**Systems Engineering**
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**Lecture - 03**
**Systems Engineering Management (SEM)**

Good morning. Today, we are into the third lecture of Systems Engineering Management and we will go through some of the further details I am Dr. Deepu Philip and I am from IIT, Kanpur.

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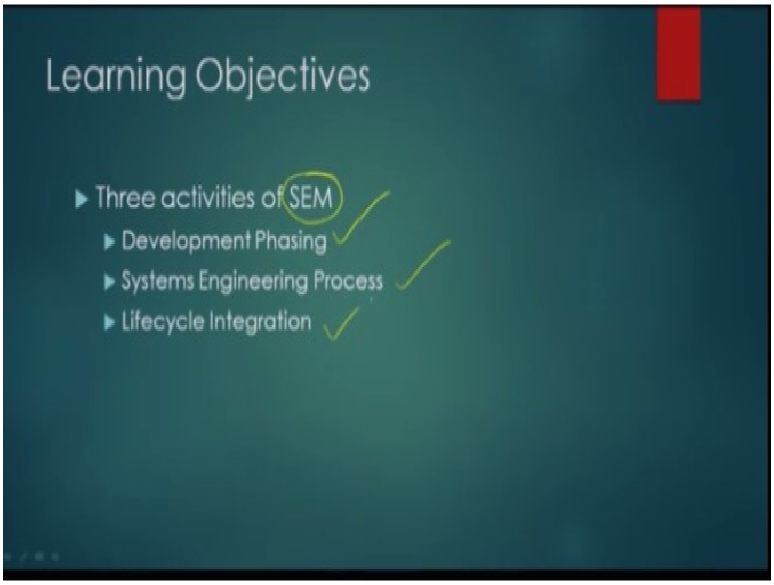


So, today's learning objectives, major learning objectives include talking about the three activities of Systems Engineering Management. Throughout this lecture the SEM the word whenever you see that we will be referring to the process of course Systems Engineering Management. The three activities are the development phasing, systems engineering process and lifecycle integration. We have seen this briefly in the previous presentation.

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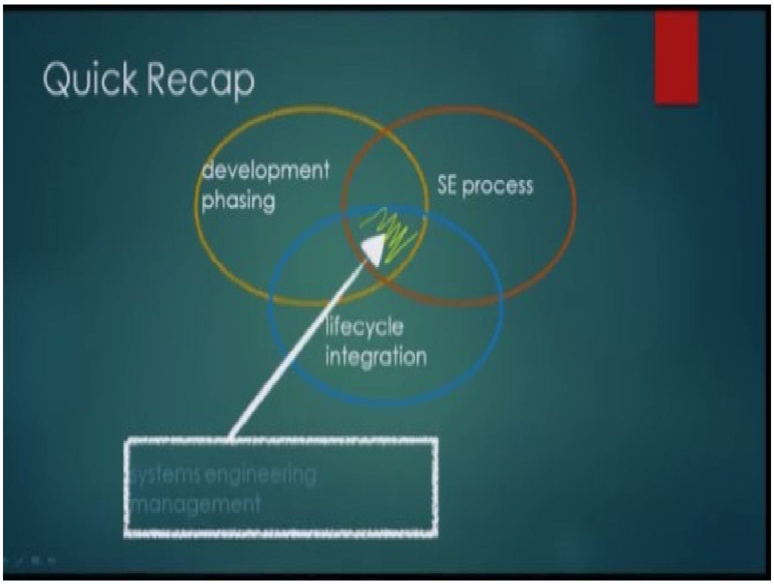


So if we remember the quick recap, we drew this development phasing bubble followed by the systems engineering process bubble followed by the lifecycle integration bubble and we said that the systems engineering management is the center portion. This area is what we talk about or it is actually is a conglomeration of all the three things where systems engineering management and we supply to all the three.

Now, in this lecture we will actually expand the whole system and study what are the major aspects of it, what are the major components of it and how it proceeds.

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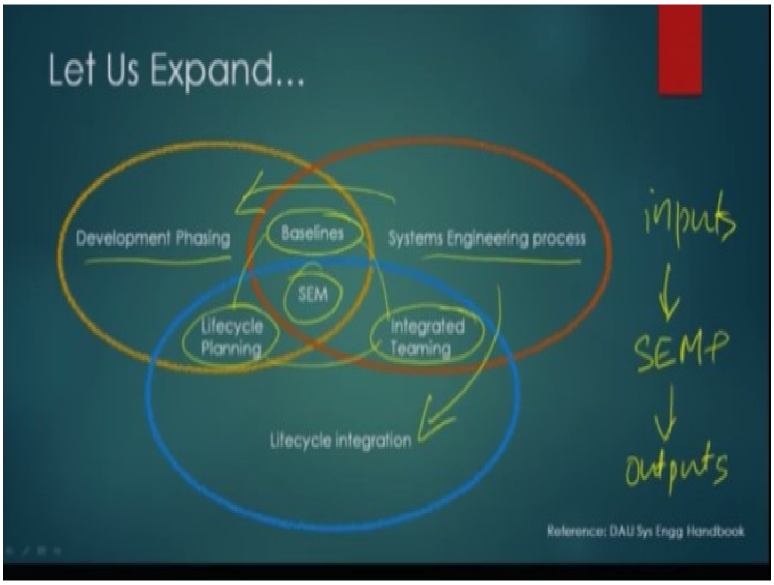


So if we expand the diagram it will look something like this, taken from DAU systems engineering handbook. The systems engineering process this red circle interconnects with the yellow circle which is a development phase which results in what we call as baselines. We will discuss in details, system baseline what it is. Then the systems engineering process and the lifecycle integration when it interconnects, you will get what we call integrated teaming.

Similarly, the development phasing in lifecycle integration when they connect you get the lifecycle planning and all of these things are basically done with the help of same processes Systems Engineering Management Processes. We will take first study what is development phasing then from there we will see how the systems engineering process get applied to the development phasing.

And then followed there we will see how the system engineering process get apply to the lifecycle integration in which complete products. So you have a bunch of inputs and that inputs come to the system engineering management process or SEMP or whatever you want to call it from there we will see how the output, a system designs specifications how do they come out. This is what we will be studying in today's lecture.

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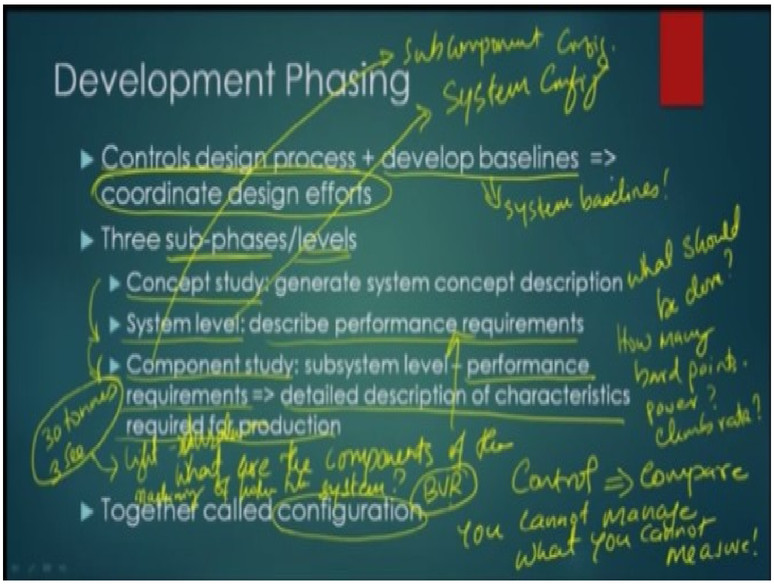


So first let us talk about development phasing. Development phasing is the initial part, the first aspect of the system engineering. There are many names and nomenclature associated with this. People discuss this in different aspects, but the primary aim of this step is to have to control the design process that is the first part. So the entire design process you have to have mechanism to control.

So control means you should establish benchmarks. So in one way to do this if you want to control something you need something to compare with or one of the simple principle say you cannot manage what you cannot imagine. So this is the first aspect of controlling. You are trying to manage things what you are able to measure. So here in this you are establishing aspects for measuring or controlling the design process and also in which you develop the baselines. The baselines means this is the baselines of the system. These are system baselines.

We will see what are baselines and how they are developed relative down the road or these two together gives you, allows you, it helps you to do what you call as the coordinate the design efforts. Whether you are designing the complete system or whether you are designing the subsystem or whether you are designing even the minute components if this all gets coordinated based on what happens in the development phasing.

A development phasing you can think about it that being subdivided into 3 parts or three phases or 3 levels. So whenever you see this word levels or somebody talks about sub phases in system engineering both are talking about the same thing it is a subcomponent of a major strength. So the first part of this is called as a concept study. There are many names, fancy names associated with this then some people even call it as a feasibility study, but that is not the right term that we would like to use.

We will like to use it as a concept study. So here what happens is we basically trying to decide in this phase what should be done to a large extent. So the system concept like somebody says I want to design an aircraft or a fighter jet so then is the fighter jet needed then what is the fighter jet, what are the capabilities, some of the basic in a very broad sense we talk about the concept of that will it be a fighter, which will be a bomber, which will be an interceptor which will the multirole aircraft, will it be self so those kind of basic broad functionalities as part of the concept study.

But once you have the concept study done and everybody decides okay from there we know wanted to go into the second phase which is called the system level, then the system level what happens is you are describing the performance requirement of the system what are the aspects that you are need to talk about. So if you take the previous example of an aircraft then here you will be talking about how many hard points for carrying ammunitions, power, climb rate.

So, you are here, you are specifying the performance requirements of the system how is the system going to perform in different conditions that aspect this is the from the concept stage you come to the system level, the translations from once you say agree on the concept then you say what are the performance requirement of the system. From the system then we move to what we call as the subcomponent level or what we call as the subsystem level.

So you try to decide here what are the components of the system? You just do not decide the components randomly. You decide the components, what are components of the system that helps you to realize the performance requirements. So the major question is how are we going to realize the performance requirements and which components should be used. So if somebody says I want to hit a target which hit an enemy aircraft that is 100 kilometers away.

So then you might say, I might then use a beyond visual range missile system to accomplish that. So they hit a target that is very far that you cannot see is a performance requirement and then indentifying the subcomponent to realize that component level decision. So here what happens is what are the performance requirements of the subcomponents we are specifying that.

Once you are identifying what are sub components and then what are the performance requirements of the subsystems. Here you also end up doing much more detailed descriptions of characteristics. So once you decide that okay I am going to use this specific landing gear for an aircraft you say that this should carry let say 30 tons and it should be able in damp in like 3 seconds so something like this.

These aspects then translates to will you say light weight material maybe a duralumin alloy and then we will be using a manufacturing process called like a machining of a hollow tube or something like this. So, you specify all these kind of aspects as part of the subcomponent because you are also looking at something that are required for the production of the subcomponents.

So all of these things put together we actually call it as the configuration. People call it in multiple names this is the - some people call here this as the system level it is sometimes called as the system configuration. This is called as the subcomponent configuration. All are pretty much the part of the development phasing where the aim is to control the design process and develop the baselines.

So there are multiple names and other things associated with this, but the general idea of this whole system is that you develop the baseline and which you use to control the design process and through this you will be able to coordinate the entire design effort.

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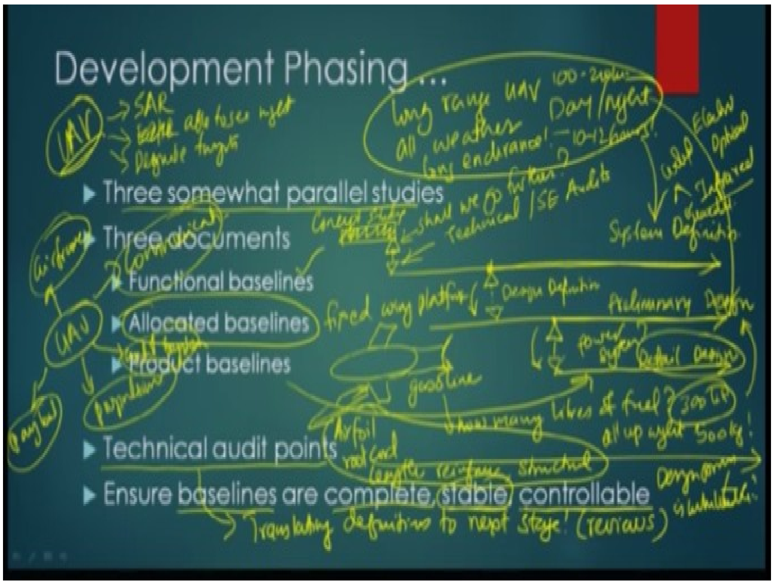


Moving on there are this whole thing is accomplished through somewhat 3 parallel studies or 3 documents that gets generated out of us outcome of the development phasing. When I say somewhat parallel studies this is of importance because they are not really parallel they are kind of done sequentially but sometimes they do overlap so if you think about this or if you want to draw it in a timescale.

If you assume that here is your time axis going on time in the x axis then somewhere you complete your concept study. We can think about this as your concept study Everybody agrees on okay we need something we need to so lets say for lets take an example of an unmanned aerial vehicle UAV say everybody decides okay we need the country, needs the UAV.

So now, this UAV is to we should be using it for it should be capable of doing surveillance and-reconnaissance it should be able to do have an electro optical and infrared payload. It should be able to designate targets. This instead of you will see, able to see in night. So these kind of things the broadly you every, everybody agreed on okay this is what the capability so the system is then once you agree here.

Here is the first decision point which this decision point decides shall we go forward, go further so is it so should we go more into this. The answer is yes. And we think that there is enough capabilities within the system to do it, then you start the first phase of the development phasing or the systems engineering process associated with the development phasing which is to the end will result in what we call us a system definition.

This is called as this system definition is actually called as the functional baseline so you decide you basically kind of start this process. And somewhere in between you would say okay I am facing this stuff here no more and this is another decision point. So these decision points, these triangles that you see or what we call these as a decision point. They are typically the technical audits, technical or system engineering audits.

This is where you basically reach a milestone you decide and define things where we want to go from here. So the system definition the first phase kind of gives you what you call as the functional baseline of the system. Once you have the functional baseline the same time somewhere in parallel you can think about that you will have the second aspect going on. It will be something like this which will result in what we call as the preliminary design or the technically known as the allocated baseline.

So this also has another somewhere you will end up facing the preliminary design, but there is a transition point that you should think about that from here when the audits happen in the system definition gets frozen then you translate that into the preliminary design. So these translations, this movement from the translating the requirements from one step to another this usually what we call as the design definition.

So have design to something from there you are moving to the next phase to develop further design definition and throughout some place you will conduct an audit under the kind of technical audit and those kind of stuff from where you will actually say okay the preliminary design looks feasible, nice and then from there we start something called as this is not strictly overlapping this kind of starts from here.

And it is kind of an outcome of another design definition audit, another technical audit which generates which we called as a detailed design. This detailed design is also what we call as a product baseline. Product baseline is finally equivalent to the detailed design and this again translates from the preliminary design. So if you take this UAV as an example, everybody has decided to go forward and then the system definition.

The basic system definition welcomes something like this. The system definition of the UAV will be okay it should be capable of eying, flying 200 kilometers range about 10-hour endurance and this actually comes as preliminary design not necessarily, sorry let me repeat this. The basics first is that the system definition will be it should be a long range UAV people say all weather and then day night long endurance like these all these aspects that we just draw up here come in that comes as part of the system definition.

We are not really come into what we call as specific very specifically. In a broad sense we have come across these are the capabilities of the system and then from there once we agree on some of the stuff sometimes it will shell out into somebody will say long endurance, somebody will say let us say 10 to 12 hours. Sometimes you might come across these kinds of numbers in this process even or a broad agreement is not a really well defined target.

But a broad agreement somebody will say long range let us say 100 to 200 kilometer sometimes you will come across these kind of numbers also being as part of this one, but it does not have to be it can be a broad system specification what you want to accomplish. From there once you translate to what you call as a preliminary design, then this is where some of the questions get answered. The questions will be like what type of a platform will be.

So sometimes you will say okay you want to fly for a long endurance and a long range so then somebody will say okay fine let us do a fix wing platform. So then the people will have this design like okay here is the fuselage here are the wings and here is the tail so people will do all sort of designs this way. So some of those stuff will be the preliminary design aspects of it.

Then the range in the long endurance says people said 10 to 12 hours, okay then the question will be like okay there should be gasoline propulsion and then people will say how many gallons of fuel or how many liters of fuel. So if somebody says okay we require 10 to12 hours maybe 300 liters of fuel, so then to this with the engine weight another things translates to what we call as okay the total payload or the total-all up weight to be close to 500 kg something like this.

So this iterative process results in what we call as a preliminary designs where some more things will get more crystallized, the performance aspect of the system will get crystallized further and said day and night capabilities so then the part of the day and night and part of the preliminary design people will say okay there we would probably end up using electro optical payload whereas in the night we will say infrared.

Somebody might say whether this is cooled or un cooled infrared. So those kinds of questions to a preliminary design are reasonably good document which is actually called, this is why we called as an allocated baselines. We kind of allocate the functions to different aspects of the system. Once it is done then the detailed design comes into picture then somebody would say you are no longer sketching just as the shape of the wing, but here you are basically bringing the detailed design aspect.

So their space engineer might come up and say in this aspect will be this wing will be made of a specific air foil then somebody will talk about the root code, then somebody will talk about the length then what type of reinforcement structural rigidity all those aspects will come out of as part of this. So here the detail aspects of the wing are subcomponents actually gets specified somewhere someone will say about the engine okay it requires 12 hours.

So it should be air cool liquid tool what type of an engine 2 cylinder, 4 cylinder how many cc what RPM, what type of propeller, what type of power generation capability it should be what type of alternatives will be matter to it, all those aspects actually comes out as the part of the detailed system. In this video, you might even decide what will be power system, what will be the communication system. So in a UAV if you think about it in this system initial part you might think about as a UAV as having 5 components.

So the UAV will love airframe it will have a propulsion, it will have a communication, it will have a payload and it will also have a control systems. In broadly in the functional baseline we will talk about the all these things in broader sense. In allocated baseline we start talking about these ones and then from there we start specifying much further into detail what are the aspects of the system and as I told you these rectangles.

These technical audit points is not a tangles triangles. There are the points at which you translate from this is used for translating definitions to next stage. This audit freezes thing or some extent revises things once you freeze it, it helps you to move to the next stage of the process. And audits are required and necessary or some people call audit as reviews, but we will use the phrase audit because it is a dispassionate just looking at the document there is no what we called hard feeling nothing involved in this.

And the aim of this whole process is to ensure that the baselines whatever baselines whether you are talking about the functional baselines or you are talking about the allocated baselines or you are talking the product baselines any one of the baselines there should be complete, complete in a sense that once it is done somebody should be able to pick up the document and design forward what to do and should be stable and it should be controllable.

The complete stable and controllable are complete in a sense we are not missed out anything major stable in a sense that it is you are not changing things are left, right and center or simple way to think about it is okay we all decided that the endurance is 10 to 12 hours and it can be 11 years, it can be 10 and half hours it could be say 11 and half hours that okay understandable.

You are not going to come back tomorrow and say let change endurance to 24 hours because such changes then design of the system completely. So stable in a sense is that within acceptable ranges few tweaking are permitted, but generally agreed upon generally forced upon. Controllable in a sense that you know what are the aspects of the systems and you know that the capability is that you have within the system you can control the design process. So here is the design process is controllable that is what we are worried about.

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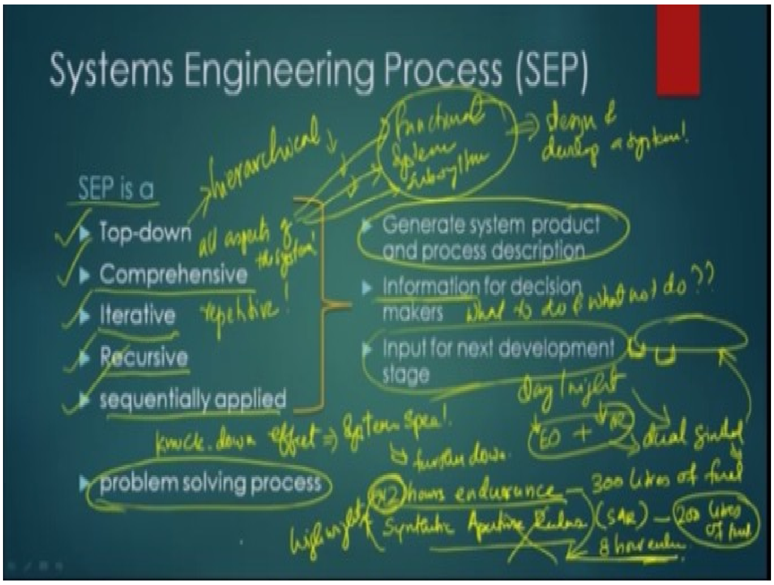


So the systems engineering process so SEP what we talk about the second bubble is actually is a top down approach. Top down approach means it goes in a sequential step by step process, the hierarchical process. So the top down you can think about it as hierarchical. You start from the concept phase and then you move from one after another from one step to another.

It also comprehensive, comprehensive in a sense it looks into all aspects of the system. It is not just all aspects it looks into what we call as the functional aspects, it also looks into what we call as the system aspects, it also looks into what we call as a subsystem aspects. So it is a comprehensive system so once you are done with this you can use this process that document are comes out of it to design a system or design and develop a system.

Then it is iterative that means it is repetitive is the better way to think about it or you can think about it as we design okay let say keep an endurance of 12 hours, everybody told about this and then at some point of time we are taking the UAV as an example then after some point of time we came up with the okay, we also need to integrate synthetic aperture radar as a payload.

But let say for the time being this hour in heavy payload, assume it that way then we will say okay fine then when your house are so this endurance translate it to let say 300 liters of fuel, but because of the heavy weight high weight of this payload you can only carry let say 200 liters of fuel. So then this 200 liters of fuel directly translates to a reduced endurance so then you might not get the 12 hours endurance.

You might be looking at an 8 hour endurances. So then your endurance aspect get revised at this process so during the design phase or when you are developing these documents these kind of considerations will change okay we might say that 12 hour endurance normally with SAR it will be an 8 hour endurance this process is called iterative process one leading to another.

So it is so it goes in a one cycle then it comes back in another so it keeps on iterating about it. It is recursive. Recursive and iterative are kind of different because what happens is recursive is situation where a decision kind of calls the previous decision or it kind of goes in the loop of talking about the forward details with kind of drilling down further in this case. So like an example in this case, you would be like you will say okay we want to see the capabilities of day and night in the UAV.

So then the obvious question what will be the way to see in the day, let say we call it as electro optical in the night we call it as infrared. Now the next question is do you have them independent or do you want to have them together. So if you say okay these both have to be together then we need a dual gimbal and we continue this process okay we need a dual gimbal then what are the mounting aspects that are required where it should be mounted.

So then that results in okay you might have started with the shape of the UAV fuselage and you said okay, here is what where we will mount the payload but then once you decide okay it is a dual gimbal you cannot do that you might want to change the mount somewhere here something like this. So you might end up iterating through, not iterating through you went drill down further you went recursively go down.

And then you will iterate backup to where it goes out. So this is also done and it sequentially applied sequentially applied because lot of the time you make one change in some place this part is that this is also called as the knock down effect. When you are doing some change in the system spec somewhere it will have some effect on further down which a sub component might need to be changed to create that.

So you need to go through this process sequentially to ensure that any change anything that is decided at this goes down all the way to the subcomponent level where all the aspects of the system, subcomponents another aspects have taken down. So in a way to think about this is it gives the generator system product and process descriptions by following this so in a broad description in a product.

And the processes product means let talk about this as a system product for designing a system and the processes involved in designing the system both of the descriptions we will get out of that and it also provides key informations major informations for the decision making like what are the aspects or like for example if somebody says okay the endurance is important.

You cannot compromise below 12 hours endurance, then the decision makers says okay synthetic aperture radar ruled out no more needed. So the decision makers capability to decide what to do so this is like what to do and what not to do. These decisions, the decision maker kind of makes based on these system engineering process documentation and we are able to develop and it also becomes the input for the next stage of the system product development.

So once you freeze all these things you have gone through this you have taken care of all those aspects of the system development, system product development then the further stages we will use kind of the documents and we generate out of this as the bible to go forward. So at the end of the day it is a problem solving approach it is a top down comprehensive iterative recursive and sequentially applied problem solving process to realize a system that is well taught through as a capabilities as needed and required.

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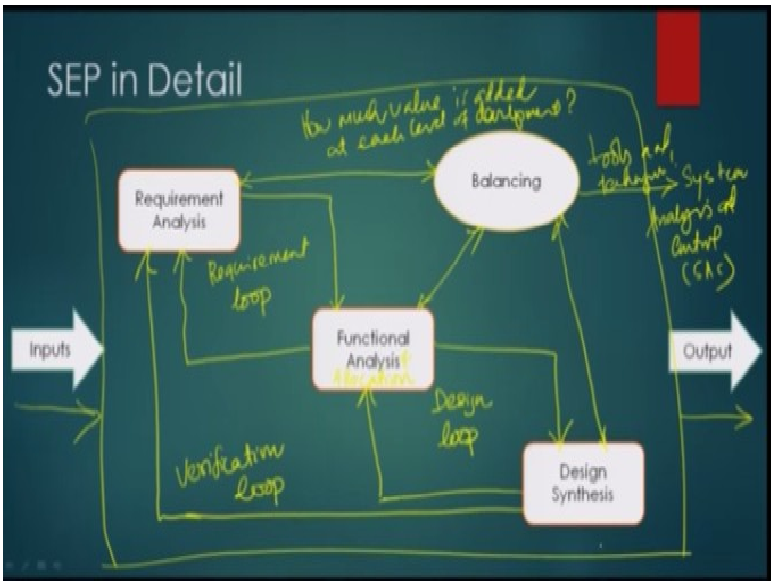


So, in a detail if you think about it this is kind of the 3 major aspects of the system engineering process, the requirement analysis being the stage one and then the functional analysis and the design synthesis so how this whole system works out we will try to talk about so the inputs comes in then the systems engineering process. So you can think about this whole thing as the systems engineering process.

And then from there we get what we call as the output which is the design of a system. So the first thing requirement analysis, we suggest we showed in the previous slides how the requirement analysis is being done which kind of is part of the development phasing which is the concept studies and if you think from there you kind of get into what you call as the functional analysis and allocation.

We will talk about what it is later but to a large extent the requirements of the system gets translated to what we call as the functional analysis. So the requirement is it require it is a long endurance and the functional analysis is like what does it required to realize the functional what is it require to realize the long endurance, how much liters of fuel, what type of engine, what type of cooling system, what type of automated control.

So that the pilot fatigue is the remote pilot fatigue is not impacted by that all this kind of things comes out as the functional analysis and then sometimes during the functional analysis you will come across okay it can be done or it cannot be done so that feedback goes back into this, then the requirements gets revised and then appropriate functional analysis is done. So this is sometimes also called as functional analysis and allocation.

This is called as because you are sometimes at the end of the day you will say this is being this function is being allocated to this subsystem that also sometimes happens as part of this. So this loop that you did, this loop is called as the requirement loop. So, all the requirements of the system and the functionalities that we are going to put into the system are synthesized out of this loop.

So once you are done then from the functional analysis and allocation. You allocated the function to different stuff and when you successfully complete this loop, the system has all sort of functional capability with it which will be able to satisfy the system requirements that came out of the requirement analysis. From the functional requirement what we get to do is the designs synthesis.

You try to design stuff and once you start doing the design synthesis then you will say that does not really work because we do not have the capability to do that which we thought we had. So let us go back and change it actually. When this change happens then you have to go back to the requirement loop and you have to iteratively do this. So this loop is called as the design loop.

So this is why I was telling earlier that this process is sequential and it is toped down and it is hierarchical and also recursive. So from requirement analysis you went to function analysis you finish this loop you think you really got a level where you are gain the confidence with this then you went into this design synthesis and you realize something okay that is not really feasible.

You went back to function analysis and allocation and modified it which you found out okay that will actually compromise some of the requirement analysis then you back and do this loop process. So this sequence process by doing this up and down you actually iteratively involve what the system is sometimes in the design synthesis you might even go back to the requirement analysis directly which this loop, this big loop what we call it as the verification loop.

So the verification loop sometimes when you do the design is this what the requirement said really or is this something what else you wanted to do and at the end of the day you can sometimes the problem with this whole system is that you can keep on doing this endlessly there is no end sometimes to this kind of a process. So the primary question in this is there need to be some amount of balancing.

This balancing happens at each step the process get balance out of here so how is this balancing done. The balancing is done by answering the fundamental question how much value is added at each level of development. So here the fundamental question is by doing this are we adding any value or is just doing things for the sake of doing it. So the system engineering process to a large extent has called as the set of tools.

So this balancing activity is also sometimes called as system analysis and control. SAC so this balancing activity ask the fundamental question how much of value is being added and if there is no value being added there is just futile discussion ignore it we do not want to go back or we do not want to do it, but if it is something that is worth doing it okay plus repeat doing this.

So this balancing activity is also an integral part of what you call as a system engineering process. So SAC is a set of tools and techniques that allows you to balance the entire requirement analysis, functional analysis and allocation and design synthesis in such a way that your system analysis can be done with sufficient detail and the whole process is well within the control.

So you put the inputs into the system and you get an output in the form of system specification which will satisfy the initial requirement which was part of the concept studies.

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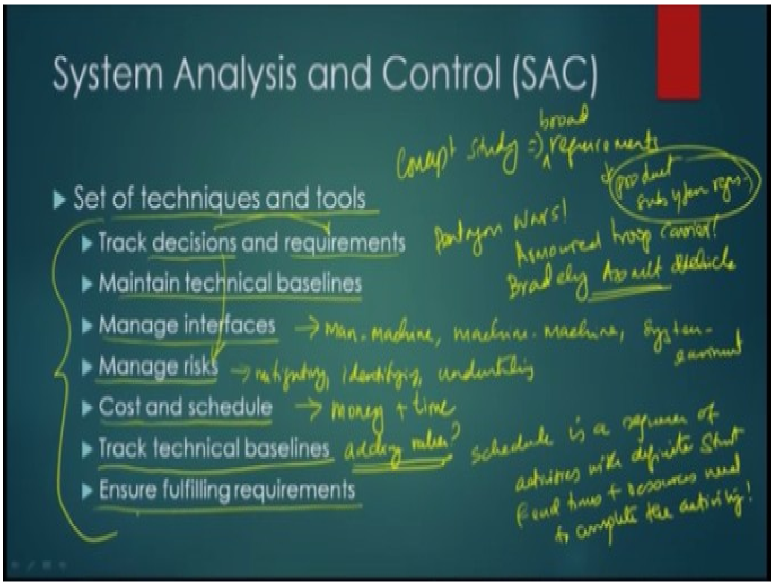


So we talked about system analysis and control and I said that earlier said that it is a set of techniques and tools so I am repeating the same statement basically saying that SAC is a set of tools and techniques and what are those tools and techniques do. These tools and techniques actually do what we call as track the decisions and requirements. So at some point of time if you make a decision and how does that decision impact the requirements of the system is basically is tracked here.

There is a video that I would recommend you guys to see there is a movie called Pentagon Wars and this movie actually shows the development of armored troop carrier and it is an example of how sometimes making decision on the fly compromise the requirements. I would recommend you guys to watch this how does the Bradley development process is, there is a lot of comedy as part of this.

But if you see the Bradley assault vehicle development, that is described in this one can gives an idea how sometimes decisions do impact the requirements. So sometimes you make decisions which will fulfill certain aspects of the requirement of the system also second aspects of this tools and technique this is SAC ensures that you maintain the technical baseline.

So the technical baselines were derived as part of the requirement facing, from there we came up with okay these are the technical capabilities that the system need to have and we ensure through this SAC that these baselines are met to some extent to all the possible extent and in this process if you come across okay you have to do some interfacing, interfacing in a sense here you have the man machine interface, you have a machine interface, you have a system environment interface.

So there are many interfaces as part of this how do we mange those if you have an electrical system how does it actually get connected, how does it get connected to a mechanical system and electric signals how does it gets translated to a particular movement of the torque of the servomotor all those kind of things actually get done as part of this. How does the human being who is supposed to operate the system will operate the system?

How is the guy who is in-charge of producing this system, will result in producing system all those aspects are part of this managing the interfaces. It also involves managing the risks like as I said earlier if somebody says okay fine in this Bradley assault vehicle carrier somebody says okay we need to put a big gun that is one of the decisions that they make, but putting a big gun gives it an appearance of attack.

So then the enemy is going to hit it with a much heavier weapon which will be much of a skipper portion proposition for the troops that are travelling in the system. So sometimes what happens is the decisions well create risk. When you see this video you will understand what I am talking about but anyway and the SAC goal is to how to manage you are looking at mitigating, identifying and understanding.

So, once you know the risk then you basically decide how to deal with it, how to manage it. In all these process one major aspect are come of it the cost and the schedule. What about the cost and how long the development process is going to last is it within the schedule, so here is the money plus time? So schedule in a way is schedule is a sequence of activities with definite start and end times plus resources needed to complete the activity.

So we use schedule in that sense in this discussion of this whole system engineering. That schedule is a sequence of activities with a definite start and end times along with the resources necessary to complete the activity. So the cost and the schedule the money how much money is required and what is the schedule, the time within which it will be done along with the resources is it there that part also is being the control aspect of the system analysis and control.

We also keep on tracking the technical baselines. So maintaining and tracking is different because sometimes what happens is you might end up doing something which would really result in not being able to achieve the technical baseline. So you have to have a corrective action to get to back to achieve the technical baseline. So you keep on tracking that the technical baselines are fulfilled at all the levels in a way.

We also told about this earlier that the question adding value, are we adding any value and this question sometimes says okay no let us not do it, but the question of adding the value, it is always again is the technical baselines. So you are measuring again as the technical baselines to decide, is it adding value or not then you ensure that the requirements, the things that came in the beginning you fulfill those requirements.

So the requirements actually came in at the beginning as part of the concept study gave us some requirement that is call as the broad requirements. These broad requirements we keep on trying to see then you crystalized into what we call as a product and subsystem requirements. So these requirements we ensure that they are being fulfilled that also part of the system analysis and control aspect.

So the tools and techniques allows you to do all of these aspects that is what you call as a SAC or system analysis and control aspect of it and in this case again as I told you earlier that you have a requirement facing on which you actually apply system in the SEP system engineering process in a name to realize the details the architecture of the system.

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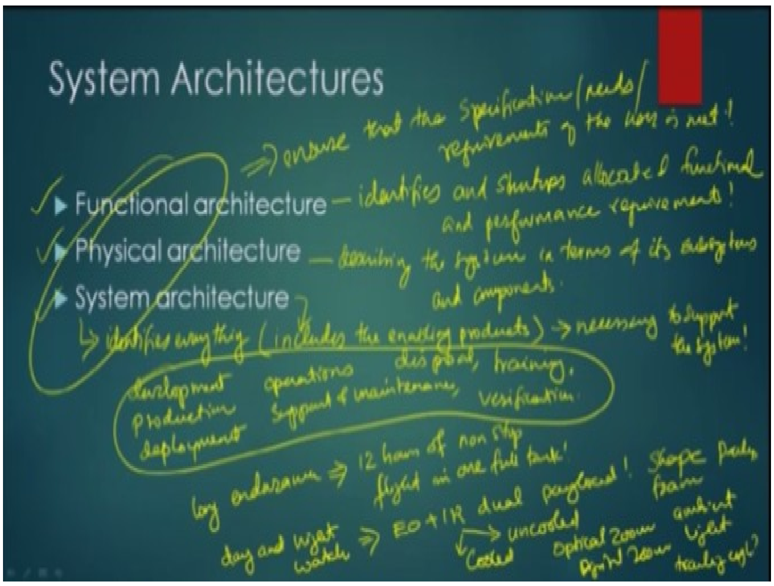

And in this we actually will be discussing three architectures that pertaining to us, so the SEP supply properly to the development phasing or the requirement of the system then we will be able to derive what we call as a functional architecture, a physical architecture, system architecture. So what is a functional architecture it basically what it does is it identifies and structures allocated functional and performance requirements.

So the functional and the performance requirement are identified so if you think about the UAV that we talked about somebody said it should be long endurance which translates to something called as let say to allow us of nonstop flight in one full tank something like this. So this will be a performance requirement so similarly the functional requirements and it is associated performance requirement will be coming out of this.

It should be capable of doing day and night watch or surveillance that comes and then you will say and translates to EO plus IR dual payload. So these as we can think about it in a broader sense I am just giving you some examples. So the functional architecture to some extent gets actually described out of this. Similarly, the physical architecture, physical architecture is if you are basically describing the system or depicting the system in terms of its subsystems and components.

So here is this much more detailed you are not just talking about so here you will be like a infrared. In this case the IR payload you will probably will be having something like there is a uncooled or cooled, what is the optical zoom? Is there is a digital zoom involved in it, what is the ambient light, is tracking capable, so many aspects of this the subsystem capabilities and its components are of a system is both the system as well as the subsystems are completely specified as part of the physical architecture.

In this case also we will talk about the shape, the form and we will also talk about the packaging and that kind of a system as part of this.  All these things will come into what you call as a physical architectural system and then comes the systems architecture. This is little bit more broader because it identifies everything. I would say, I use the word all overarching world everything because it also involves it includes the enabling products.

What are the enabling products? These are the enabling products, they are first of all they are necessary to support the system, what are some of the stuff that are necessary to support the system you would require things in the development, you will need something called in the production, support system in the production, there is stuff in deployment, there is stuff during the operational system, there is support, maintenance, training they are all part of this then there is disposal, training  and it also involves in verification.

So all these aspects, these are all the enabling aspects of a ensuring that the system is doing what it is supposed to do. It is done in both senses that sometimes you might come across something during the physical architecture which might stands into a system architecture and says or we would require something extraordinary to realize this that is fine as long as you end up meeting all of these things are done.

All of this is to ensure that the specifications or the needs or the requirement of the user is met. This is the reason why all of these things are, so these three documents put together it ensures that the specification needs of the system what the user has specified or user wanted is being met out of this. So that finishes of today one part of the presentation we will come back with the next aspect of the systems engineering management process in the next presentation. Thank you.