Systems Engineering
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Lecture – 22
Timeline Analysis Sheet and Requirement Allocation Sheet

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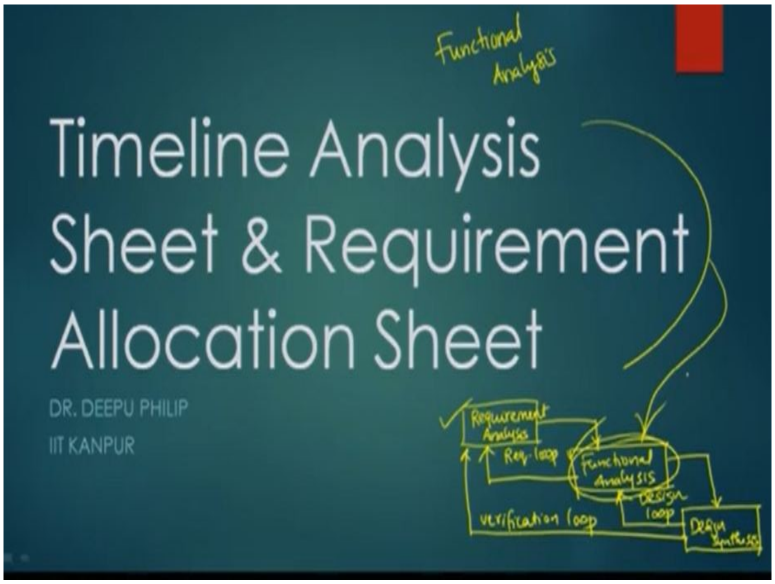

Good evening. Welcome to the next structure of systems engineering where we are discussing about functional analysis and different tools that are associated with functional analysis. Today we are going to talk about two major tools called time analysis sheet and requirement allocation sheet. So the time analysis sheet and requirement allocation sheet both are tools that are used in functional analysis.

Both time analysis and requirement allocation sheets are used in functional analysis. We have already seen the three step process in systems engineering as we called about it as requirement analysis followed by functional analysis followed by design synthesis. Thus we have seen that the functional analysis and requirement analysis completes the requirement loop and the design synthesis and the functional analysis completes the design loop.

And design synthesis and requirement analysis completes the verification loop. We have already seen requirement analysis. This is already completed. We are just going through functional analysis this is what we are working on and these two tools are actually tools that are used in the functional analysis were to do certain aspect of it.

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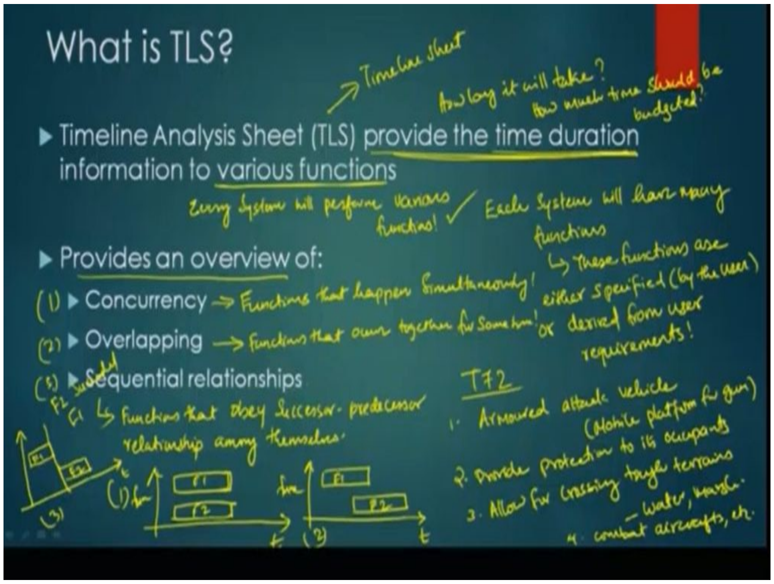

So firstly we will talk about the tool called TLS or the timeline analysis sheet it is not TAS it is TLS timeline sheet is what typically the abbreviation is. This stands for timeline sheet even though the actual name is timeline analysis sheet. What does it do? It provides the time duration information of various functions. So we know that each system will have many functions where do these functions come from? These functions are either specified who specifies it?

Specified by the user or they are derived from user requirements. So the functions that are associated with each new system either they are directly specified by the user or that is derived from the requirement that is given by the user. So every system will have various functions. We can think about it as every system will perform various functions. You might have seen the video in which we demonstrated the tank T72.

So in the T72 tank it is actually an armored vehicle it performs the function. So the first function is an armored attack vehicle okay. So it provides the function of a mobile platform for gun that means a big howitzer is mounted on it. It also provides protection to its occupants. It is also you know allow for crossing tuff terrains like water, marsh etc. So you have seen this it has different function it also can provide you know combat aircrafts etc.

Quite all a lot of functions the tank is capable of doing. So all these function when the time it was designed or somebody conceived that product it was either specified by the user or it was derived from the user requirements that were provided. So every system will perform various functions that we already know. Then once when systems perform various function it is important to know the time duration associated with each function.

How much time it will take? So this means how long it will take? Or other way to look at it is how much time should be budgeted? So these questions are answered with the help of TLS. So what also TLS does is it provides an overview provides the user with an overview or the designers with an overview of concurrence. Concurrency means functions that happen simultaneously. Concurrent functions how many of them happening in the same time that part is told.

Then there is overlapping function which means functions that occur together for some time that is another case. Then the third one is called sequential relationship and this is called as functions that obey successor predecessor relationship among themselves. So if we draw this in a graph an example of this would be the concurrency number one as concurrency.

We can think about these as this is time and this is the functions then you can talk about these as concurrent functions both of them happening in the same time F1 and F2. While as overlapping functions you can think about it as something like this. That is your time and function axis F1 and F2 okay and sequential on the other hand will look something like this. It will be the time axis and it will be strictly this okay F1 and F2 means the function will only happen after.

So F2 will only happen after completion of F1. So you can say that in this case it is F2 succeeds F1 or F1 precedes F2 okay. So these three things are happening okay. So this is your two and here is your three okay alright.

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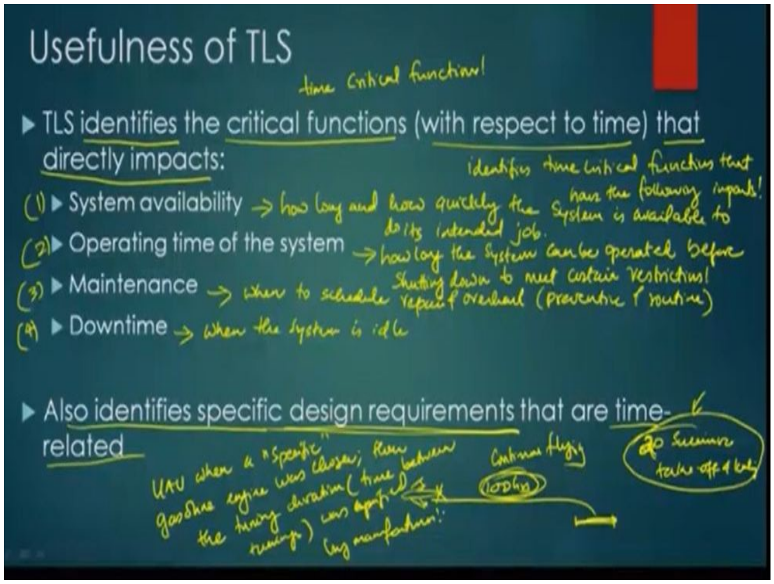

So what are the major uses of TLS or the timeline sheet or timeline analysis sheet? So the TLS the major utility of it is it identifies critical functions. The criticality of the functions which is purely with respect to time so these functions are also sometimes called time critical functions. The criticality of the functions with respect to time is identified with the help of TLS and these functions have the capability to directly impact.

So here we are saying that it identifies time critical functions that have the following impacts. What are those impacts? Number one is system availability. System availability is okay in another word to think about it is how long and how quickly the system is available to do its intended job okay that is what we call as system availability. So by understanding the time critical functions and understanding the time requirements associated with these time critical functions.

We can fairly very well estimate the system availability. How quickly is the system available for doing something and when the system is made available how long the system is available to do the stuff before it has to be taken out for maintenance or something else like that? So that is the first and foremost aspect. Second one is the operating time of the system okay. This is to an extend related to the system availability but this is more precisely how long the system can be operated before shutting down to meet certain restrictions.

Like for example in an aircraft or in a fighter jet it sees that after 100 hours of flying you have to do engine overhaul let us say it does the time. Then the operating time of the system operating time of the engine is 100 hours of continuous fly. So in one way to look at it is let us say an aircraft takes off from one runway flies around comes back so the aircraft takes off okay it flies around.

It is an engine and then come back and this all process it finishes 100 hours that might be after that you will have to overhaul the engine. Sometimes it is also said that the engine need to be overhaul after twenty successive takeoff and landing. So that means let us say you the aircraft takes off twenty times and landing so whichever one this twenty successive takeoff or landing or 100 hours whichever gets completed first will force the engine to be overhaul.

So the operating time or so both of this will be like continuous flying will be one critical function and successive takeoff–landing will be another critical function. So which one of this function happen first will be the one that actually will force the overhaul of the engine. So the operating time of the system the time available for the system to perform its operation is also made available or we can get that from the TLS.

Third one is maintenance so this is like when to schedule repair and overhaul okay where we are talking about both preventive and routine okay. We are not talking about accidental breakdown but maintenance because such that happens and then you basically have to repair it there is no other go. Hence very hard to predict them even though there are models to predict them but still you know that is not part of the puzzle at this point.

So the planning of the routine and as well as preventive maintenance or repair and overhaul of that aspect is also something that we get from the TLS. And we also able to estimate down time that is when the system is ideal. When it is not doing anything when it is not doing it is intended job okay that is called as the down time okay. So these much are the criticality aspects with respect to time the TLS allows us to identify and as well as help us to directly quantify the impact on these kinds of aspects.

Also TLS identifies specific design requirements that are time related okay. So like when you are designing the system certain time related design requirement will also need to be identified and those things that will be identified by the TLS. So one classical example of this in our case is our design requirement is when we choose the engine in the UAV when a specific gasoline engine was chosen then the tuning duration or time between two successive tunings was specified by manufacturer.

So we will be like after every 50 hours of flying we will have to go and check the engine and adjust its tuning to ensure that the engine is doing what it is supposed to do. That is because we decided to choose that engine so that is a design choice and we did chose another engine which might have done something else and that tuning time would have been different. So sometimes the choice that you make at the time of designing the product will also sometimes create certain time related criticalities that also you need to be aware of and TLS is a good tool to create that awareness.

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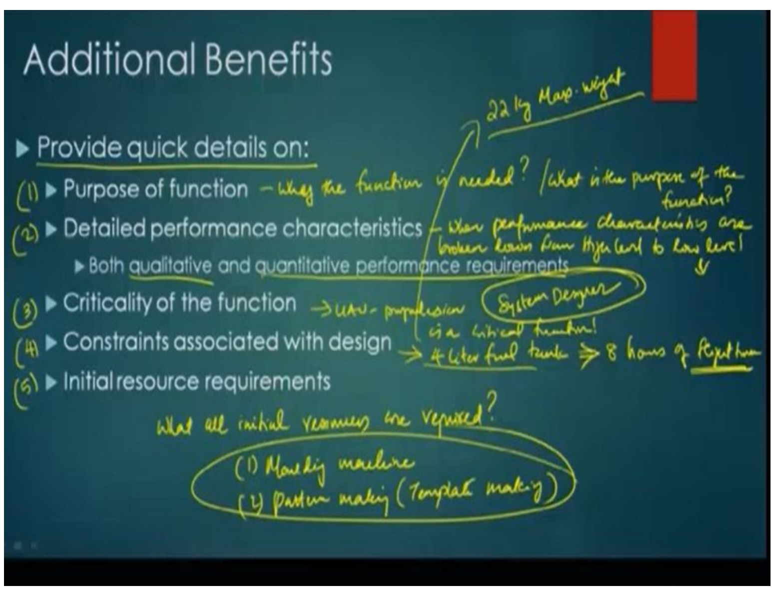

There are also some additional benefits that are associated with the TLS. And those additional benefits are it also provides quick details okay. Details that can be quickly grasp. Number one will be the purpose of function okay. Why the function is needed? This question what is the purpose of the function okay. Some people also say what is the purpose of the function? Second one is the detailed performance characteristics okay.

So as we said earlier that functions and performance characteristics are specified by the customer. So when performance characteristics are broken down from high level to low level then that performance characteristics need to be specified with each low level function. It will be both qualitative and quantitative performance requirements and that is necessary for the designer or the system designer.

Remember this tool this functional analysis output goes into the input of the design synthesis where the system designer uses this document to design the system. Then third aspect is it also allows you to identify the criticality of the function how critical the function is? So if the function is like if it is a critical function and if it does not happen then the system will not be able to do what it is supposed to do.

Like in an example the UAV propulsion is a critical function. Because if the propulsion stops then there is no more power available with the system and the aircraft of the UAV no longer flies. The all it can do is just glide and then as long as the altitude and every time we lose an altitude it glides some forward distance but that is it. When the altitude lost it comes and crashes to the ground.

So the propulsion ensuring that the engine of the electric model both is continued to work. It is very critical for the successful flight of the UAV. Then the fourth one is the constraints associated with the design. This is also important because sometimes this constraint translates to certain time criticalities. In our case one of the constraints was four-liter fuel tank which translated a time of something like eight hours of fly time.

So flight or flying as a critical function and the maximum time with which our UAV can fly was capable of eight hours because of the limitations on the fuel tank and the four litre fuel limitation was further imposed from the 22 kg maximum weight criteria that are given. So the constraints that are sometimes translate to something else the high level constraint get translate to thing lower which could actually impose a timeline limitation on certain things.

Using a TLS sheet these kinds of things can be easily identified and the last one is the initial resource requirement. What all initial resources are required? This is a major question in this regard. An example is now in the UAV we are making some of the initial resources that were required was you know mounding machine okay. Second one is a pattern making system or template making you can think about it okay.

As a multiple axis welding machine stuff like that so these ones were initially required but ones the mound is built then these machines were not necessary because then you are making for a different process. So sometimes the initial resource requirements that is, necessary for it to successfully start manufacturing the system and building and delivering the system. It can also be identified from this document.

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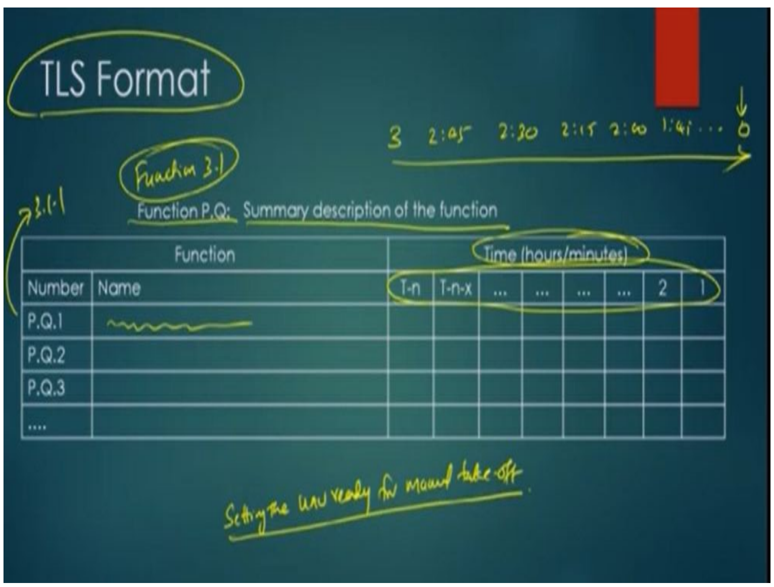

So what is the format? How is the TLS document looks like? How does a timeline analysis sheet look like? So the first thing will be you are identifying the function. The function PQ or P.Q is a kind of a like a number so somebody says it will be like function 3.1. It will be like a particular number and the 3.1 will be something in like is the third may be critical function and the first level of that function that is what we might be talking about.

And then you will be having a summary description of the function. So when you look at the sheet then you know what you are talking about. Then the number P.Q.1 is what we can call it as

3.1.1 in this case. This will be 3.1.2, 3.1.3 so in that main function 3.1 what are sub function that are associated with it. What are the subsets that are part of it? And then you have the descriptions or the function right here put the name of it.

And in the time the thing that you need to remember about the time is many a times is represented in the reserve manner. So if somebody says you know that function is we will do an example. But in this case a lot of time it is set up in this way somebody says okay it is like do this for three hours before the takeoff of the UAV. So then you will counting it as three hours two hour forty five minutes, two hour thirty minutes, two hour fifteen minutes, two hours, one hour forty five minutes like this okay.

And you will reach zero which means as the time has had reached you are ready to launch the UAV. So sometimes this decreasing count of time is also used sometimes the increasing count of time is also used but lot of the time you will actually come across this. And the time is usually expressed in the terms hours and minutes. What we will do is we will do a simple example of setting the UAV ready for manual takeoff of is what we will use it as an example in the next case and see how this all thing actually works out.

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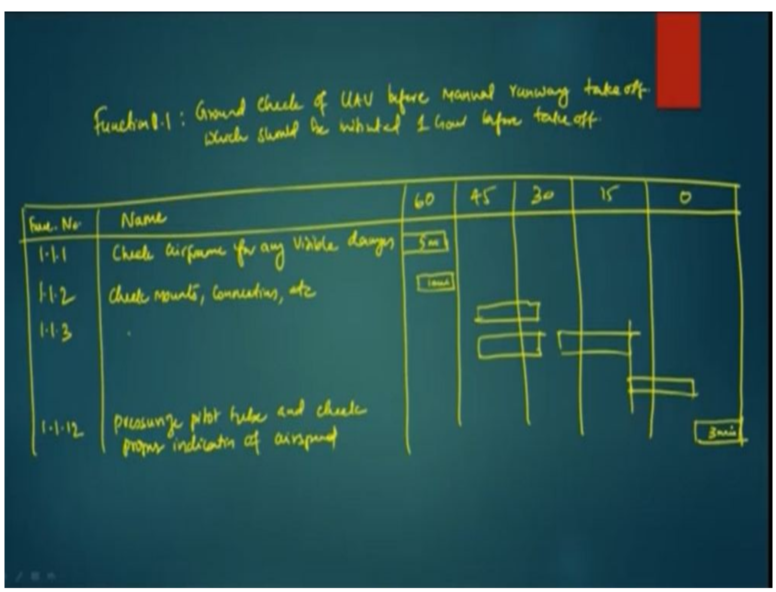

So in our case we will say function 1.1 okay ground check of UAV before manual runway takeoff okay which should be initiated one hour before takeoff okay. So this gives you a brief idea of the function 1.1. What is the stuff you need to do and then if you thing about it is in a table you can have many functions as part of this okay and we will think about it this way. You will have function number, name of the function then you will have time here.

So you can think about it as sixty minutes then you have forty-five minutes, then you have thirty minutes then you have fifteen or zero something like this. Let us say for the time being we think about it and you will have function 1.1.1 no. We will say check airframe for any visible damages and that is probably the first thing you have to do and you will say okay it takes like five minutes something like this okay. So you can put that time period then you can say 1.1.2.

Then you can say check mounts connections etc. We can say okay fine. When you are checking the airframe also that is where you decide whether it is concurrent or whether it is sequential so you can partially overlap okay at the same time also you can okay this is like a ten minutes kind of a think so then 1.1.3 you can put the other think and finally at some point of time you will say last will be 1.1.12 or something like this then you know pressurize pitot tube and check proper indication of air speed.

And then some where you actually would say okay this is something that should happened all by itself and you would say that will be like three minutes stuff. And then you can see that. So the different functions will continue and you will allocate them and different time period this is what it will happen something like this okay. So this gives you an idea of what the order in which the function will happen. The functions will happen sub-functions will happen.

And whether they are so you will probably end of saying that these two are sequential function. These two are you know overlapping functions there might be another function which might be something like this which you will say these are concurrent functions all those kind of stuff okay alright.

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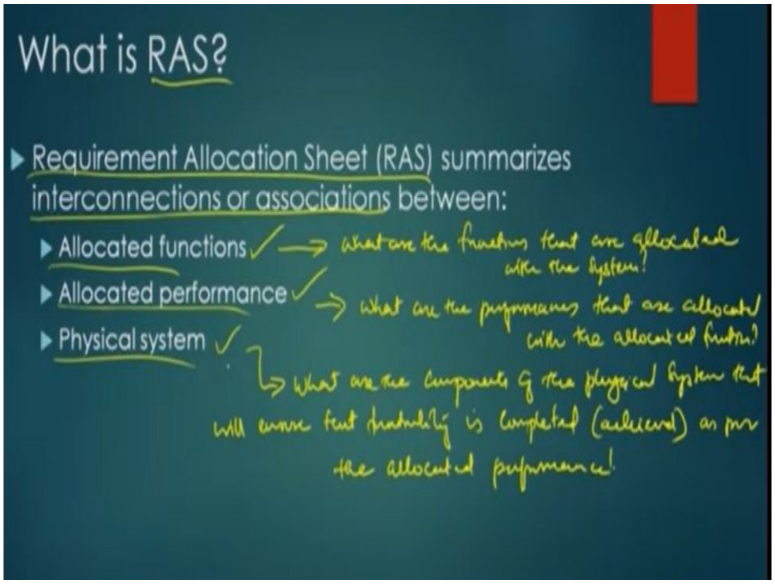

Now the second one what we talk about is another tool called as RAS which is called as a requirement allocation sheet. It is very popularly known as RAS and what it does is it summarizes interconnections or association so different interconnections and associations between allocated functions, allocated performance and the physical system. The interconnections and associations between them are clearly stated in the RAS the requirement allocation sheet.

So the allocated function means what are the functions that are allocated with the system. This is the first part. Second one is - what are the performances that are allocated with the allocated functions. So once you have a function then you have performance associated with it. Then combine both of them what are the components of the physical system that will ensure that functionality is completed or achieved as per the allocated performance right okay.

So these are the major aspects of the requirement analysis sheet. It gives you the interconnections and associations between allocated functions, allocated performance and the physical system.

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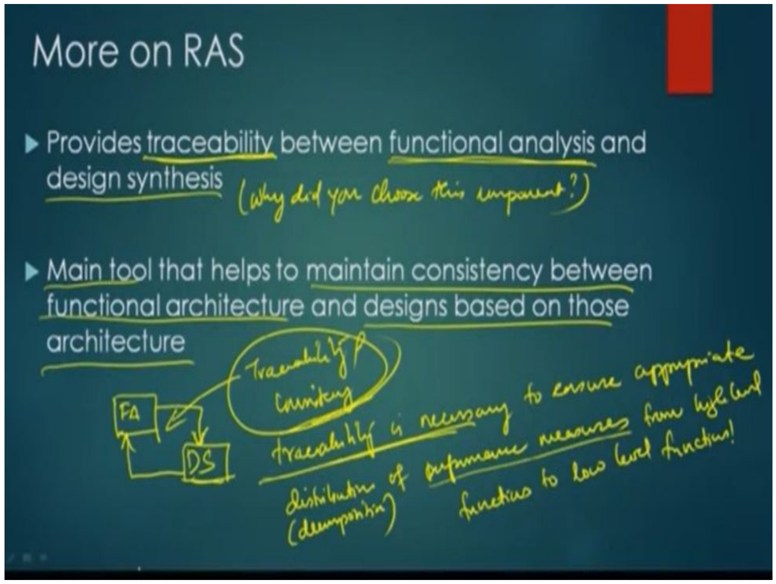

And also talking more about the RAS, it also provides one of the most important things in systems engineering called traceability okay. Traceability is necessary to ensure appropriate distribution of performance measures. Probably distribution we can also call it as decomposition of performance measures from high level functions to low level functions. So as we move from one level to another we need to be sure that the appropriate performance measures where decomposed from high level functions to low level functions.

And it needs to be traceable it needs to be established that this proper allocation has happened. So the traceability is an important requirement of systems engineering and the traceability between functional analysis and design synthesis is quite important. So the question that usually gets asked here is why did you choose this component? What is the reason behind choosing this component?

And the answer to that it is that is chosen because of the performance measures or the performance parameters that were specified with that particular function. And that is part of the functional analysis document. So the designer need to actually be able to trace or be able to justify the choice of a particular component which is associated which is what we call as traceability.

It is also the main tool that helps in maintaining consistency between functional architecture and design based on that architecture. So when you are doing this part of the loop the functional analysis and the design synthesis these two loops and when you are doing this requirement allocation sheet is one of the major tools that allows us to ensure this traceability and consistency.

So here you require traceability and consistency. When you are doing this process when you are translating the functional design of the product system to a realistic physical design then this traceability and consistency are two important things that is necessary and that is achieved. Our requirement allocation sheet actually helps us to realize that.

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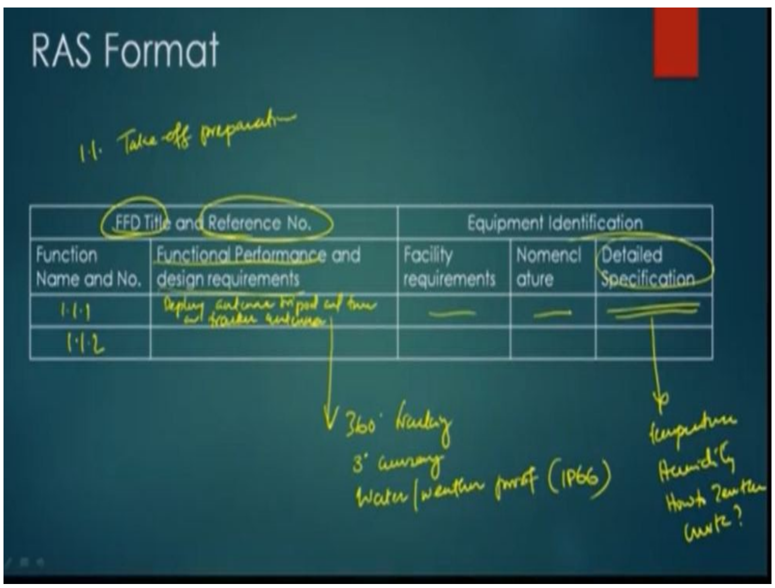

So what the typical format of the RAS? The format of the RAS is something like this. The FFD it actually comes from the functional flow diagram title of the function and has the reference number so it will be something like you see earlier you know takeoff preparation and it will be like 1.1.1 or something like this. And then there is a functional name and number each one of them is like 1.1.1, 1.1.2 something like this. Here this is not 1.1.1 this is just 1.1 okay.

And here the functional performance and design requirements are stated out. So like some where we would say you know deploy antennae tripod and turn on tracker antennae. This will be simple thing but it also would require a performance requirement which would be like 360 degree tracking okay. Some three degree accuracy something like this and also it is like a water/weather proof. Somebody would ip666 something like this.

And then what are the facilities that are needed then some other specific nomenclature if you are going to use a specific nomenclature that also needs to be done. And then other details of the specifications some specific aspects like temperature requirement okay humidity. How to zero the north? All these things are part of this exercise okay. So once you go through this document we actually will be able to say what are the functions intended to perform.

What is the performance requirement of the function and what are the design requirements of the function? And the detailed specification gives us the intricate or very intensive and intricate details that are necessary for us to decide why this particular choice was made. So with this we will actually complete today’s lecture and we will look into the design synthesis and the last part of this lecture since we are moving towards the end of the course.

So now we will get in to the third component which is called as a design synthesis from the next class and that process we will also try to see few more additional tools and if you want to learn more about this thing then you are more than welcome to attend the advance level of this course in which more tools and additional cases are actually discussed. Thank you.