they will just give the specification for these components and parts to a design specialist, then the design specialist will design the component he will select the material he will select the software or whatever subsystem required for that particular design they will identify those requirements and then develop the parts of companies and pass it to the next level where the components are assembled or they are integrated into a subsystem.

Then there are some systems and systems which are actually the domains of systems engineer. So, the system engineer is the person who actually do the integration of systems or they are directly involved in getting these components into subsystems and integrating them into the major system. So, the domain of the system engineer actually is in this area, where you can see that the subsystems and to some extent the components level integration are part of the system engineer responsibility and the design of parts and subcomponents are purely done by design expert.

So, they are the people who are from the electrical engineering domain or mechanical engineering domain or with electronics or software specialist who actually do this or specialization in a particular component development. So, there will be design teams who will be charged with the designing of these components and finally, it will go to that system engineer where the system engineer will integrate them to sub assemblies do the testing verification and although required procedures to ensure that these components and subsystems are performing to the desired requirements and then they go for integration to the system level and finally, the system will be delivered to the customer by the system engineers.

So, there is a clear role for the system engineers who actually responsible for the delivery of the system and therefore, they have that big picture what is actually expected from the system and accordingly they will work in order to make sure that these components have systems sub components designed by the specialist are meeting the requirement of the system.

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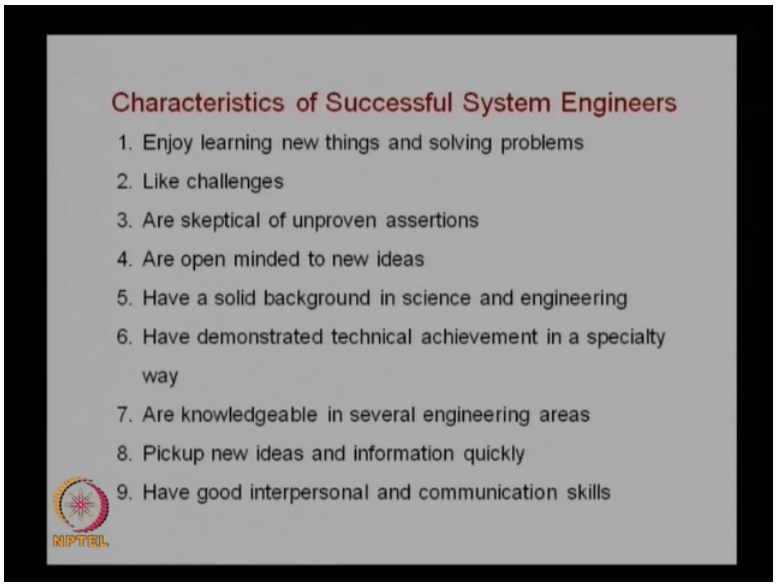

And then as you know these are the responsibilities of the system engineer, so a good system engineer need to have some characteristics which are actually needed for managing the whole project. So, these are the people who actually enjoy learning new things and solving problem, so every time there will be a, I mean every project there is challenge, every project is new to the system engineer and they really enjoy learning new

things and solve problems. And they like challenges, these are the people who really like challenges to take and then design something new and try them and then chances of failure they will try to make sure that these systems I mean these are the new challenges and they keep on doing these things because they love taking challenges.

They are skeptical of unproven assertions. So, in order to there is an unproven assertion then they will question that particular assertion and then keep on challenging that one to make sure that they understand the whole concept and they are working with the complete knowledge of the whole process or the system. They are open minded to new ideas, so every time which is a need to be have new ideas and new concepts for developing systems. So, they always open to new ideas and they have a solid background in science and engineering that is important. So, it is not that they do not know engineering just because they do not do the real design of components or sub components that does not mean that they are not engineers or scientist they have a very good solid background in science and engineering which actually helps them to understand all the complexities of the system and identify the components and parts for the system.

They have demonstrated technical achievement in a speciality way. So, they have because of this particular job role they have demonstrated that technical achievement in a specialty way there is a system engineers. So, like a managerial capability or a problem solving skills or a identifying the risk involved and then time to find out new ways of avoiding these risks. So, these are some of expertise they have developed during their career and they are good in such activities and that is why they are there a system engineer. So, they have demonstrated the technical achievement in a speciality way.

They are knowledgeable in several engineering areas. So, that is another important aspect one problem with our engineers are that a mechanic engineer is a pure mechanical engineer it is difficult for him to communicate with electronics engineer or an electrical engineer because they talk in different terms or the terminology in electronic engineers may not be fully understood by a mechanical engineer. But system engineers are not that kind of engineers they actually understood different streams. So, they would have a good knowledge about a mechanical engineering concept, electrical engineering concepts, communication and software though they are not the real experts in that area, but they understand the most of the things what is happening in this areas and they are very

comfortable in dealing with the a mechanical engineer or an electrical engineer without any problem.

So, this is one of the important quality of a system engineer they can actually have multiple domain knowledge and this actually helps them to understand the various procedures and processes in system design. They always pick up new ideas and information very quickly, so that is again a important these guys are of smart enough to understand the new ideas and a new concept very fast and implement it in system with design.

They have good interpersonal and communication skills, as I mentioned there are lot of a man power involvement in the design development and a integration testing and all those aspects of system engineering. So, these people are very good in interpersonal relationships and communication skills. So, they can communicate well with others their subordinates as well as their seniors and their colleagues they can actually have good relationship so that everything goes smoothly within the organization without any problem. So, these are the good characteristics of a successful system engineer.

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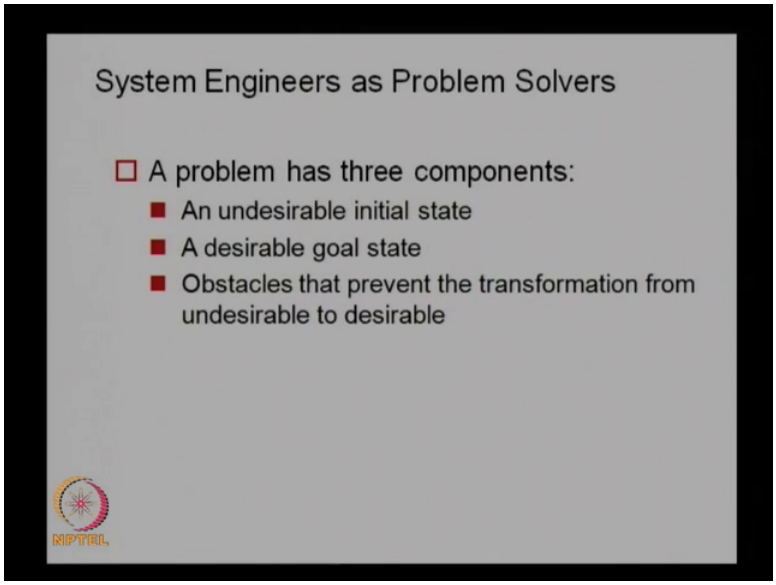

Then what actually system engineers need to do so, system engineers are as problem solvers. So, these people are readily into solving problems is almost every day. So, every problem has three components as you can see there is an undesirable initial stage, a desirable gold stage and obstacles that prevent the transformation from undesirable to

desirable state. So, these are the three components of a design problem and every engineer will be trying to sold these to get a solution.

So, as a system engineer as a problem solver we will look at the problem what is the undesirable state and what is the desirable state and what are the things which actually prevent from reaching the desirable state and then try to find a way to reach that desirable state. So, that is the role as a system engineer.

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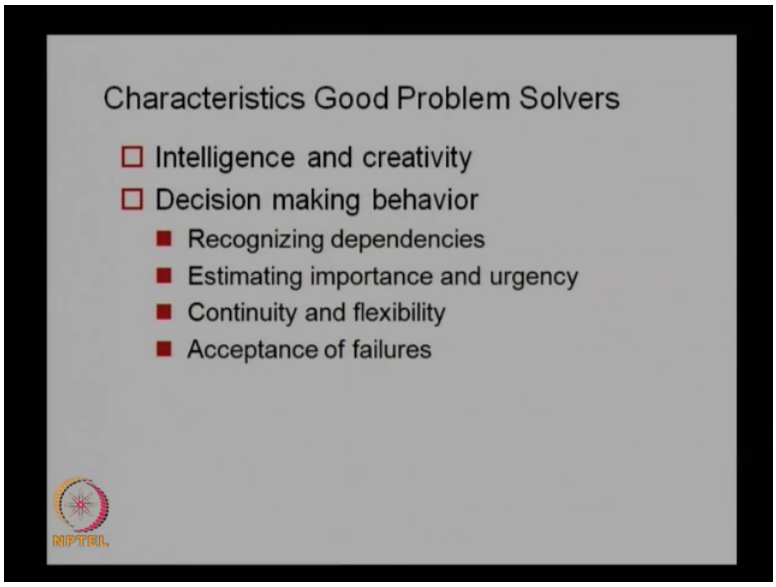

And the characteristics of good problems always are they are intelligent and creative. So, creative thinking is an important quality of a good problem solver he need to look at the problem in an intelligent and a creative way and try to see whether he can adapt a an existing technology or it has to look for a new technology or he can try to find a totally new or innovative way to solve that problem.

They are good decision makers. So, their decision making behavior is very good, they recognize the dependencies very fast, they estimate the importance in urgency of the particular problem and their continuity and they are very flexible they maintain the continuity with the problem and flexible enough to make changes whenever it is needed and they are very good in accepting failures.

So, there is no fear of failure for this problem solvers because always there is the risk of failure and it is which part and parcel of any problem solving. So, these people are they

are not worried about failures because always they take it as a stepping stone for the success. So, these are the good characteristics of problem solvers.

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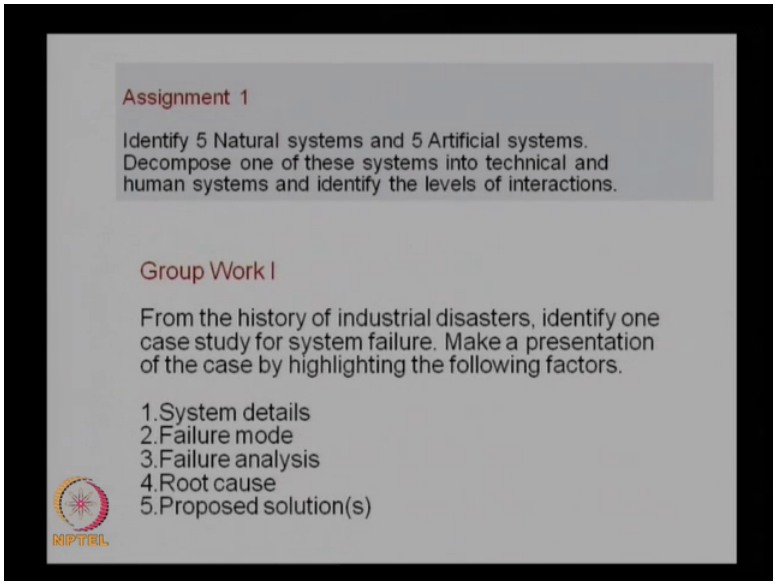

So, at this stage I would like to give you a few assignments and the project work. So, the first assignment for you is to identify 5 natural systems and 5 artificial systems.

Decompose one of these systems into technical and human systems and identify the levels of interaction. So, as I mentioned there are many natural and artificial systems. So, you identify a few of these systems and take one system anyone system and then decompose into technical and a human system and try to understand the interaction between this system. So, there will be always interaction between human system and the technical system try to identify what are the types of interaction taking place between the system.

So, you can as I give you examples for like a railway reservation system or a satellite system or a missile system. So, you take any artificial system which is of which you find it is interesting try to analyze the system and then get the technical and social dimensions human dimensions and a interaction between human and the technical system.

This is the first assignment and I would like to give you a group work of course, if group work is not possible you can take it as a individual assignment. You take from the history of industrial disasters identify one case study for system failure. So, which I explained

many system failure case studies. So, I request you to consider one system failure which is not discussed in this lecture these lectures. So, take one system failure identify the causes for the failure and to make a presentation in the case by highlighting the practice like the system details failure modes, failure analysis, root cause and the proposed solutions. So, these are the things what you need to do with this particular case study.

So, once you go through these case study you will a lot of information what actually it went wrong whether it was a real system failure or it was a component failure and if there was a system failure what actually could have been done to rectify it or from the history if it is available what actually was done to solve that particular problem in rectifying the mistake of that particular system.

So, make a good presentation and then you can send it to me we will discuss it if you want to do so.

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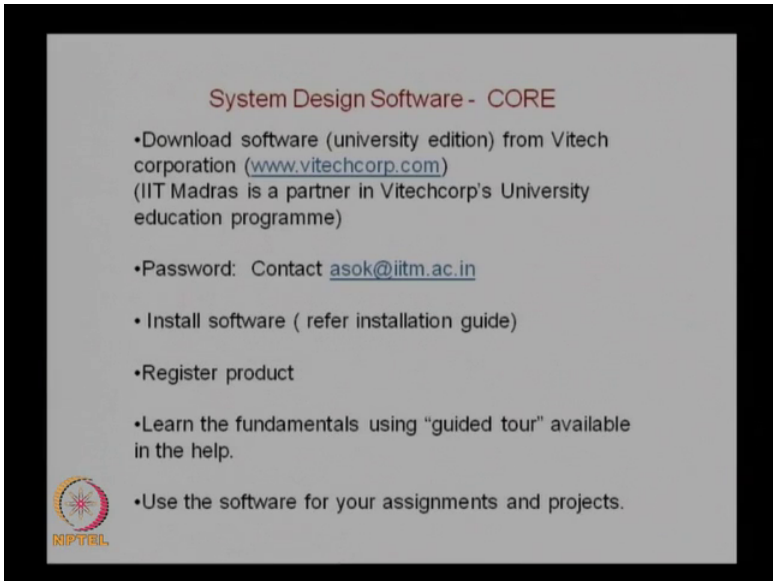

There are multiple softwares available for a engineering system design. So, one of this software is a core there is another software called a sysml, this core is available commercially it is from a Vitech corporation www dot vitechcorp dot com. Ultimately there is a partner in a Vitech's University Education program. So, our students are allowed to download the student edition and use it for their assignments and projects. So, if you want to use this particular software you can send me an email I will send you the password and to the procedure to download the software, you can use the software for

your educational purpose and you can use for your assignments and projects I will be giving you many more projects and assignments which require this kind of softwares.

I will be giving you a lecture on how to use these softwares in later stage. So, till then you can actually get refer to the manual of this particular software about using the software Vitechs corp software as I mentioned there is another software also it is known as the sysml s y s m l. So, this also can be downloaded and can be used for a system engineering applications.

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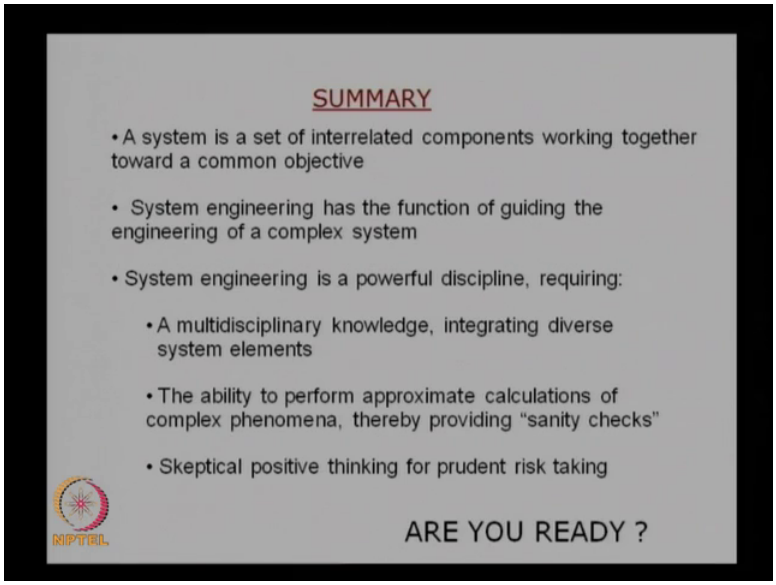

To summarize this lecture, we identified that the system is a set of interrelated components working together to provide objective or a goal for the project. And the system engineering is the function of guiding the engineering of complex systems. So, system engineering is nothing, but how do you guide the design and development of a complex engineering system.

System engineering is a powerful discipline requiring a multi disciplinary knowledge integrating diverse system elements and the ability to perform approximate calculations of complex phenomena thereby providing sanity checks and the skeptical positive thinking for prudent risk taking. So, that actually ends this lecture. So, from next lecture onwards we will be looking more into the complete design or the development of systems from a system engineering prospective I will take you through some of those methods and procedures to design engineering systems. So, till then goodbye.