Systems Engineering
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Lecture - 04
SEM - Lifecycle Integration

Good evening. Today, we are into the next lecture of systems engineering. I am Prof. Deepu Philip from IIT Kanpur and we will continue on our discussions on systems engineering with today's topic being Lifecycle integration.

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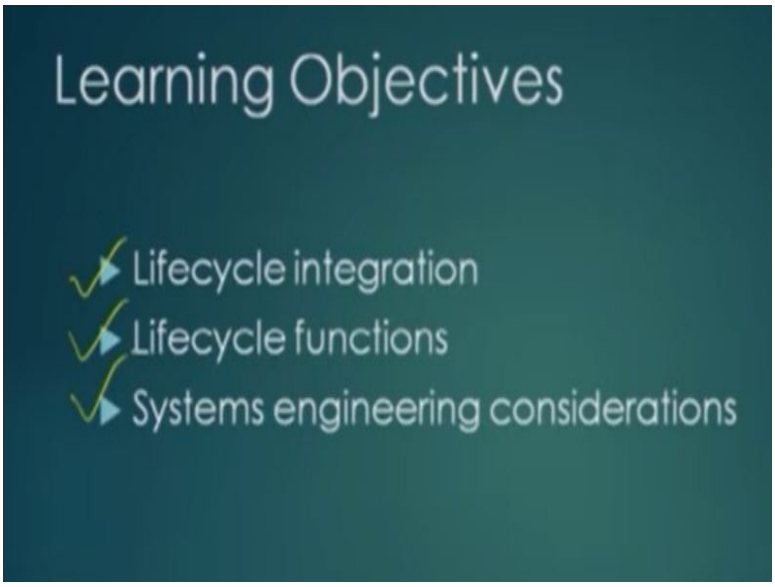

Today’s learning objectives include three major things. We will discuss about what is Life cycle integration and its importance to systems engineering and we will also talk about what are the Life cycle functions, the rate of them and we will discuss in detail what are the Lifecycle functions and some of the systems engineering considerations is kind of like a recap of what we actually studied so far.

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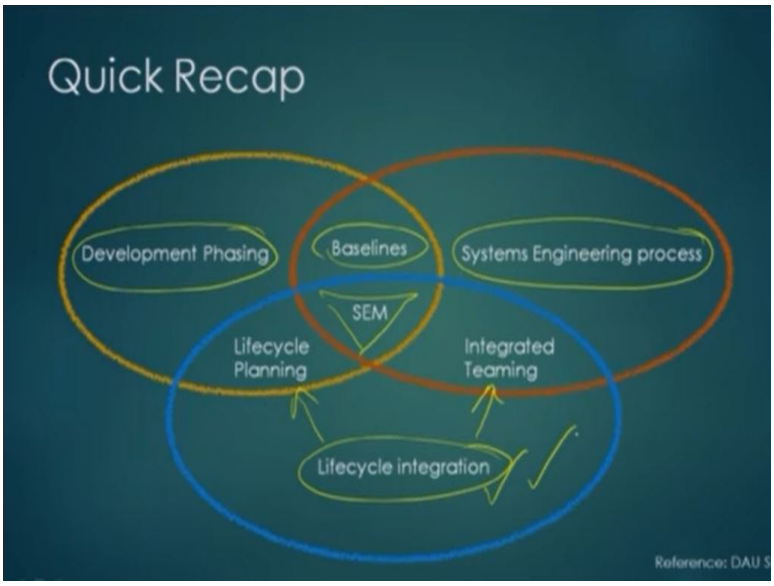

So quick recap for we begin, we actually saw this figure and we have been discussing the three aspects of it. We studied what is a development phasing? We also saw what is systems engineering process and how the product baselines are created and now we are going to talk about the two things, which is life cycle integration, which results in life cycle planning and as well as integrated teaming, the two major aspects of it.

We also see what is this Systems engineering management, why it is an important system? And why this is an important aspect of realizing complicated and large projects? So, we will do life cycle integration in today's discussion.

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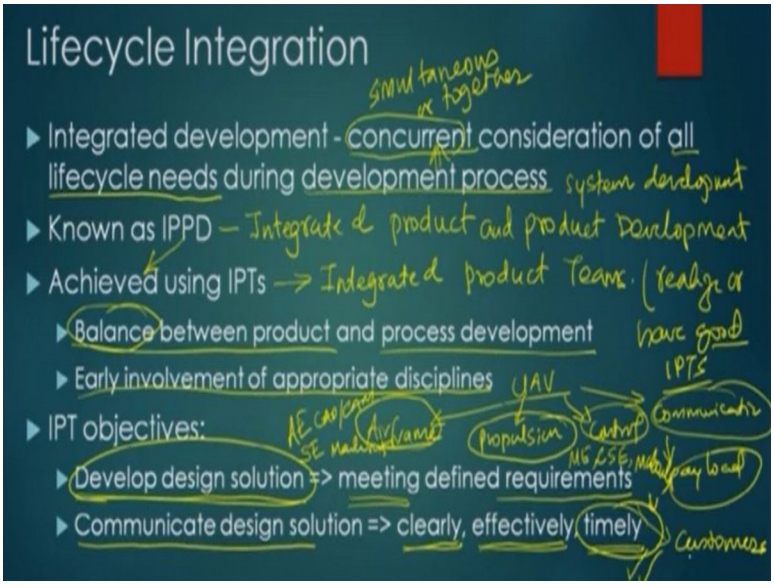

So, what is life cycle integration? It is an integrated development because of what it means is, it is a concurrent, concurrent means simultaneous or together, it is simultaneous or together consideration of all life cycle needs during the development process. So, when are you doing the development of a system, this development process is the system development process. When you are developing the system you need to consider all life cycle needs of the system or the product, whatever it is concurrently or togetherly.

So you do not design the product and then decide on the life cycle. When you are doing the development phase along with the same time you concurrently consider the life cycle needs of the product development during this systems engineering process. That's why it's called as an Integrated development. It is also known as IPPD. IPPD stands for Integrated Product and Product Development.

So the technical term for Lifecycle integration is IPPD or the Integrated Product and Product Development, where concurrent considerations for all life cycle needs during the development of the system or the product is done. And how is this IPPD is achieved or how do we realize the integrated development, it is achieved using IPTS, IPTS stands for Integrated Product Teams. So, this realization or when we go back to the previous slide.

We were talking about the Integrated teaming this aspect and the Life cycle planning both of these are interconnected in this present discussion what we said is through IPPD is achieved or realized, IPPD is achieved using Integrated product teams. And what is an integrated product team? This is always a big and good question and to a large extent systems engineering development, any systems engineering endeavor survives due to the existence of good Integrated product teams.

So one of the requirements is realize or have good IPTS. I would probably change this good to excellent IPTS as the right phrase and what does the characteristics that makes a good IPT. The first characteristic is that there should be a balance between product and process development. So the team should be capable of looking at both product development and as well as the process development, there should be a balance.

Certain times what happens is people develop really good product but the process is to realize the product does not get developed in that process. So resulting in which product development does not really survives very well. Sometimes what happens is the product development become (()) (04:58) whereas the process is extremely developed very well. So at the end of the day, you have a very good process to realize not so good product.

So there should be a balance, this keyword is balance, this team should be able to realize a balance between product and process development. And the second part is that there should be early involvement of appropriate disciplines. So if we have been using UAV as an example, so if you think about UAV we talked about the five aspects of the UAV. So the first one is an Airframe, then you have is a Propulsion, then you have is a Control.

Then you have Communication and then you have is a Payload. So if you think about this 5 aspects, the Airframe here you would require Aerospace engineers, Structural engineers, then you would require CAD/CAM experts, machinists, manufacturing people, moulding experts. So, the interdisciplinary team or the IPT there will be taking charge of the airframe will be an one (()) (06:15), there will be a Propulsion team who will have mechanical engineers, computer science engineers, who will be developing the engine control system or the ECU.

There would be people, who are actually working in materials, who might end up doing the development of the engine mould those kind of stuff. So, for each subsystem, we can realize IPTS and earlier we can realize an IPT in the life cycle of the systems engineering, system product development, you are the most successful you will be. What are the objectives of the typical IPTS?

The IPT objectives involve the first part to develop a design solution. Thus are initially based on the requirement specified, who would specify the requirements? The requirements are always specified by the customer. So the customer requirements are specified at some point of time and the aim of the IPT is to develop a design solution. Do a product of systems engineering solution to meet the requirements of the customer that is a first part.

Then the second part of them is they should also be able to communicate this design solution. When you doing this communication it should realize three things, the communication should be clear, so the customer should understand what the product or the system design is all about. It should be effective, so that the person can visualize, understand how the needs or the requirements are being met and it should be timely.

For an example, let us say if we are talking about developing a mobile phone or let us say somebody talks about developing a mobile phone that can be charged through Wi-Fi or through the Bluetooth that is currently one of the hot areas in the market. So, people are trying to find out how to charge the mobile phone through Wi-Fi signals or Bluetooth signals. And that process if you have come across says that okay.

Here I have developed a system which is bulky and it would require solar power and also nuclear power plant to charge the mobile phone. It might not be a timely solution at that point. People might laugh at it because the thing, there are much better solutions available. So, this is where lot of the time many of the systems engineering or system development process fails because the communication is not very timely.

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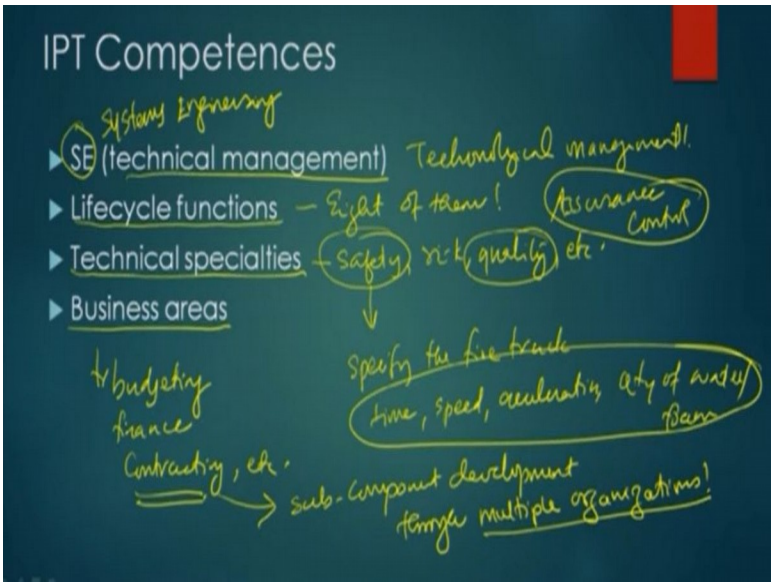

The Competences of an IPT or an Integrated product teams, they are supposed to have a quite a lot of competences and the first competences is about systems engineering. This SE stands for systems engineering or in another way to think about is, it is a technical management competences. The person should be able to manage the technical process or Technology process involved in it. So, you are doing a technological management.

The second part is the IPT people should have competences in the life cycle functions. Life cycle functions, there are eight of them and we will discuss what those eight functions are later down through. These people also should have technical specialties or the IPT team should also have technical specialties. The technical specialties typically involve things like safety, risk, quality those kind of things etc.

An example of this is like let us say you are designing an airport or a runway, so the person, who is in charge of the safety he or she should be able to specify the fire tender or the fire truck that is necessary, the time, speed, acceleration, quantity of water or foam whatever it is you want to call it, all these aspects, the person this is part of the safety. So the person should have knowledge on this if they are in the process of developing an airport system or airport runway or aprons or whatever it is or the airport aircraft handling aspects of an airport.

Similarly, quality person should be able to know what are the ways in which quality can be enforced like quality assurance and quality control all these aspects, they should also be able to do. So, these are called specialties, so the team on the other hand more than having knowledge about life cycle functions and the systems engineering or technical management, it is desirable to have technical specialties and quality as part of the team capabilities.

Also the team should have some expertise in the business areas, the business areas typically involve budgeting, they should know how to do the budgeting, finance, contracting etc. Contracting is an important aspect because many a times lot of the sub-components of the system will actually be derived, described, developed by different people. So, the contracts are to a large extent that we talked about subsystems or sub component development through multiple organizations.

When you are a having scenario like this when multiple organizations are involved, then a clear knowledge of the contracting is really necessary to realize a complicated systems development. So if the IPT, the integrated product teams have competences in these four areas, then they will be able to do much effective job of realizing a good product system development.

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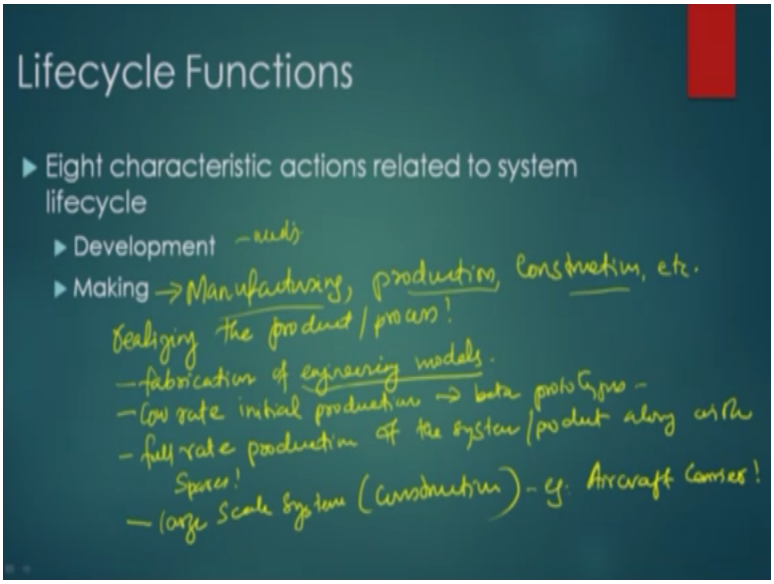

So as I told earlier, they should have competences in the life cycle functions. And I also mention that, there are eight functions or eight characteristic actions, so these life cycle functions are characteristic actions that particularly relate to the life cycle of the system or the life of a system. So the life cycle functions are we will go one by one because each one of them are important. So the first one we'll talk about is lifecycle function called development and the development function, it includes all activities necessary to evolve a system or a product from specified customer needs.

So the customer has specified some needs, the customer needs are specified to you already and from there whatever you need to do, the activities that are necessary to evolve a system or a product from the customer needs is actually part of a, is called as a development aspect of, which is development function or the development aspect of the life cycle function. It can be a product or a process solution.

So it can be a product or it can be a process does not matter but at end of the day the customer needs gets translated in to a system or a product. Then we talk about the second life cycle function, which is called as a making or there are many names available for this particular function one of the common name is manufacturing, some people call it as production, certain people call it as construction etc.

All these things come out of making or realizing, some people even call it as realizing the product or a process, so, known in different names. But the major aspects of this is, the major activities covered under these are fabrication of engineering models that is one aspect of it. The engineering models are the initial models, in which you are actually testing all the capabilities and fine tuning the design, final design.

It is also the low rate initial production, your proto types, beta proto types, perhaps the functionalities and you are basically testing them for further improvement and other aspects. Then we have is the full rate production of the system or product along with spares also. You just do not produce the product alone. You also need to produce its spares and things that are necessary to run the product.

Then in cases, if we are talking about a large scale system and we talk about construction of it. The construction, example you think about this in aircraft carrier. So if you talk about building an aircraft carrier like USS enterprises USS limits, one of those large super carriers then it is not just a manufacturing process, it is actually a construction. We are building one of its kind of an aircraft. But it is such a complex system, where so many substances involved.

So it would require, it will go through a complete life system engineering process to realize that one product. There will not be a large scale manufacturing, one type of and one of the type will probably be built. We can also be thought about thus building a large aircraft also that is also possible. So anyway, all these aspects, the manufacturing, production, construction, whatever you mentioned about in realizing the product of her process, which was, which meets the needs that were specified in the development phase, is the second lifecycle function of a product.

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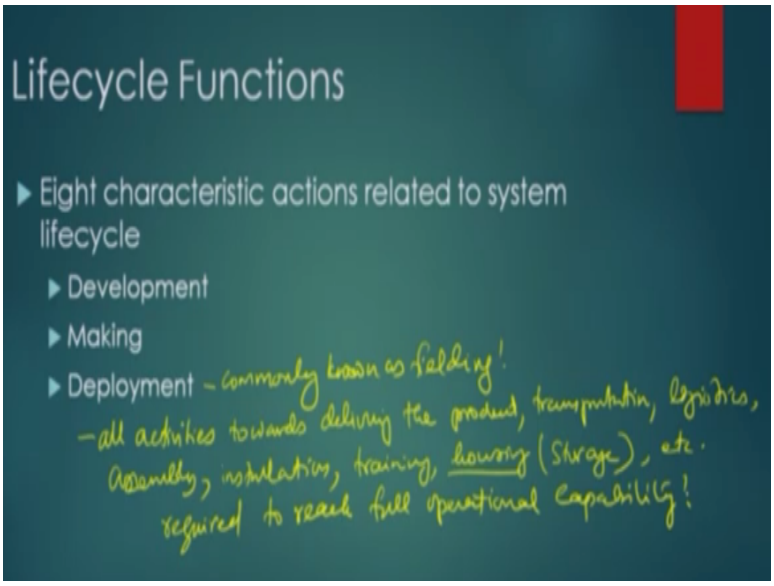

The third lifecycle function of a product is what we talk about as deployment. Deployment is also another common name, it is commonly known as fielding, is not the fielding in cricket, but this fielding the product realistically. And what is fielding or deployment? It is all activities towards delivering the product, in a transportation, logistics, assembly, then installation and there is check out or like let us say training, housing.

It is not the housing but storing the product, we can think about a storage, then all these functions, extra required to reach full operational capability. This is the deployment aspect of a lifecycle function. The third function of the lifecycle, the third aspect of the lifecycle function or third action of the lifecycle functions.

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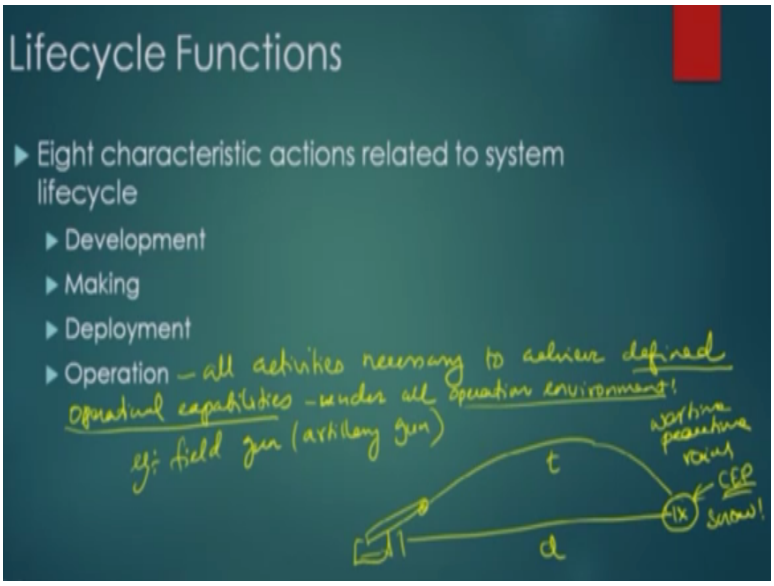

Now we will talk about the fourth aspect of the life cycle function, which is an operation. The fourth aspect is usually includes all activities necessary to achieve defined operational capabilities, it in under all operational, operation environment. So if you think about that, an example, the second example of a field gun or artillery gun, it should be able to do deliver a projectile from a given point to a specified distance, so you may have a gun right here and it should probably deliver a projectile to a given distance.

So this distance is ‘d’, the time of flight is ‘t’ known to that and here is when it supposed to land. There is something called as CEP, circular error probability, how accurate it will be. All those aspects will be part of that. So it should be able to do this, whether it is in war time or peace time or rainy season, snow, it does not matter. Whatever be the operation environment, this system should be able to do or perform, deliver the task.

The defined operational capabilities should be able to be delivered at whatever type grade, whatever the situation is, whatever the operation environment is required. So this is the lifecycle, fourth lifecycle function called as the operation lifecycle function of a product or a system.

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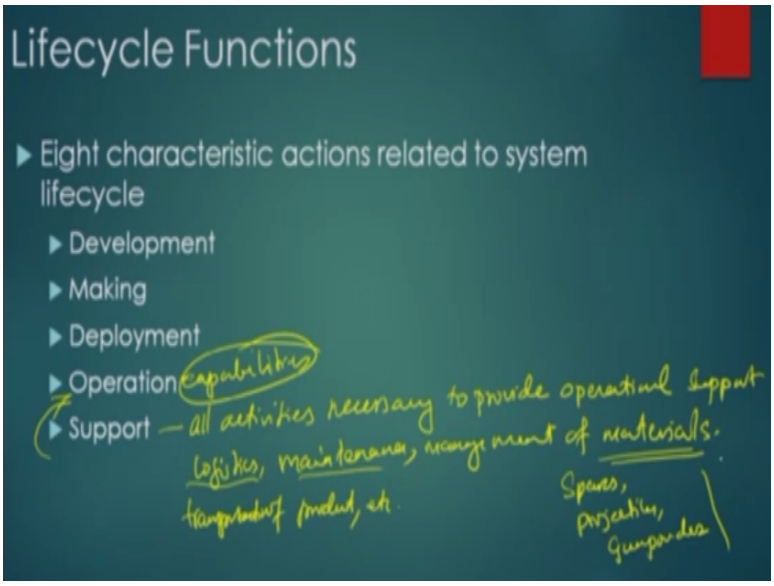

Then we talk about the fifth lifecycle function, which is called as a support. And support is the, it is a naturally interesting function because it involves in all activities and necessary to realize, to provide operational support. This involves stuff like logistics, maintenance, then it also involves management of materials or materials management. What we do here is that, to realize these operations, whatever the capabilities that was specified in the product, to achieve that what all support is necessary that is part of, that is another function of a lifecycle.

So it will how logistics that are necessary, maintenance that is necessary and material management is necessary. If we take about the field gun that we talk about it, it is transporting the field gun, so that is transportation of product etc. is part of this. Maintenance is periodic maintenance, schedule maintenance, some schedule maintenance, all those kind of things are part of the maintenance.

And management of materials would involve spares and then what it also called as a projectiles, then gun powder, all those aspects, which are related to the field gun is another management of how do we manage these kind of things, how do we realize these, this is also one other aspect of this support.

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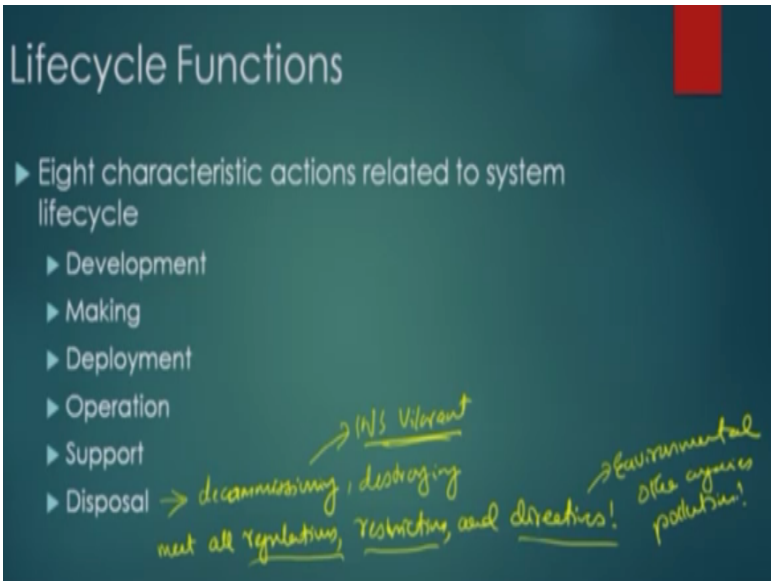

The sixth one is actually the disposal. The disposal is there are many names for this again. One common name that is used is decommissioning. Another name that it is also used for, used for this is destruction, destroying. So either you are talking about decommissioning or destroying a particular product or a system or it is to be done in such a way that, it should meet all regulations, restrictions and directives.

So another one example of it is how the nuclear fuel disposal happens or how do you decommission a big ship. In an example in India, people talk about the decommissioning of INS Vikrant, which is an aircraft carrier in India. And what are the things, care that was taken to ensure that the ship was decommissioned properly by while meeting all regulations, restrictions and directives.

Some of these directives will be like something like environmental stuff, environmental and then other agencies like pollution extra will also be part of this.

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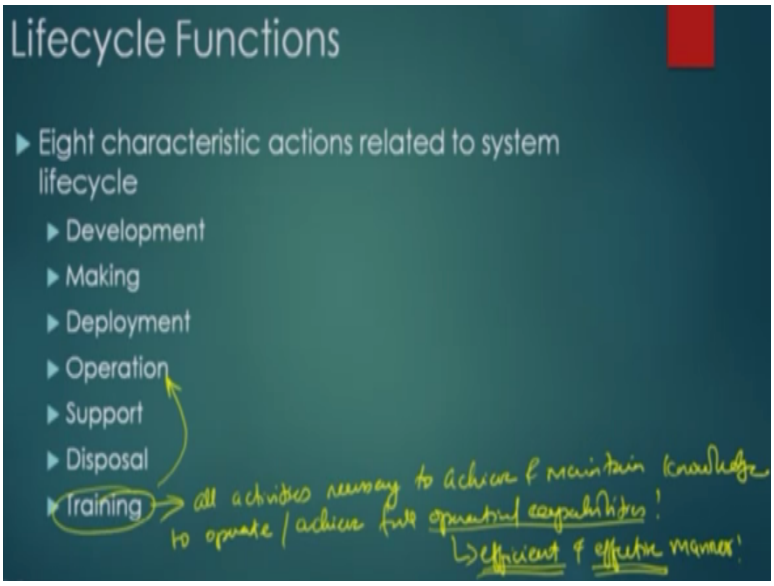

The seventh lifecycle function that we are going to talk about is called training. And the training, it is the all activities necessary to do what, to achieve and maintain know how, knowledge to operate the system or to achieve full operational capabilities. This is the training aspect of it. It involves, it is the full operational capabilities in an efficient and effective manner. So if we take about the example of the field ordinary gun that we were discussing earlier, the efficiency is about being able to fire as quickly as possible, with minimum amount of time.

Deliver the fire accurately at the given point and effectiveness is about to do inflecting the maximum damage with minimum amount of projector, so minimum amount of firing. So both efficiency defectiveness are aspects of the operational capabilities or achieving the operational capabilities. So training is related to the man power or the human resource that is involved in operating the system. That is the seventh lifecycle function that we have discussed today.

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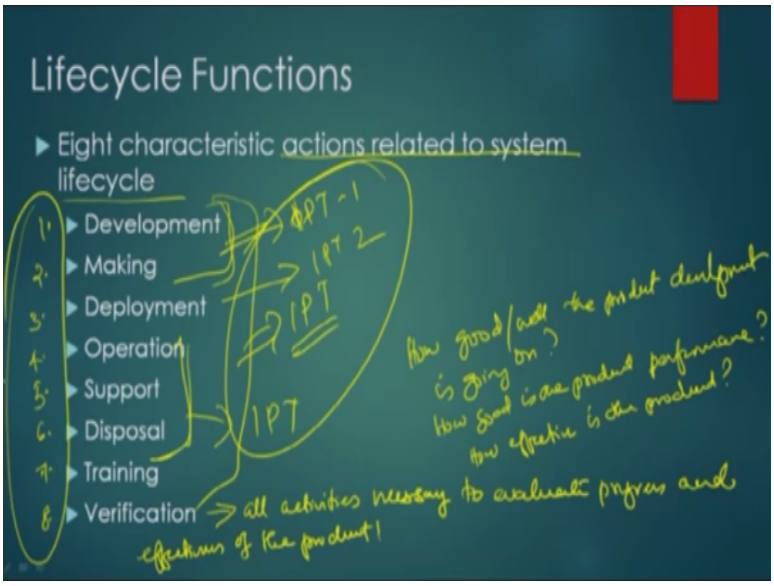

And the last one is the verification or the verification as the eighth lifecycle function. And this involves all activities necessary to evaluate progress and effectiveness of the product. How, so here what we are talking about is how good or well the product development is going on, how good is the product performance, you also talk about how effective is the product. The effectiveness can be again a something like a competition or other products, which are similar products that are in the market.

So all these eight aspects the development, the making, the deployment, the operations, the support, the disposal, training and verification, all of these eight of them, these eight actions related to the system lifecycle is also one important aspect of the lifecycle function because all these things together is also something that is the IPT, the integrated productive needs to be capable of doing.

They might not have expertise in everything, but they were probably be having expertise in parts of things. Some people might have expertise in development and making, so this could be one, may be like a IPT one might take care of this, deployment might be taken care of by IPT two, which could be doing something else, whereas some of these aspects might be taken by another IPT, stuff like that.

So in the totality, the total teams, all IPTs put together should be able to achieve all these eight. And if that is happens, then systems engineering process achieves full capability.

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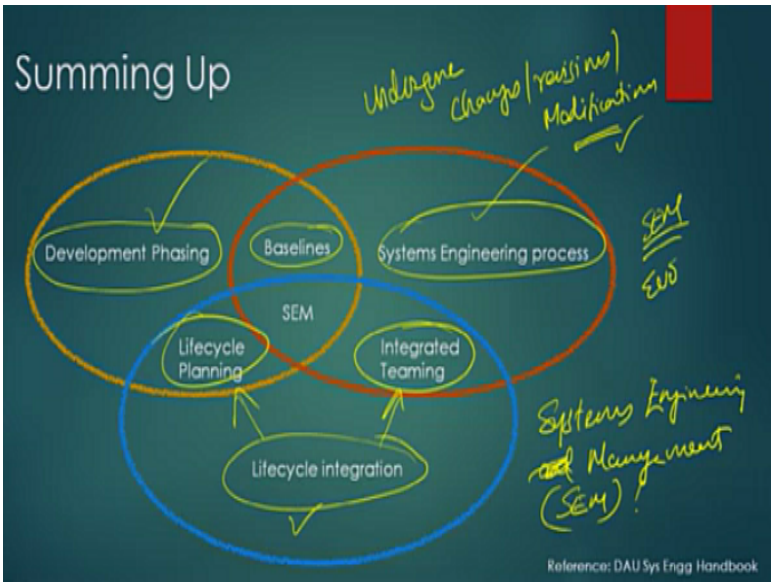

So summing up as we discussed earlier, the three aspects we talked about the development phasing in which the system details, the base lines of the system are developed from here by applying the systems engineering process. So again as these baselines, then the lifecycle the integrated development of the system or the product happens with the help of the lifecycle planning and having an integrated teams.

With and all of these things put together, all these aspects put together forms what we call as central node of it, which is called as the Systems Engineering and Management or we can call it as Systems Engineering Management also, SEM. So we have seen the major functions of it. And over the time these all three aspects the development phasing, the systems engineering process, the lifecycle integration, they have all undergone changes/revisions/modifications.

Things have been changed, modified, improved. So we will see some of, what are the new changes, what are the new additions, what are the new upgradations that has happened in this basic process, in the next classes to come. And in that process also, we will realize what the new tools are and how systems engineering process SEM also is an evolving process, evolving and

improving process. With that, we will conclude today’s lecture and we will catch up with the upgradations to these things and new tools with the next classes to come. Thank you.