Design Practice
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Lecture – 07
Generic Phases of the Design

Hello and welcome to this module 7 of the course of design practice, we would like to describe in this particular module the generic phases of the design which we had described earlier as per this particular map.

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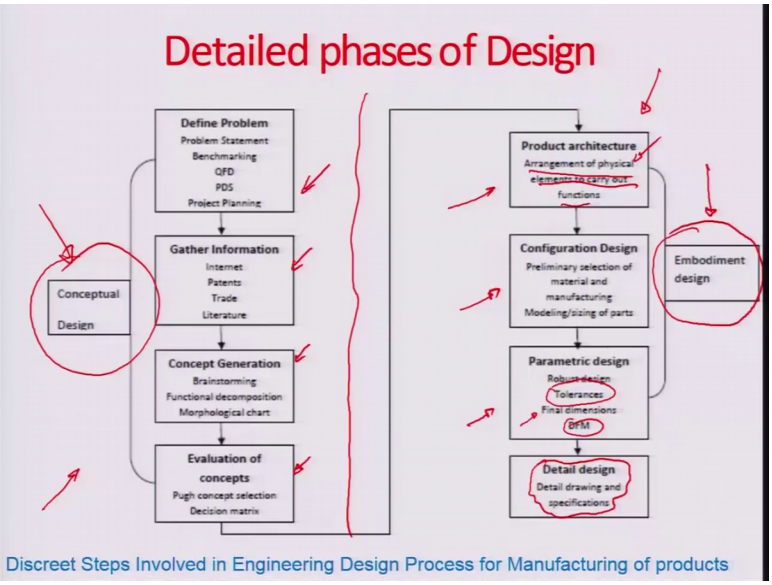

We are in the first part we talked about how to formulate a problem or generate a concept to solve the problem and then finally, evaluate the concept in an organized manner. So, that finally, there is ah, there is an overall scheme of what needs to be done in the whole design. So, this phase is also known as the concept framing phase or conceptual design as it is more commonly called, the other phase of course, is related to the actual design of the embodiment which is being planned in the conceptual stage which will solve the need of the problem.

And this would basically necessitate a stage of you know defining the architecture of the product that is underlying which talks about maybe arrangement of physical elements to carry out different functionalities, put together in a single page. Or even the sort of a configuration aspect of the design where there may be the question of functionality based

mapping by putting things in space and how the product would like to interact with its environment. So, it is a kind of a well defined map to talk about the overall configuration of the architecture which has been planned in the last phase. And then finally, fixing out the different parametric aspects of the design and how to make those design aspects more robust after particularly implementing the design in a process and trying to get an output from the processes of feedback to control the design itself ok And then finalizing of these tolerances or dimensions related to the different aspects of the product architecture which is being talked about and then finally, the design for manufacturability.

So, all this comes into the real hardware part, the conceptual design part is about more determined the essence of the need which is underlying or a problem which is underlying and how to address that need and the embodiment part is that what are the logistics which are involved in sort of addressing that need. So, this is what we have so far discussed about the detailed phases of the design process and. In fact, we had done some work in this particular phase on the right here in the last about 2 3 modules where we talked about how a problem can be identified or how solution can be brainstormed and may be prototyped in great details ok.

But at the outset once this whole concept building has been done, the real hardware part starts developing here where there is a question of how you are going to realize what you have developed or how you are going to also the see the economics of scale when we talk about implementing a solution or existing in an existing scenario ok. So, which this basically is a phase which would like to bring out finally, the detailed design with drawings and specifications of the product or the solution for the problem step which is in the last phase and. So, here we will be focusing mostly on 3 different aspects.

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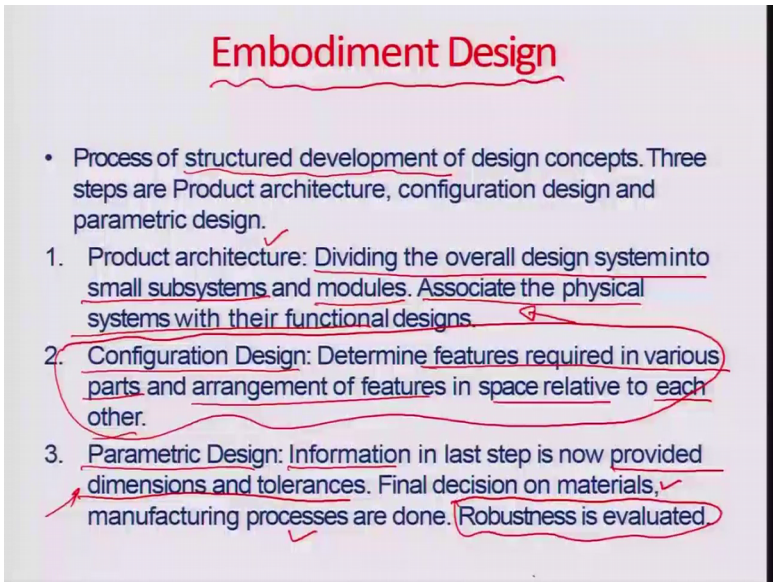

One is the product architecture and this would really be a structured development of the hardware part of whatever has been conceptualized in the earlier phases ok. So, the architecture part would focus typically on dividing the overall design of the system into smaller subsystem levels and modules ok.

And then the other also issues about associating the physical systems with their functionalities ok. So, in context of that there may be a very simple example of, let us say if you are talking about a small pen, when we when we talk about a ballpoint pen we having many different components within a pen. For example, there is a outer housing, there is a refill you know which can be replaced, there is also a push button system through which you would like to project the refill forward or backward withdrawing it into the casing at times and there is also a spring loading aspect which is. So, all these are independent subsystems of the overall system that is a pen and if I wanted to associate functionalities with each and every subsystem.

So, obviously, they are in unison or in assembly functioning with respect to each other and then the pen is also functioning with respect to the surroundings which is actually the paper on which the pen makes a mark or a writing or let us say the environment around which the pen is kept. So, that there is an aspect of temperature of the particular let us say casing, which would be held by an individual. So, for example, when we are designing for pens this choice of material etcetera should be such that they are sort of

insulating in nature and there should not be any heat storage or there should not be any problem associated with the temperature of the casing going up. So, that its inconvenient for the user and then on one hand a part of this also is the environment associated with the fingers of a person which holds the pen.

So, when we are talking about the whole architecture of the pen there are several external factors which are involved like the paper the fingers which are holding a pen or the environment with which the vane is interacting and at the same time there is something which is within the product and that architecture each and every component has some functionality associated with it.

So, the product architecture when we talk about this we are talking about just that division into smaller sub systems with their basic probably functional understanding of each subsystem, but when we talk about a little bit detailed configuration design what we determine here is the features required in various parts which have been figured out in the last step and the arrangement of the features in space relative to each other.

So, that you can think about the assembly to work in unison as such and then of course, there is a parametric design phase where we are talking about the collection of information in the last step which is laying out in space of all the different components together and then providing dimensions and tolerances based on the functionality and the flow. You know of the product and final decisions which are to be arrived at on let us say the materials use, the manufacturing processes which are to be deployed and the overall robustness of getting something manufactured and delivered being evaluated this all comes into the parametric design aspect of a product.

So, we are going to lay out some different discretized products and try to give you an understanding of how this structure development of the design concept is done. So, let us look at in details.

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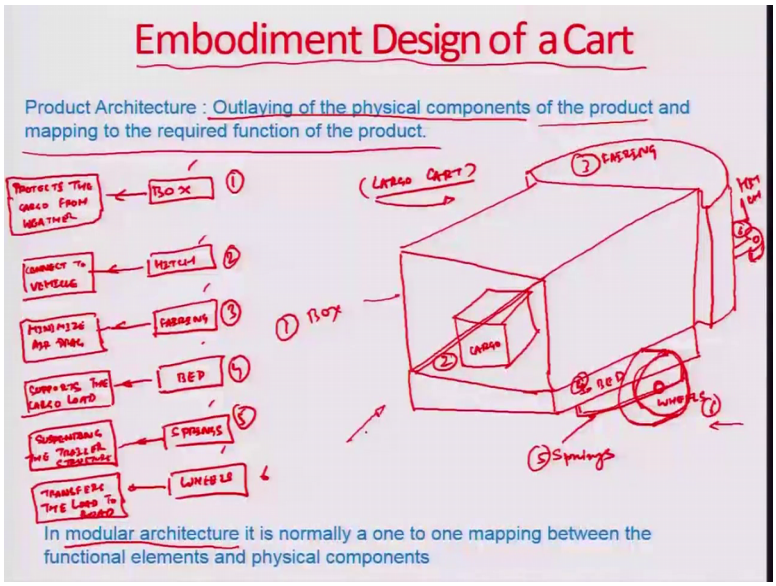

So, the first part which is the product architecture in the embodiment design can be better understood by this example of designing of a cart ah, there are these cards which are used for carrying luggage from the at the airports from the collection stations all the way to the airplanes and back and. So, if we wanted to design such a cart, it would be really about out laying of the individual physical components of this product this cart and the mapping that will be needed ah. Because, we want to associate functionalities with every subsystem level component or every small component associated with that whole overall physical description of the embodiment of the cart.

So, let us say if we wanted to draw such a cart, a card is somewhat you know it looks somewhat like this where there is a component associated with some kind of a box where is typically used for protecting the cargo particularly from weather, you know let us say rainy season etcetera cargo should not get wet. So, there is a box. So, this is the box part and let us say this is the bed which supports the cargo. So, typically the cargo is placed somewhere in between here, let us say this is this is actually the cargo ok.

So, and if I looked at how this card is positioned and oriented and designed there may be some leaf springs which may be connecting the card to a set of wheels. So, probably just draw it in this manner. So, you have this part of the spring. So, we call this let us say leaf spring or just general springs. So, the spring carries weight and. So, there is there is a

wheel on either side. So, there is one wheel here and again another wheel here which is not visible in this drawing and then there is of course, this fairing.

So, this is sort of a shape which has been deliberately laid out for reducing the aerodynamic drag associated with this component. So, it is connected like this to the different side of the cart and then there is some kind of a hitch which is again used to connect it to a vehicle right. So, this is a sort of a hitch you know which would be used for carrying the cart forward.

So, you have a cargo here, we have a box you can see the box right about here there is a bed, there is a spring, there are certain wheels which would be the load bearing members, there is a fairing here just for reducing the aerodynamic drag and then this is the hitch which will be use for pulling the typically the cart. You know this hitch is attached to the end of a power provider it could be either a tractor or some kind of a small Indian driven mechanism which would carry out these cargos crag so sort of a cargo vehicle from the airplane to the main station or terminal or back.

So, if I just whatever I said I wanted to organize in terms of different subsystems and different functionalities. So, there are about close to 1, 2, 3, 4, 5, 6 and 7 subsystem level information which are needed you know in this particular embodiment of the carton, if I wanted to lay out in terms of the different components and what are the associated different functionalities. So, for example, the box in this case would be providing a protection of the cargo against weather ok. So, we can say that the box protects the cargo from extremities in the weather condition okm then you have of course, the hitch which has a functionality of connecting to the vehicle.

So, you connect the hitch to vehicle then of course, you have the fairing which is a component used for reducing the aerodynamic drag. So, if I write the functionality of the fairing this will amount to minimize air drag then of course, there is a bed which is used to support the luggage or carry the luggage. So, we would say that it supports the cargo load.

So, you have these 5 components already built in there are also springs which would again have the role of suspending the trailer structure ok. So, you are suspending the trailer structure and then finally, the wheels which are the load bearing members ok. So,

you basically say that this transfers the load to road ok. So, this is how you can design the embodiment in this particular illustration which is a cargo cart ok.

In a one to one mapping of each component associated with some functionality ok. So, in a way if the if such an architecture can exist where each component would typically add to only one particular functionality and there is one to one mapping between the individual subsystem level and the function carried out by the whole system. They are typically known as modular architecture and there may be many instances where as I will show you just probably in the following slide that if TI slightly change the design of this cart it may be that multiple components are associated with multiple functionality. So, there are going to be complex modularity which is involved whether the mapping is really between you know, in one side if I have all the individual components and another side I have the functionality.

So, one component may be responsible for providing multi functionalities and that is become slightly complex than modular. So, we call it more towards complex modular geometries then of course, there are a third category of architecture or product architecture where there may be even a case where even a single function is done by multiple members or components and there as suitable in motion as is felt in most of the products the architecture is rather known as integral in nature.

So, therefore, we have a certain categorization in the way that we are laying out the individual subsystems of different components together to carry out so called the functional design off the product that is in question. So, let us look at a slightly different design of the same cart that we are, we have just talked about in this particular slide.

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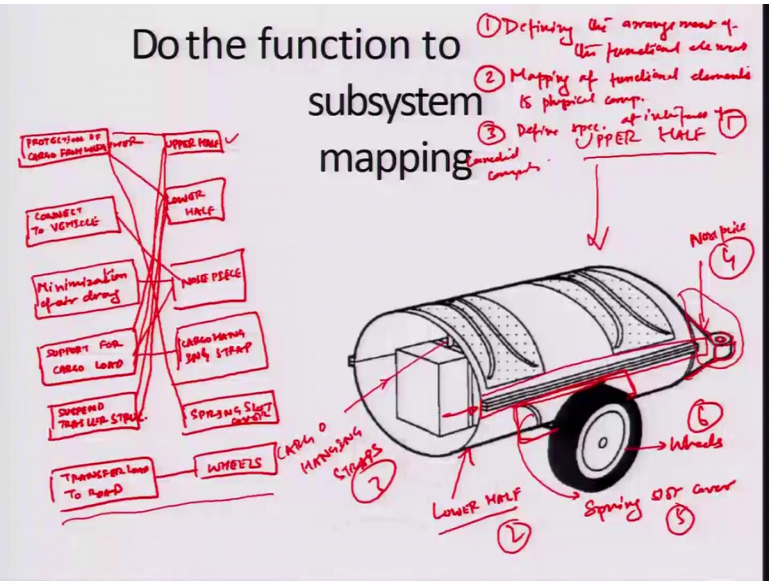

And if the design changes really to, what is represented here, you will see that the functional mapping of the subsystems in this particular architecture may be slightly different than what you saw earlier in the more simpler design.

So, in this particular cart really there is an upper half which is actually working as a you know weather shield for the cargo as well as is also responsible to a way, in a way to support the cargo loads there is also a lower half in this particular module let us say this is the lower half the lower half circle ok. So, here also there is both protection from weather as well as support for the cargo ok. So, that is how this system has been kind of defined there is of course, a nose piece which is somewhere here of this particular cart and then of course, there is a cargo hanging strap in this particular case as you see the cargo is hanging upside down and the load is supported from the upper segment of the upper half of the design.

So, that is how it is oriented actually. So, this is again the cargo hanging straps there are several straps inside the design and then we have a spring slot cover which actually is this whole cover area here ok. So, the holes supporting springs are now being covered and then of course, there are wheels ok. So, now what we see is that if I wanted to do a subsystem level mapping of all the different functions we will realize that there are multiple functions done by individual components. So, right now for example, there are at least 6 different items which are being listed here and if I looked at how these 6 items

would perform in terms of functionality towards the design, let us actually look that mapping.

So, we have the upper half here and then we have again the lower half let us just first in the same order list all the different sub system level information we related to this design we have the nose piece now ok. Then we have the cargo hanging straps and finally, have the spring slot cover and the wheels.

So, if I looked at the different functionalities that all these subsystems would have to offer. So, the basic functionalities in this design could be something like let us say protection of the cargo from weather ok. So, protection of cargo from weather, connection to the vehicle the powered tractor or trolley or truck which is going to drag this whole cargo carrier, you have minimization of the air drag again which is being done by the nose piece.

Similarly, we have the support for cargo load, the suspension of the trailer structure and finally, transfer the load to road. So, obviously, the wheels are the ones which will transfer the whole load to the road, but if I looked at the other elements you will see that there are multiple functionality is being done by different elements for example, the upper half in this case not only protects the cargo from weather, but it also helps in supporting the cargo remember that there is the there is a strap through which the cargo hangs on the upper half ok.

And also in a in a manner you know the upper half also sort of suspends the trailer structure ok. So, this suspension here as you can see in this particular zone is sort of connected in a manner so that the joint between the upper half and lower half is connected to the suspension. So, it is actually performing more than one function, similarly if I looked at the lower half the lower also performs all these 3 functions as has been illustrated. So, the lower also is used for supporting cargo load or suspend the trailer structure as well as production from the production of the cargo from weather, if I looked at the nose piece the nose piece here first connects to the polar vehicle ok.

Then also is responsible for minimization of the air drag, the nose piece is this one piece again which contains both the hitch as well as the fairing combined into one module now and then of course, the nose piece also in a way supports the cargo load because if I looked at how this nose piece is biased it gives structural stability to the upper lower

assembly ok. So, in a way it also is responsible for supporting a part of the cargo load by giving it a stiffer orientation. Similarly if I looked at cargo hanging straps typically all the load of the cargo is supported by these straps or the spring slot covers again are used mostly for protection from weather of the cargo and of course, the wheels are used to transfer the load.

So, in this kind of architecture as you see now there are many subsystem level components which are carrying out more than, one functionality. So, if I really were to look at such an item it is modular in a way that you have individual subsystems performing some of the other functions, but just because there are multiple functions being performed by a sort of a single component. You could say that the modularity is a little more complex for example, in this case the fairing and the hitch has been connected together and is now 1 module, instead of earlier 2 modules which were put in place ok. So, so, in a way such kind of an information is goes towards what you what you call complex modularity and then of course, if we wanted to look at the whole product architecture it is in summary a 3 step process.

So, the first step would be really about defining the arrangement of the functional elements, second step would be the mapping from functional elements to physical components. So, we have been doing this for both the examples given in the last slide as well as this slide. So, mapping of functional elements to physical components and then finally, we define specifications at interfaces of the interacting physical components and that is how you define the whole product architecture ok.

So, the third step involved here would be to define specifications at interfaces of connecting components for example, in this particular case if I were to look at in details how the interface between the upper half and the lower half would result in some kind of a load transfer from the upper member to the lower member, in a way we are defining specifications at the interfaces in a manner. So, that it can support such a load ok. So, you have learned in short how you can modularize a product architecture or you know you can study in architecture in terms of simpler and complex modularity.

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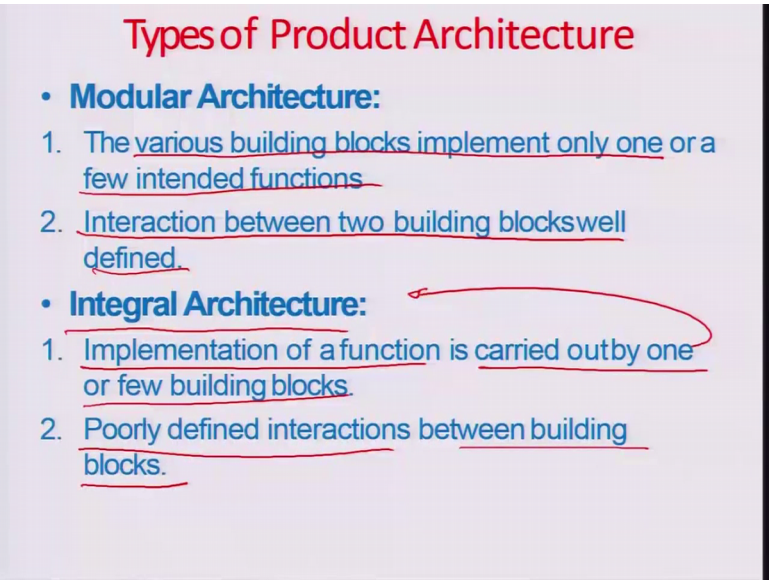

As I told you earlier that if this sort of approach changes to situation where the implementation of a single function is carried out by one or more building blocks of a particular product. Than we would regard the product as an integral sort of a architecture in such architectures it is very very common to have poorly defined interactions between the different building blocks.

As you saw that in the simple modularity case you had one function to one subsystem level information and mapping possible, but such kind of an interaction would then be very straightforward, but an integral architecture it is not the case you have to really scratch your hearts where as one has to really work very hard to define the interactions between the several building blocks.

In an integral architecture, as opposed to the modular architecture of course, where I have already mentioned is that the various building blocks implement only one or probably a few intended functions and that makes the interactions between 2 or more building blocks quite well defined and easy to recognize.

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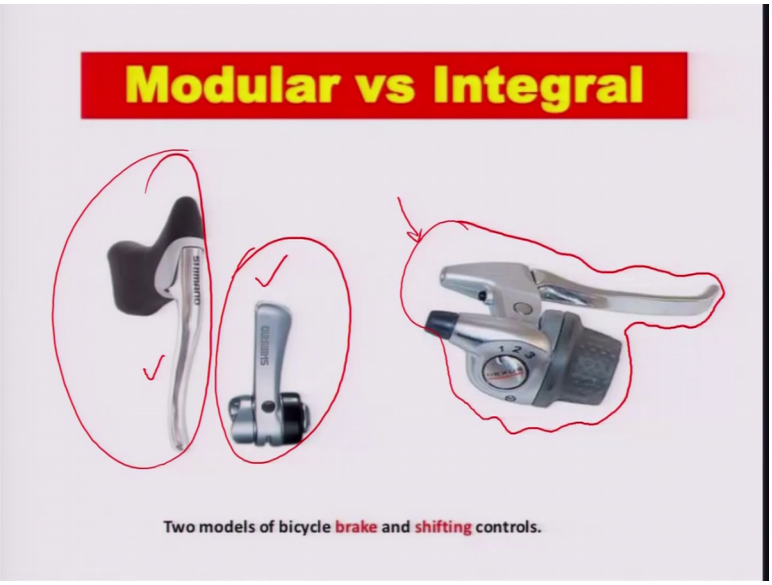

So, a typical example of modular versus integral architecture is given in this particular slide you talking about by cycle break handle as well as a gear shifting control lever. So, if you independently you know have these 2 mounted at different places one can consider them to be or modular, but when you actually couple them together they would have a much more complex nature in terms of multiple subsystem multiple functions or 1 function being served by several components which are internal to this architecture. So, in this case the architecture would then be defined as a integral architecture.

So, I am going to now close this particular presentation you have in this presentation sort of try to understand how a subsystem level mapping can be performed, if you were to understand the design in terms of different modules we will talk in details about how you lay them out in space and how do you connect the different modules together in terms of their functionalities and interactions, which we know is the configuration design which will be done in the next module.

Thank you very much.