Physical Modelling for Electronics Enclosures Using Rapid Prototyping

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Lecture – 01
Products Prototyping

I am back. If you have attended some of my earlier lectures, you will notice that this is all a continuation of them.

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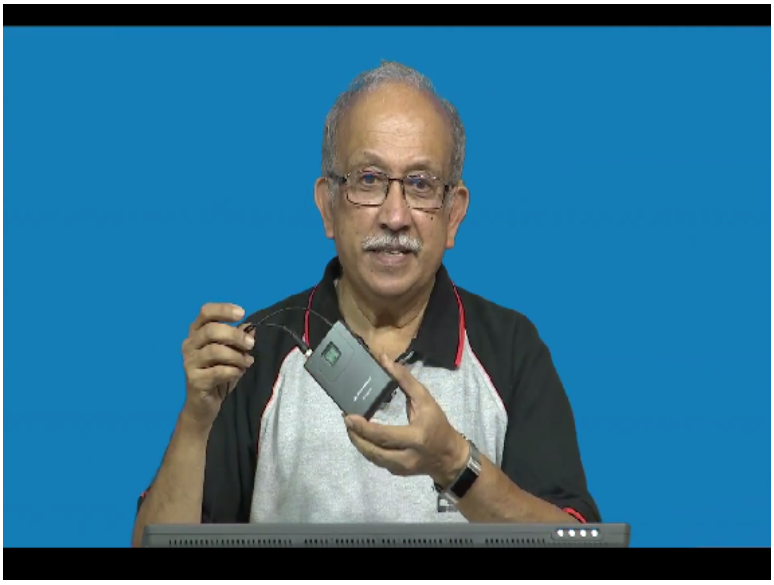

A lot of them are related to how to make prototypes and equipment like this. This is all electronic equipment.

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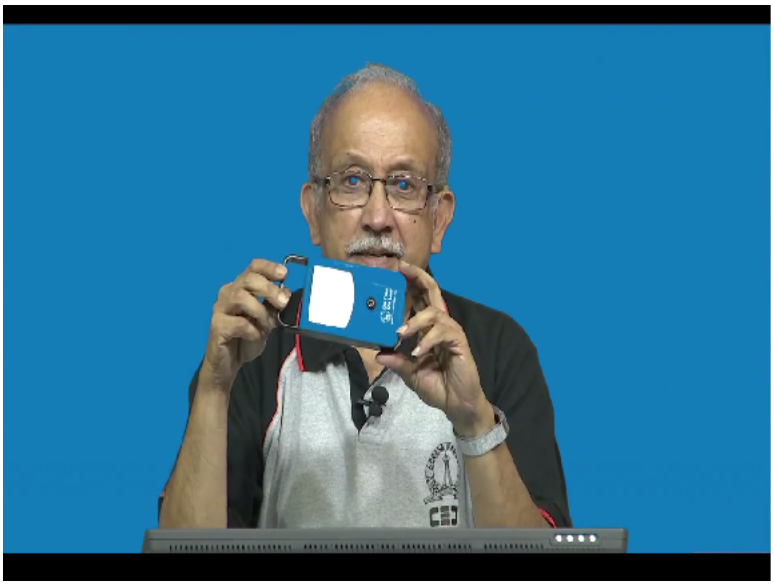

And then as I had pointed out earlier, making or designing electronics and making a breadboard, is only a small part of the game. Finally, how well it fits with what the customer wants and little bit of, I will use the word, marketability is what the game is about. But then upfront one cannot commit the type of resources that are required to produce large electronic systems. That is where a concept of prototyping comes.

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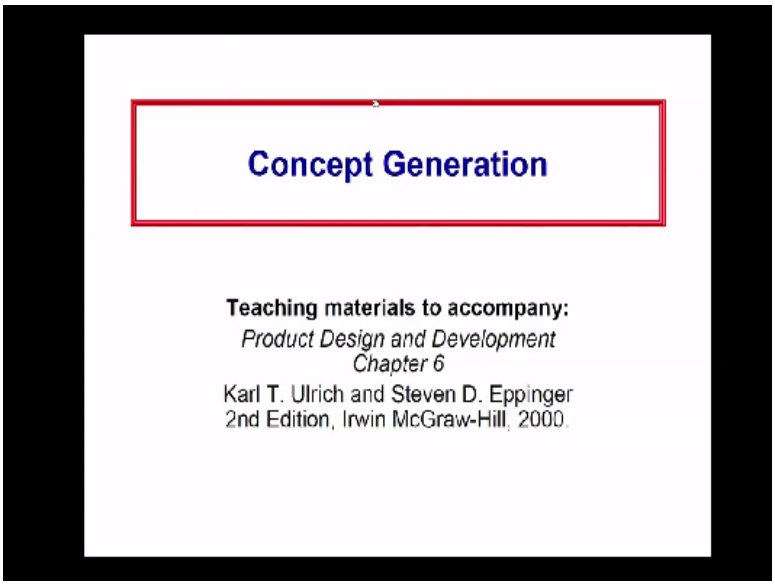

This is, please have a look at it. This has been directly taken from Ulrich and Eppinger's book on Concept Generation and then actually it is about product design and development. The idea is you buy the book, you benefit by it and this is a little old and if you see, it is in fact almost 20 years old. So I fully acknowledge the original authors and please buy the book. The starting point

of any of these is for example, if you look at this, somebody wanted to make a lamp.

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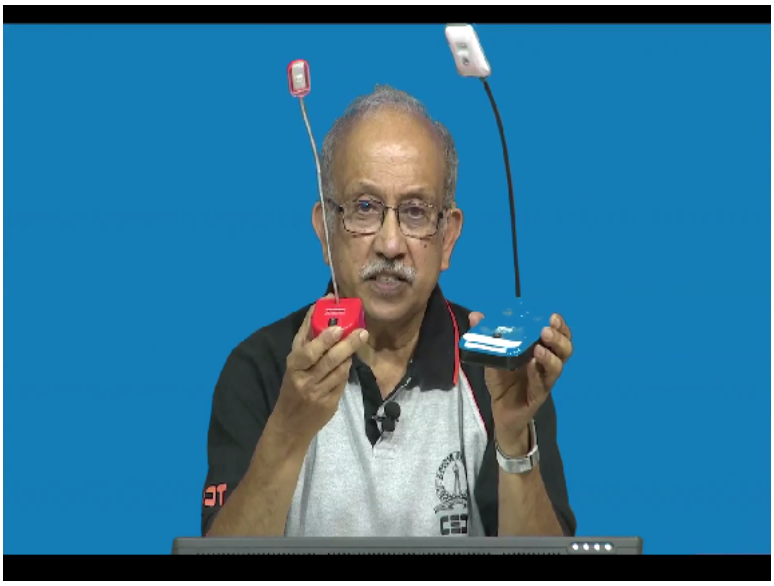

Just about a lamp. There are 2 variants of the lamp here. See here. They are almost about the same, not too much different. Is not it? Generically, they are same because you can call this a, a table lamp and then if you see here at the base, he has given a small keyhole like a device here. At this point, you can see that keyhole like thing. What this keyhole does is, here, you can probably put it on a nail on the wall and then you can use it as a, if it is here, you know, I can use it for reading a book.

Otherwise, it stays here and invariably all of them will have, this one has a small opening here for which you can charge it. So this is an LED, I will say a lamp, reading lamp. Looks good enough and the magic is, however, if you want to produce these parts in something for the market and something which does not exist.

This is a slight improvement on that. Base has been, and if you see carefully, even this too has a small connector here at the corner, see here, a small connector and as before, we have a lamp here and maybe, see it is even working. Can you see? So there is a small, what do you call, I will say, generically (()) (04:01) about a little same and specifically there is a difference. You see here for example type of storage, the type of switch, this is a simple, bistable or 2-position switch.

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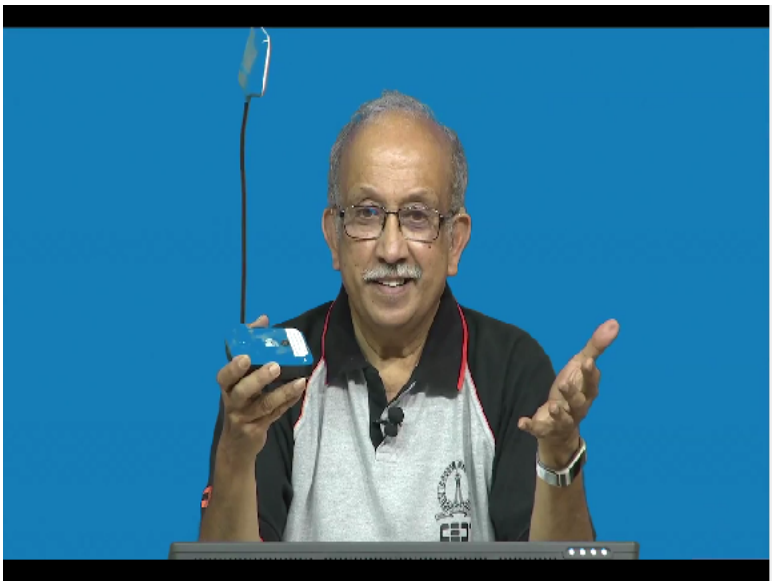

While this one is a same 2-position switch but a push button. Now comes a question, let us say as an electronic engineer, you would like to now try to produce this and to show somebody how your product is going to look like? Now we come into the small problem. The other person does not know unless you show him this. In this case, while it looks simple enough, it is still expensive.

We need to produce all these things. You understood? You will need to produce all the base, you need to produce this, you need to produce this and in some cases even, a bit of optics is involved in it. So there is an LED chip, then there is, what do you call, a stem or neck. It is called a gooseneck, I do not know why it is and then you have this base and then there is a sequence of assembly and disassembly.

Now even a simple thing like this, if it is ought to be made in plastic, is expensive, extremely extremely expensive. It does not run into 1000s. The mold which is used for making may cost a few lacs and if the market demands a large number, we need to make it on 2 things. First of all, scale up the large numbers. Secondly, maintain good quality. So towards this for maintaining good quality and large numbers, you need tooling and if you want to do tooling, it is expensive and first batch itself we cannot make expensive tooling. I will stop it there.

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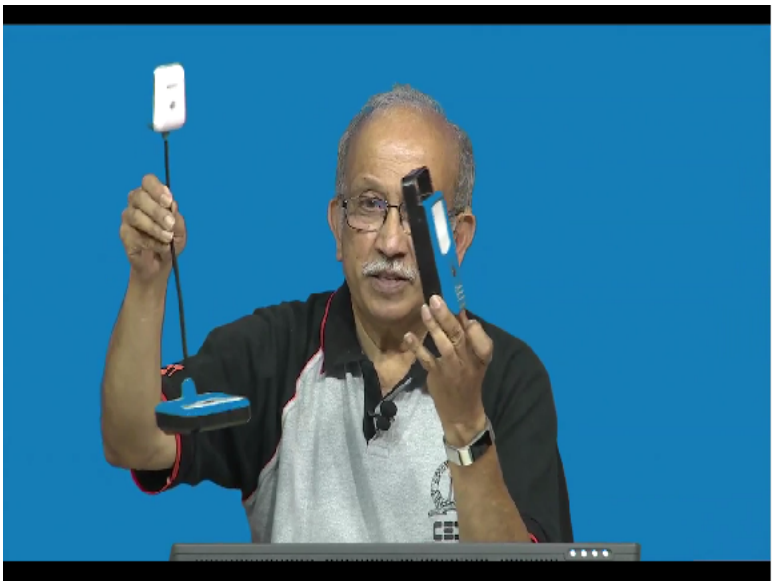

These 2, from a technical or what you say functional point of view are a little similar. Both of them have a light source. Both of them are themselves switching and then there is an energy storage, except that, this is a solar lamp which is built in it. It is a standalone. You have a solar panel. Then you have a front thing and then there is a carry and thing. The idea is being you give to your child. One lamp per child, just like you have one laptop per child, somebody give it and then they distribute it in schools.

Now the thing is, even this is expensive. It is not easy to make things. For example, you need to see how, you see here, there is a solar lamp built inside. How are you going to manufacture it? Is it going to be 1 part, 2 part? If you examine it carefully, it is several parts put together. This is where the concept of prototyping comes and then this lecture, let me now slowly lead to the thing.

Loosely people have got used to the word 3D-printing. It looks nice. Everyone is familiar with the printer and then if there is some way one can actually print objects, that will be a beauty. Conceptually it is very correct. Unfortunately, there is a little bit of hype which has been, what do you call, going around because of just like miracle cures and so on now. We have so many cures, a lot of it is hyped and it will work only in certain specific conditions.

This lecture is all about 3D-printing for the purpose of making prototypes and since we are an

electronic design, what you call, institution, lot of my examples and all are related to electronics design and enclosures. Small, how would I say, I will not call it warning, I have given you a hint already saying the way things are, people keep claiming that even guns can be printed in 3D. True and not-true also.

A gun is not about a shape. If you just want to shape, if you want to make a toy gun, or if you want to make a gun which is, you know, used in or this thing, then maybe yes it is. But then if you want something which is, what do you call rugged and made in, you have made something for a war, that is not the same gun. Something of the same shape.

Now we come to the other extreme saying, sir I have seen on the internet 3D printing demos of things like wall clocks and I have been radio-collared except that I have been radio wristed. So this one is a; I think, you know what it is? Activity monitor. Such things you can make them. Yes, you can print them, but this is not a cure all for everything. Again I am repeating, 3D printing is what it is. It can print a certain type of object for certain type of purposes.

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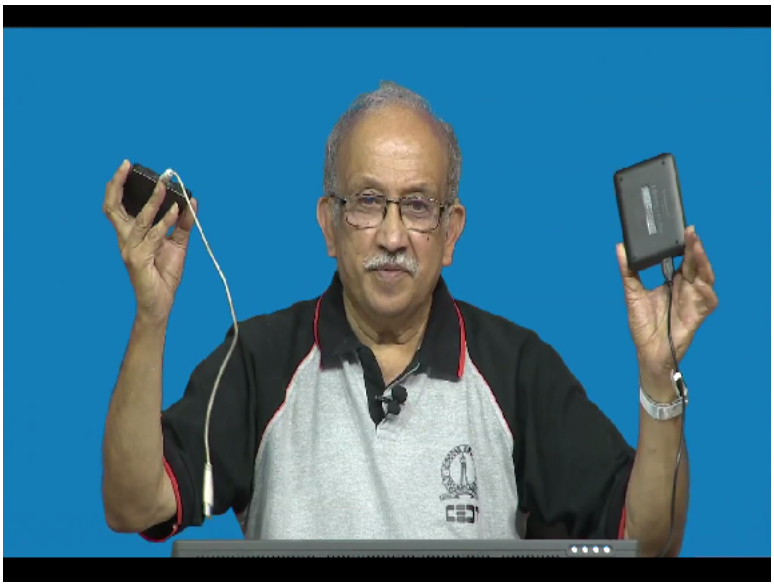

Something before 3D printing comes is, how is your product going to be? What is the physical appearance of your product? Both are pocket hard disks and first of all, pocket friendly, not very expensive, maybe they cost around 3000 rupees which is probably around 50 dollars, 50-100 dollars you can get beautiful things. But you see here, it does have certain features. First of all, it

is a little flat. It is box after all. And then other side, you have all these things like these connectors. You see here, you have various types of connectors and is it not the same as these things? You have seen that, no?

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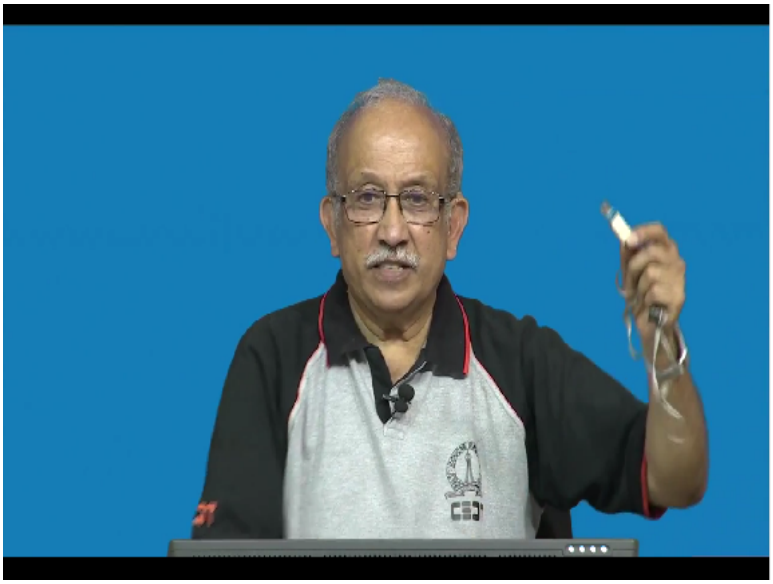

I think you know what it is. Loosely we call it a thumb drive or USB stick and so on. Only common thing is, we are all familiar with the stick. Now the actual starting point of all these is, how to generate a concept for your product? Just now, I have shown you this, if you can, if I can see this display.

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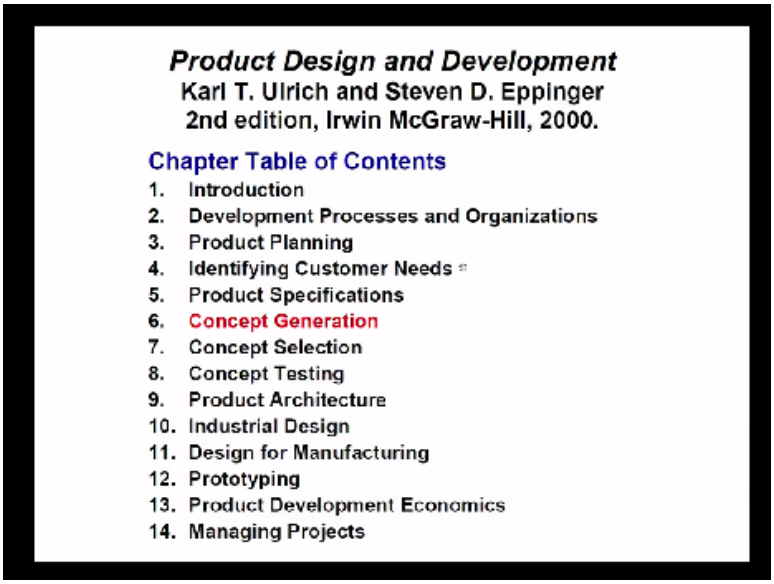

Starting point is probably, you see we have a large, what you call, selection of things here. One

of them in the selection of things is, identifying customer needs. Seen there? Product specifications.

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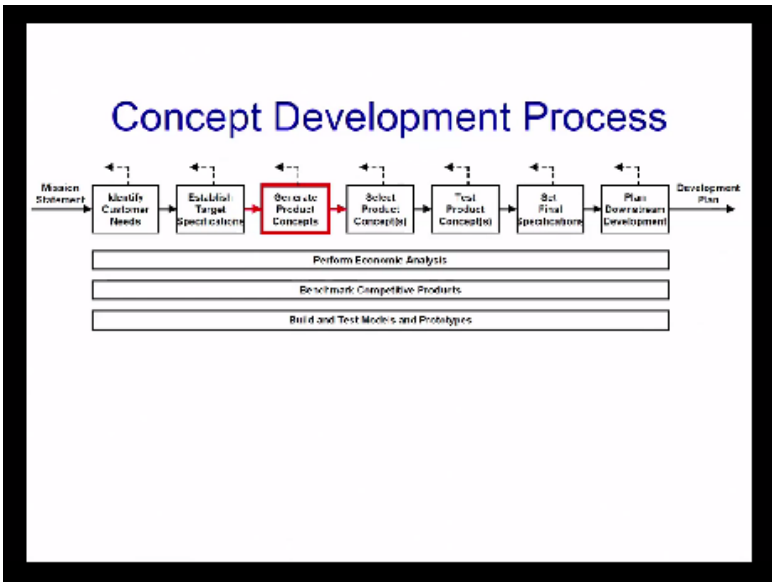

After customer needs, you have target specifications, then you have concepts and then final specifications and all that. Here, for convenience sake, things have been now made into need, small boxes and shown as a sequence. Usually, it is not there is over model, what do you call, over the wall design. Bottom, you see here, build and test models and prototypes. This is where this rapid prototyping comes into the picture.

Why it is called rapid prototyping is? The very concept of any of this development process, you need to generate product concepts, select the concepts and test them like that. So if you can make a proper prototype, you are already in, I mean, I should not use the word business, you are into it. It is tough. If you do not do it, you will end up with surprises in production. There are a few standards things, maybe I do not know.

Let us say even building a house or building, I mean, furniture, if you are copying another piece of furniture or if you are copying another house, things are easy. Just go and tell the, what do you call the mason or anybody who does it. But then if you see carefully, architects have been extremely diligent and all that. They make a new instants of well known products all the time. So prairie architecture and so on. Same thing it is with our this thing and for us to understand how

will your final product is going to look, we need to make a small prototype.

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So in the concept development process, what could this be? It says it is a Power Nailer. Some of these, you may have seen. The result of it you may have seen. The result of it is whenever they make or rather ship large items, they take a crate and they crate at the base. You have the base which they try to build everything around it. They take the base, they keep the, what do you call, your equipment on top of it and all around, they put various things and at this point, nails are fed in. They keep coming out one after the other inside and obviously, it is run by air.

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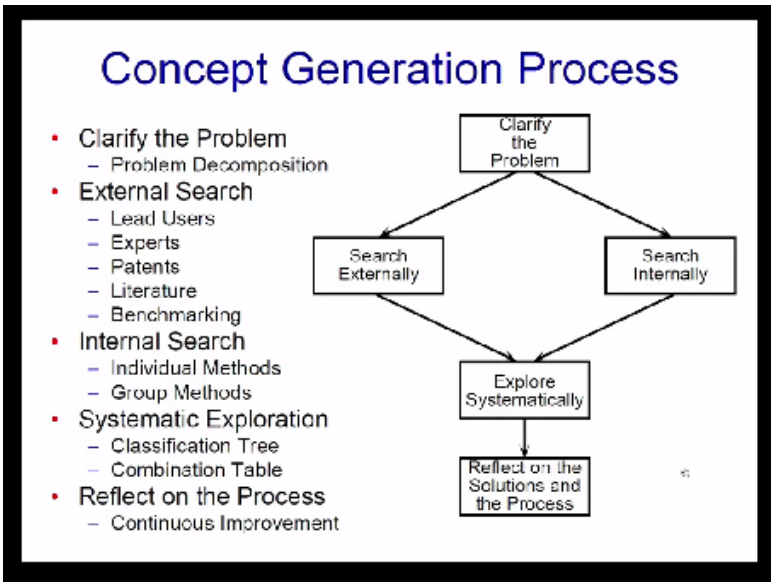

So if you see here, we have so many of these things saying you make an external search, lead,

experts, patents, literature, benchmarking, internal, group methods, systematic, okay. Then clarify the problem internally expose because this is not about design as such.

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I will skip all these things. You see, slowly things are getting interesting. I am sure, you have seen most of these things. All of them, you have seen and, I mean, it is unbelievable. Is it not? No 2 of them are alike and each of them is patentable. Each of them is sold in large quantities and this is where you need to come to prototypes. Somebody after they have made this, this one or this one, they have to make a quick prototype.

In this case, it is not impossible. Probably this is actually a plastic handle. This one is a wooden handle and this is a, what do you call, something which is made out of, type of plastic which is mixed to that. This is again plastic. This one is a sheet metal which is folded like this. You see very carefully it is done and this is again something else which is probably can be withdrawn. Now somebody needs to make a small prototype of it before they go into large production.

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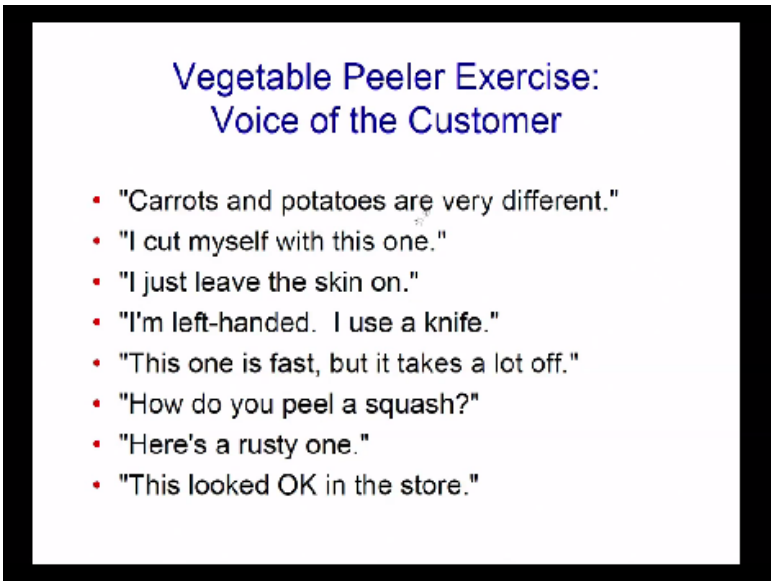

So I will go to the next slide where somebody needs to understand the Voice of the Customer. Well, at each one of the arguments is where you are evaluated. And this is where the actual concept of a prototype comes saying something needs to be done so that the prototype I am looking for, should be made quickly.

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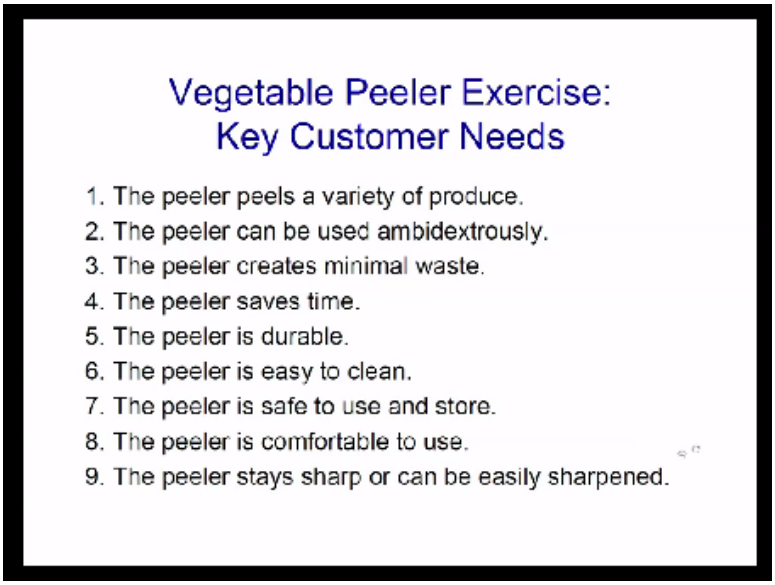

You have seen this? Obviously, you know. A minimum waste and saves time and all that. I will just skip all these things.

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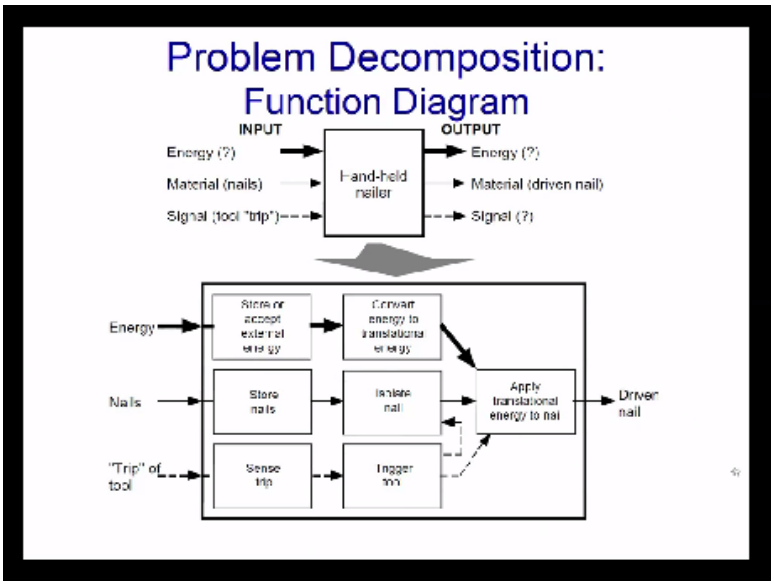

This is related to a hammer, okay.

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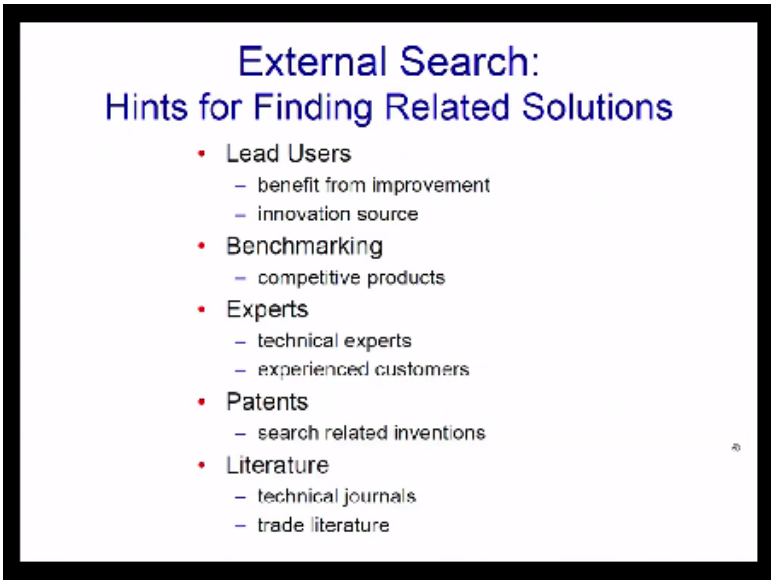

Since the concentration is not about how to come out with the solutions, but just saying, why we need 3D printing and then why it would be needed to be prototyping, I am just showing you these things.

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So you see here, so many of these things are there saying go around search.

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Find out what, okay.

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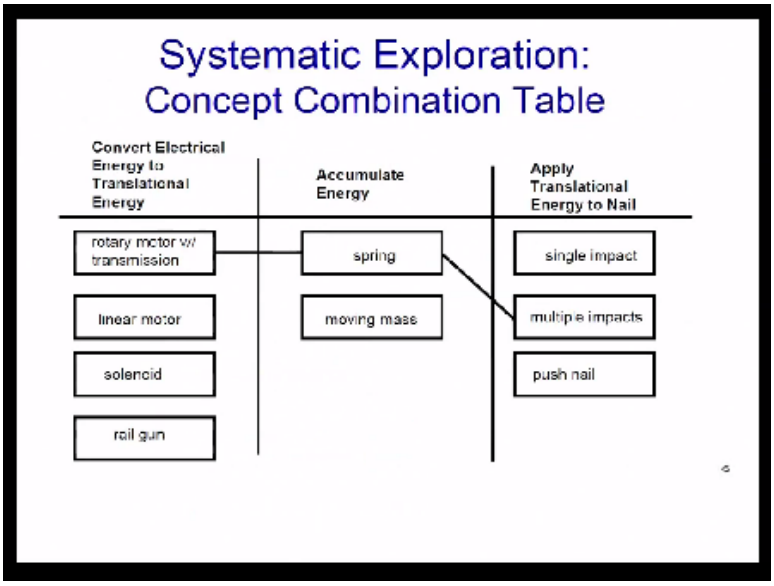

This is a usual thing. So at your leisure, I will suggest you buy the book and read it.

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After we go through the whole stage, you have seen this saying prototyping. Now we come to 2 types of prototyping. One is, we have gone through this, all the thing including concept generation, selection and testing and come to a prototyping. Another is, these prototyping is needed at every stage.

I have to integrate all these, what do you call, specs and concepts and then industrial design gives a proper trade-off of it saying what is it really that the customer wanted in and then more important is, you go up and down designing for manufacture. At each stage, you need prototypes.

The prototype will help you in taking better decisions.

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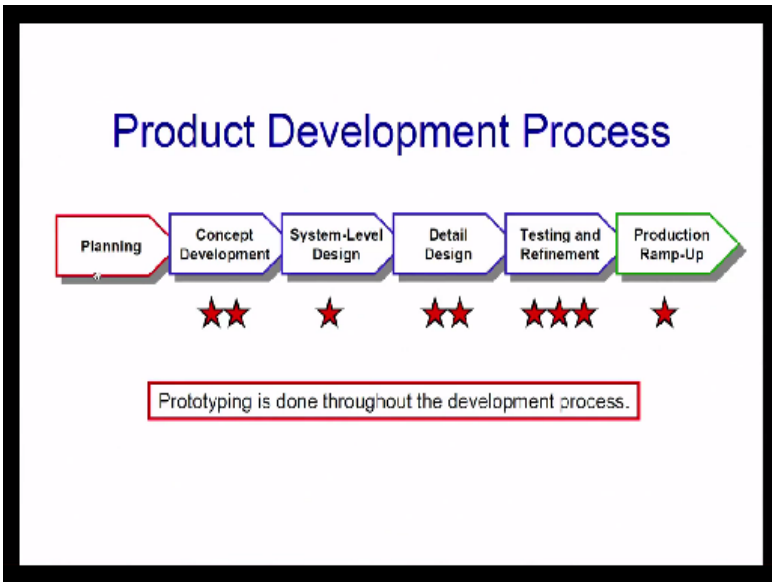

So we keep going on and so on and so on and so on. Prototyping is done throughout the development process and this is where the whole concept of 3D printing, you know, really took off. Because of the sequential chain of events. You have seen here. I have a huge chain of events. At every stage, it takes time. So there is no other way except, what do you call this thing. I will come back which I do all the time.

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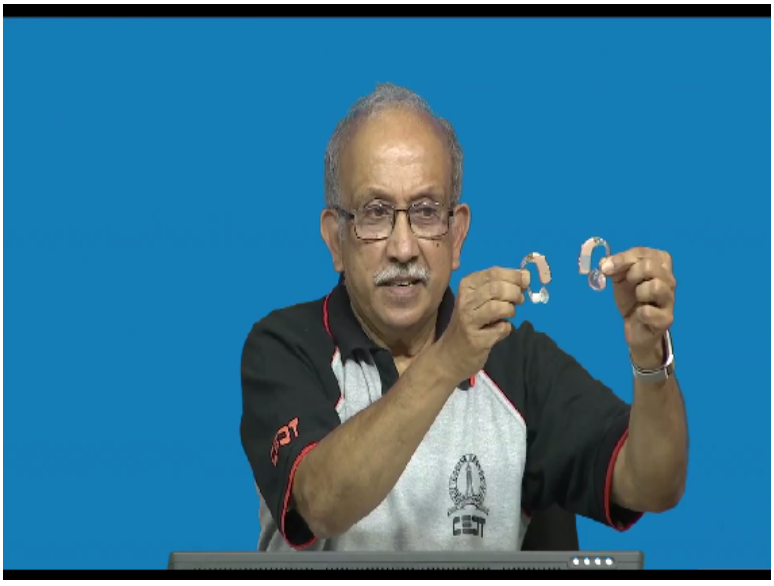

You see here, I wear this thing. I am sure some of you have seen these things. This is a? Hearing aid. And the difference being, both of these look a little similar, except this one has a tip. This

basic hearing aid is the same. This tip is different. This one has a moulded insert. Seen this? Now places like this, it is very much possible for us to make rapid prototyping. Now I come to this thing, you see this small thing inside.

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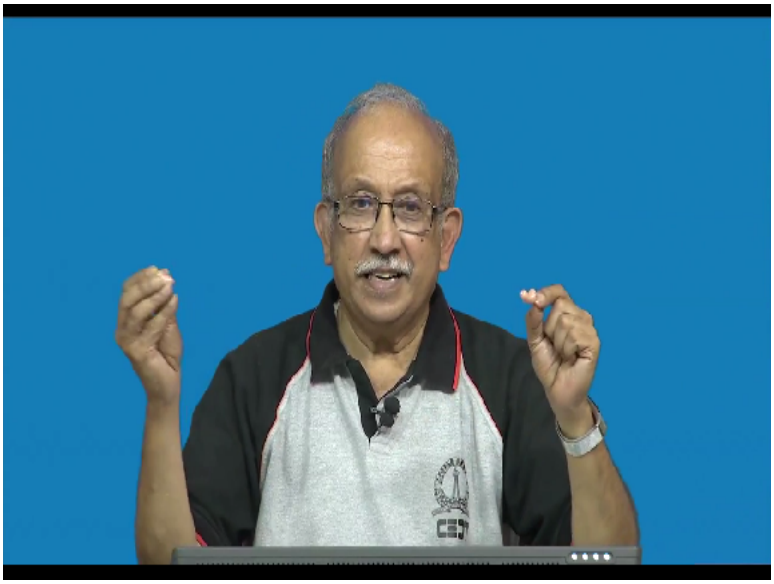

I have a in the canal hearing aid. This directly goes into my canal. It is a beauty. You have seen this? So and I have one for the right ear also. I have 2 of them. They happily go inside. You will not notice that I am wearing it. So such things, you probably need prototyping and in this case, it is now possible for somebody to scan this, I just stand there, the whole thing is scanned. Something can be made at the back. (()) (19:44) can be done and even the canal can be scanned and things can be made here.

Thing is, this is a little, you know, electronic, I am sorry, body or worn parts, little bit of thing is there. Now coming back to my this, this thing, I have concept development, system level, detail design, testing, refinement. At every stage, I need to make prototypes. You have seen this. At the concept development stage, I have shown you that we need to do system level design.

System level design, immediately we cannot talk about the actual physical thing. When we come to detail design and refinement, large number of prototypes are required quickly. This is where the concept of rapid prototyping started. So in the case of rapid prototyping, we have the advantage of keep on making things quickly.,

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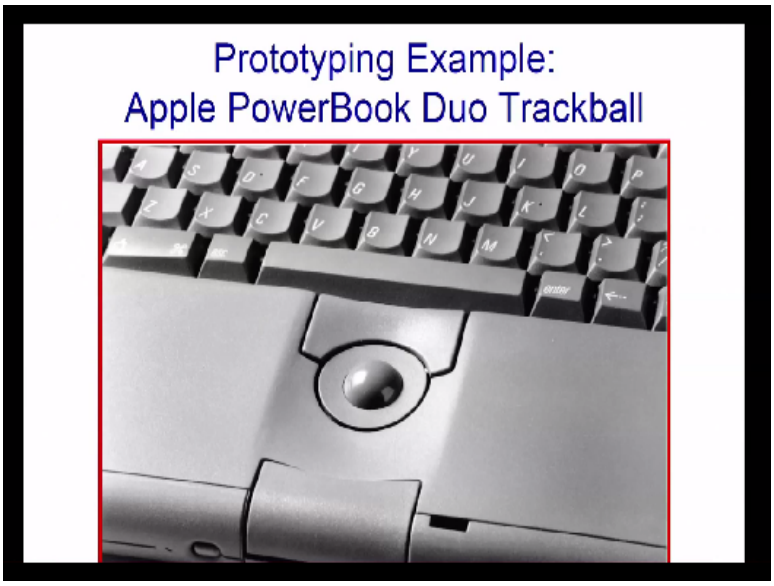

You have seen here. They can, as I said, they are not taken with due acknowledgements to (()) (20:55) and things have changed a lot but you will never get a chance to see these things. If you see this, somebody has spent a lot of time in conceiving the product and they have to make probably a few of these. This is where rapid prototyping actually meant a lot of advantage to everybody. What could be done was very quickly people could come out with a model and print it and show it to others.

There is lot about showing to others. I will call it as evaluation. For the purpose of evaluation, while this looks okay. You have seen this, this lamp. Each lamp looks okay. Oh, I am here, okay. While this is okay, you will suddenly see though this is bigger somehow, this looks more presentable and it does so many other things. This is maybe a primitive, earlier one. This is eventually something which can be used.

That has become big because the storage has been changed. Now coming back to my display here, you have seen this prototyping example. Now thing is there is a small depression here and then there is one what is equivalent to our, what do you call mouse key, then there is the trackball. All these concepts somebody needs to show and work. You have seen here, there is a switch. I am not sure what the switch is but it is a switch and this is a switch, this is a switch.

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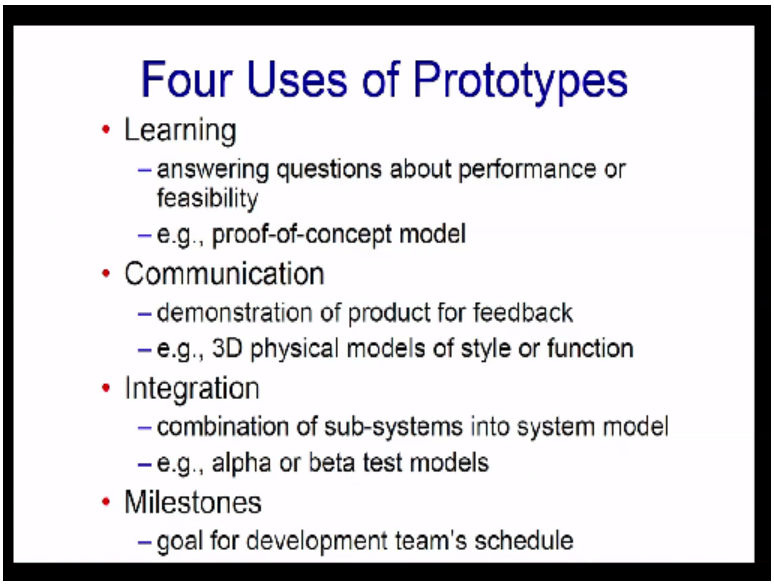

So if you go, this is where, allow me to spend a little bit of time here so that when we actually get down to making a printed model, sometimes we forget because we get caught in that whole thing saying, oh, wish we have thought about it, we have a model, now it looks like nobody wants it now. Seen this here. First thing is, learning about the product or proof of concept to model.

So depends on all the time. Let us say at one extreme, I showed you that one of the very simple thing, a potato peeler and the other extreme, we have things like a whole, huge ship, a ship maybe. The final model and the prototype itself is the same or you take an aircraft. A commercial aircraft, outside is all about aeronautics and various other things but inside, design of the cabin is finally what the customer will see and he will take a decision of what to fly by it or not.

So building the interiors as a prototype is equally important. Now in the interiors, we are just generally familiar. You know, there will be number of seats, aisle, commercial and then so on and then safety requirements saying where do you have emergency doors and see all the small integrated details of the back of your seat next time when you go there. Somebody has thought about it.

Now how should the display look? How should be that portable table in which, you know, you place things? How do you put it? How is it anchored there and even if the table is there, when the

front seat person reclines, it should not, you know, change and now how do you lay out the things, we all have seen. We are all familiar with the small depression in the corner so that we can keep, I mean, locate the cup and so on. So these things can easily be demonstrated and so on.

So coming back to my display. You have seen this here. Proof of concept also involves communication. Demonstration of product for feedback. The designer has to get back both to the user and the manufacturer and other person et al. Typically, a combination of sub-systems into the system's model. So when you are form a hearing aid, what looks very simple is actually a very very complicated thing.

It has 2 microphones, 1 for noise cancelling and 1 for direction. Then it has a 4-channel, 4-channel dynamic compander. Then there is a switch in which I can select 4 programs and there is a speaker and of course, there is a power supply and something which does not make sense to you if you are not hearing impaired like me because you are born with it. These 2 ears, the phase of the signal is maintained by having a bluetooth like device between the phases.

So if somebody talks a little far away, I mean, it can easily distinguish between these things. So you see all the stuff now has to be integrated. You have seen this? Combination of sub-systems into systems model and alpha or beta test models. Alpha is actually you start the thing and see around how well they work. Beta is finally just before release you give it to actual users, volunteers and then they make it.

Otherwise, you will not be having so many beautiful daily gadgets which you have and you see here as we go down. Goal for development team schedule, first testable hardware. Before we get to this, if you want to integrate something into anything now, have a look at this mouse. I am sure if you have a look at this mouse, you will say how well things have been integrated in to it.

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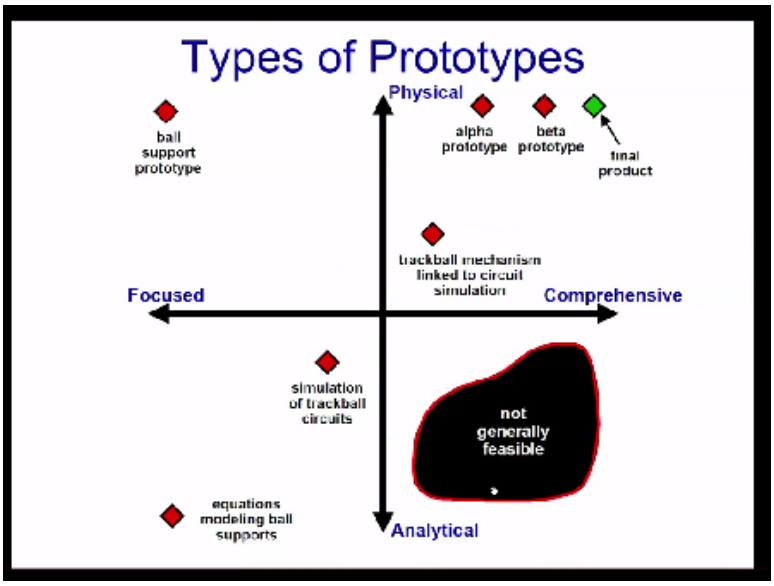

The next slide. You have seen this? Types of prototypes. Physical, analytical, comprehensive. What somebody would want is a final product having all the necessary physical features and we are ready, and some needs to go into all these things. So if you have got an engineering school when you talk about modelling, invariably they talk about analytical modelling saying how well you have understood flow of water, flow stream and in the case of extremely large system, how the atmosphere can be modelled into an equation.

That is fully analytical. And you see here focused, what you call prototype, saying one particular type of operation when you want to make a switch, how much effort is needed to push it and finally how big things are able to make. So here the physical, comprehensive involves all the things, okay. And comprehensive, analytical is not easy. Even in the case of our electronics, we all know mixed mold simulation is come about.

Meaning a majority of all the parasitic including both the digital, then the analog, has all been dealt with. But when it comes to those things being put into an enclosure and these does if you take any small mobile phone, it has 6 radios and attendant antennas and as if it were not enough, we also have accelerometers and all of them are happily integrated into that.

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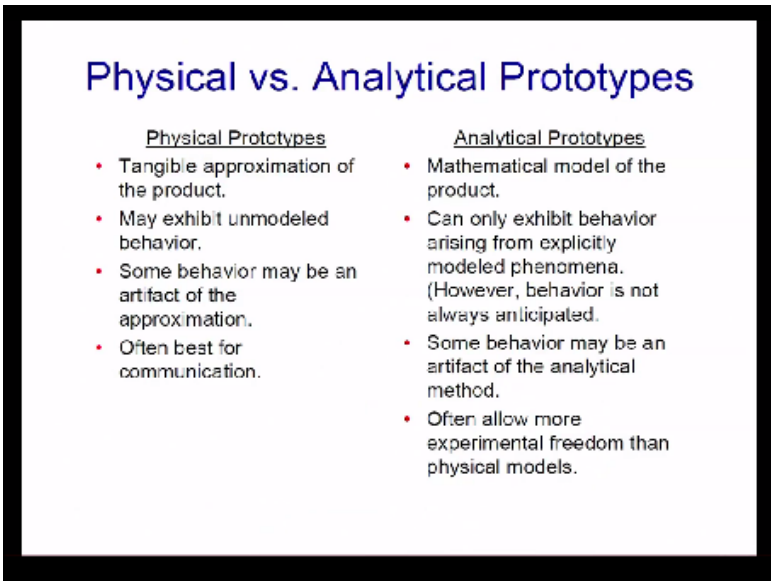

This is where now prototypes need to be built. So this lecture permits me to talk a little more about this stuff.