Physical Models for Electronics Enclosures Using Rapid Prototyping

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Lecture - 02
Prototype Concepts

Hello, this is the second series of the lectures regarding prototyping. There is what you call little bit of you know enthusiasm when somebody calls simple rapid prototyping as 3D printing or the other way. The issue being that we should first have an idea of how eventually a product is going to look like and then if you remember last time I showed you that it is a sequential thing as if you look at my this slide here.

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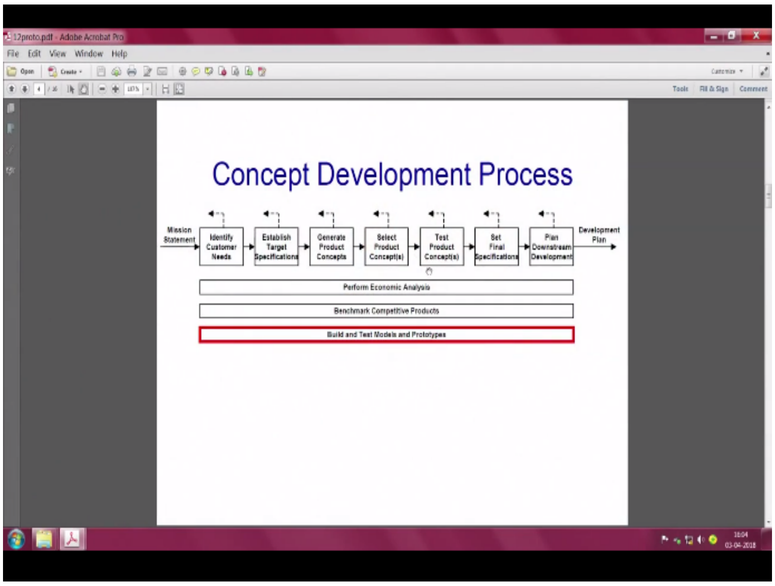

One of the things you will notice is that it is long because of the long duration looks essentially as a sequential process. It is not more than just being a sequential process; it is that the every previous stage of any decision making will influence the future step. Again, for every future step which we may or may not have thought of we need to get back to what we have started, so this all this kindly have a look at this or give me a picture of this.

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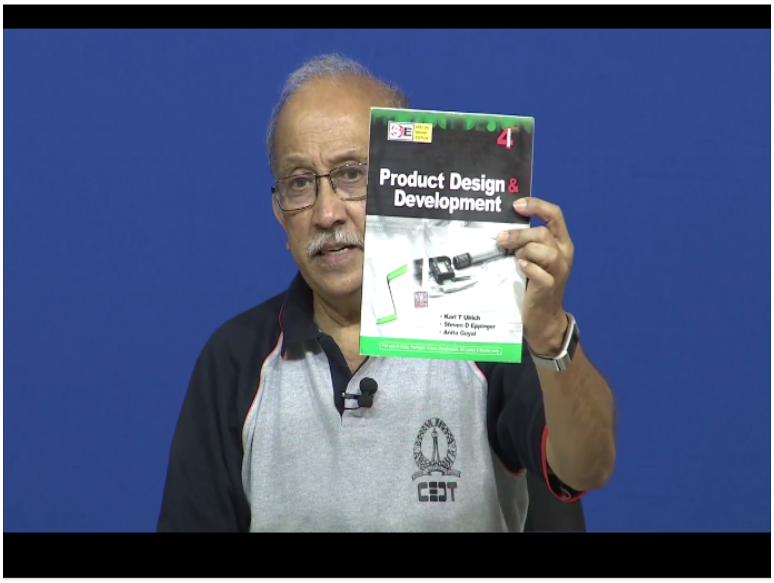

This whole thing has been taken from product design and development from Ulrich and Eppinger any edition. The edition I have is a little old but this being an educational institution and the general common license, my suggestion is by the book and read everything in the book. It is big okay, closely typed and full of illustrations and unbelievable amount of detailing including the tab on design for manufacturing.

This is where my emphasis back on little bit of advance you know working towards this is very, very critical. So coming back to the slide, at this one point, we have identifying customer needs, target specs, product concepts and select product concepts. Now when we talk about a product concept, it is real that this is not an easy thing. Have a look at this mouse.

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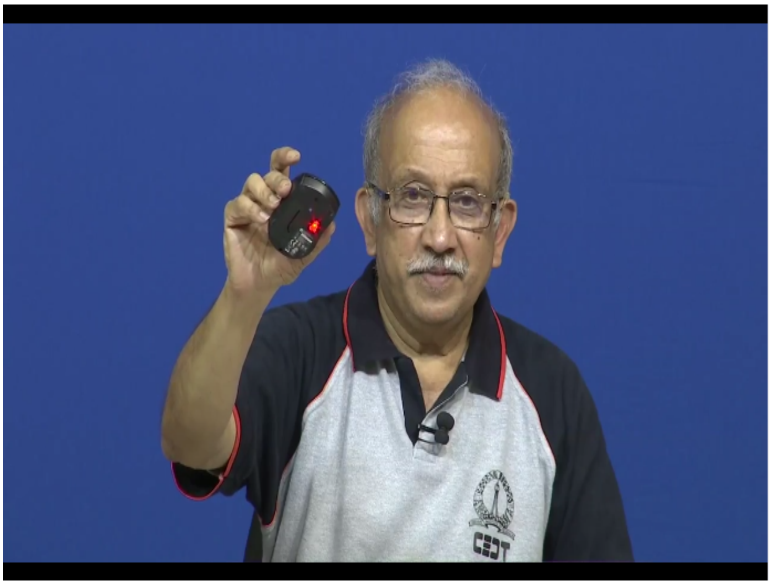

There are all sizes, all shapes, they are very tiny ones, they sit well in the hand, their sums which are flat and I am sure all of you are familiar with Apple's single button. There is only one small thing, a small what you call a roller ball and then whole thing know you press and works and then this. It is not easy, whatever product concepts we are talking about not easy to converge and come back to this again.

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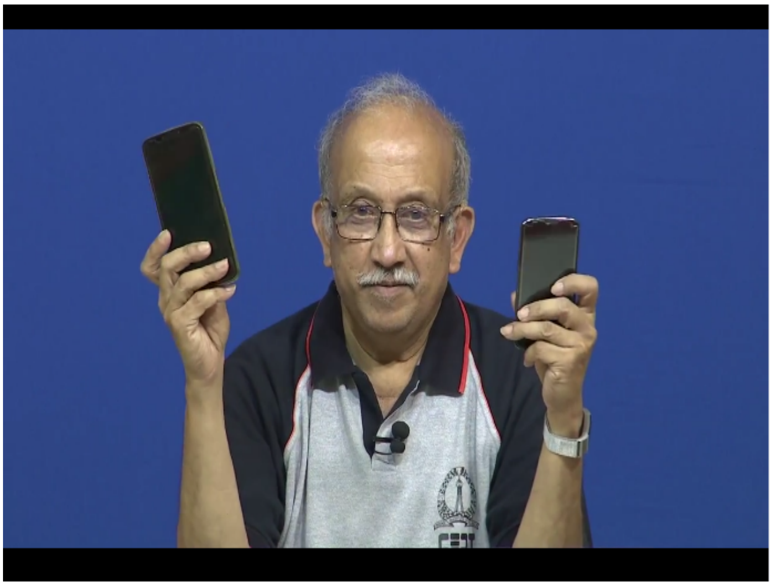

Even a very routine thing like all of you must have seen this, mobiles. Not long ago, a mobile meant you know all sorts of shapes and so on. Right now, it is flat and works more than anything else it works and almost all of them have camera now. Now when you go to a shop to buy a mobile, first thing he does is he will give you a dummy device like this saying you touch and feel it and say how it looks like.

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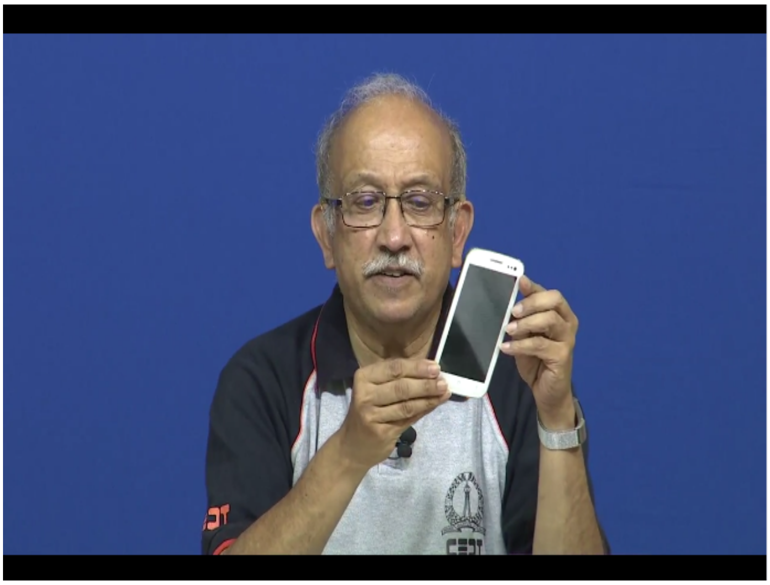

So somebody else worked has gone to great lengths and worked on all these things here. You have seen this.

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Both are about the same display size but then there is something here, something else here. These are actually identical. Now this is where our whole issue of selecting product concepts comes about. Somebody has to go out of the way to test these product concepts.

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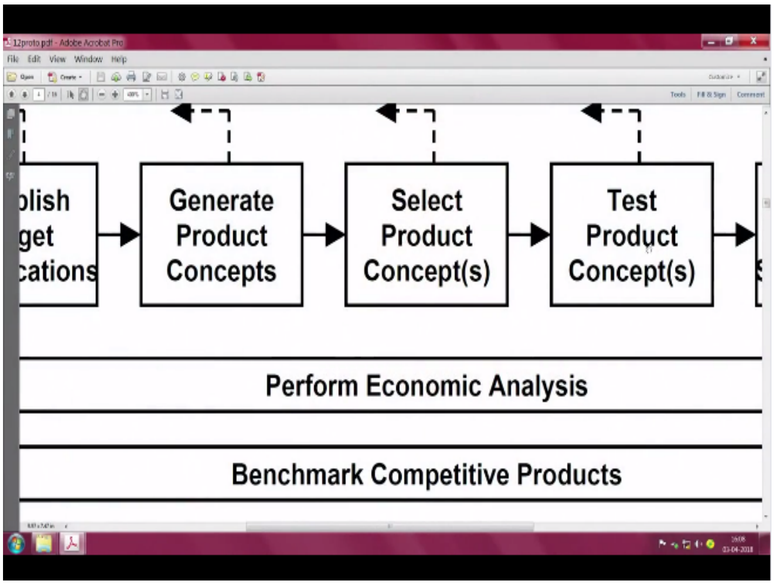

You see here, they are not easy, set final specifications. This is where we come to build and test models and prototypes what looks very easy, models and prototypes and this is even before setting the final specs. Have you seen this? Then, after the down know down we get everything know development plans and all that stuff we get below all these things. So the reality is we need to make prototypes, only when you make a prototype you will know what next will happen and what to do.

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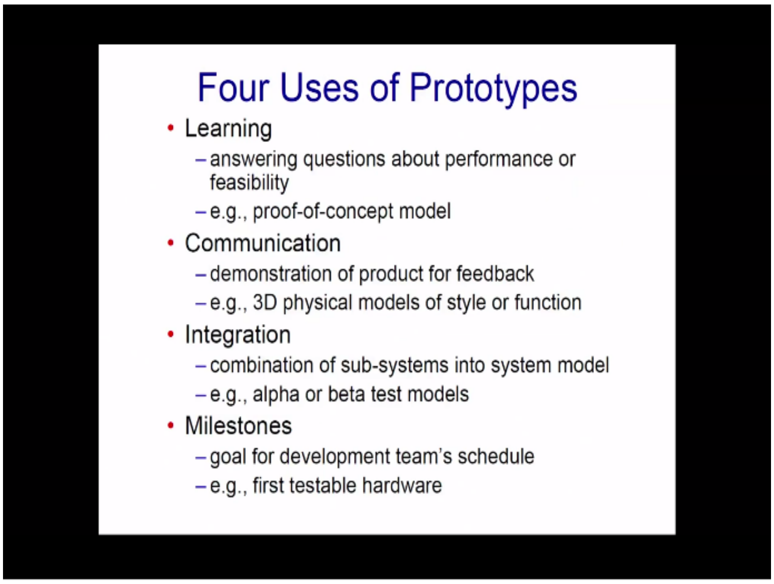

Now we will see and the uses of prototypes are learning communication, demonstrate product for feedback. This product for feedback for both the customer, ultimate end-user and all the people in between including the manufacturing people. It looks easy to say but actually tough, not easy for anybody to understand something which is written. You cannot just say, for example if you see all these three prototypes which I have shown you, description looks about the same.

Even there are numbers and sizes saying 5 inch, 6 inch and you know 5.6 and you know you have so many grams weight and all that. How do you make out all that unless you have a physical prototype? This is where rapid prototyping gets its fantastic cover and visibility saying physical models of style or function.

Now these days, if you go to any shop where they sell consumer durables, you can even have a beautiful big what you call dishwasher or a clothes washer or things which are essentially closed but then they want you to know what is inside. So what do they do they make a beautiful miniature working model of a transparent acrylic or something and the secret is they are probably all made by rapid prototyping.

And there one of the uses of prototypes is combination of sub-systems into a system model alpha or beta test which I have explained to you. Beta is almost ready and the customer is given a chance to test it. Then when do we develop the testable hardware final hardware? This is where our rapid prototyping seems to help a lot because you see everything is very, very long, it is not easy to get into this thing at all.

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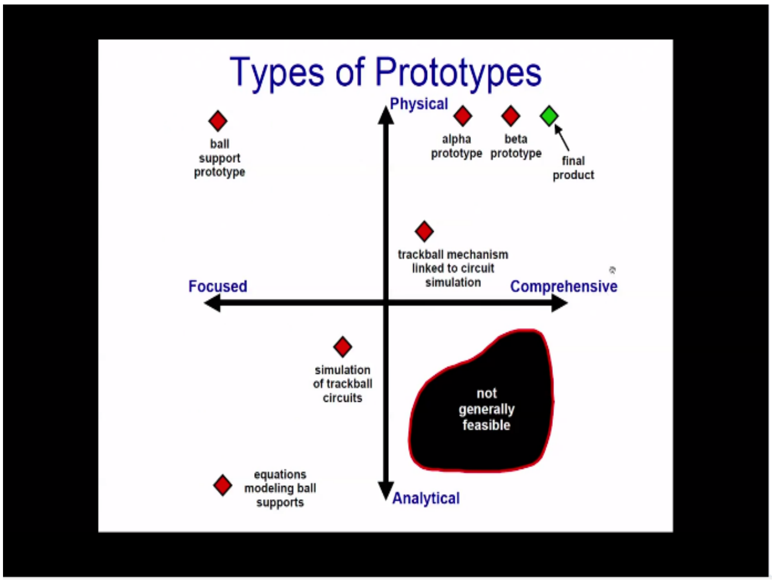

So the next one will talk to you which I have tried to you know what you call emphasis last time, it is not easy to have something all the items fully analytical thing, not easy to you know what you call put equations for each and every aspect of a product and then you see here we want a comprehensive physical product. So we can have all these final prototypes eventually everything falls in place and to avoid the lot of time consuming, we end up with this rapid prototyping.

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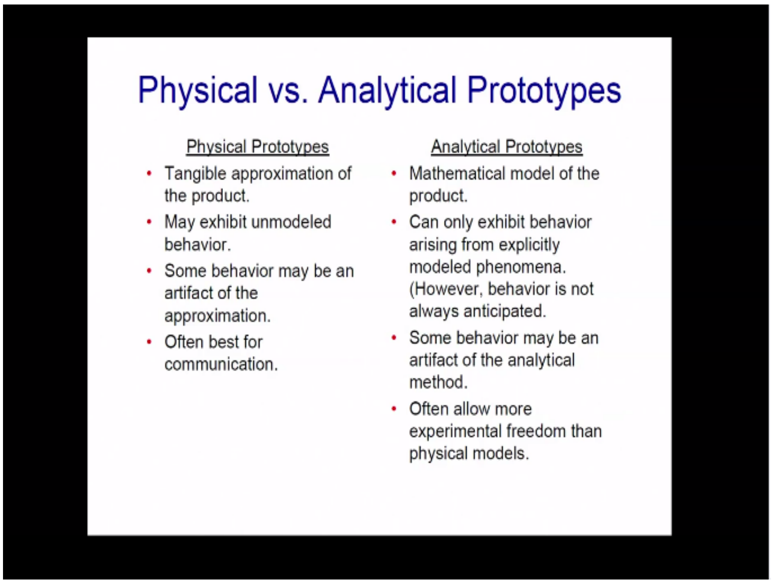

Very much related to this is the movement you have a CAD model you have the advantage of always going back and making things easier, physical approximation of the product. This is what I was telling you when you go to buy a mobile in a mobile shop. He will give you a practically identical piece like this.

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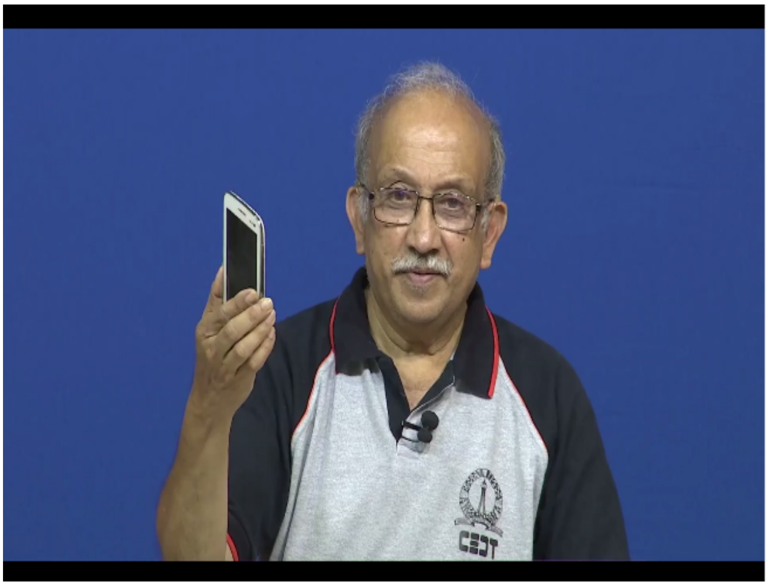

It will be you know how well it feels and you know what are all the keys, do the keys are there, you know where the charging things, you know where the headphone slot is and finally you know how well it nestles in the hand, how does it feel which is not easy and these days if you can somehow make a CAD model of this, a CAD 3D solid model, it is easy to change it.

One simple thing is if you wanted to be squeezed width wise a small comment, length wise yes, radio in the corners and thickness and then what about these things. Fortunately, for us know now using 3D printing all this is possible.

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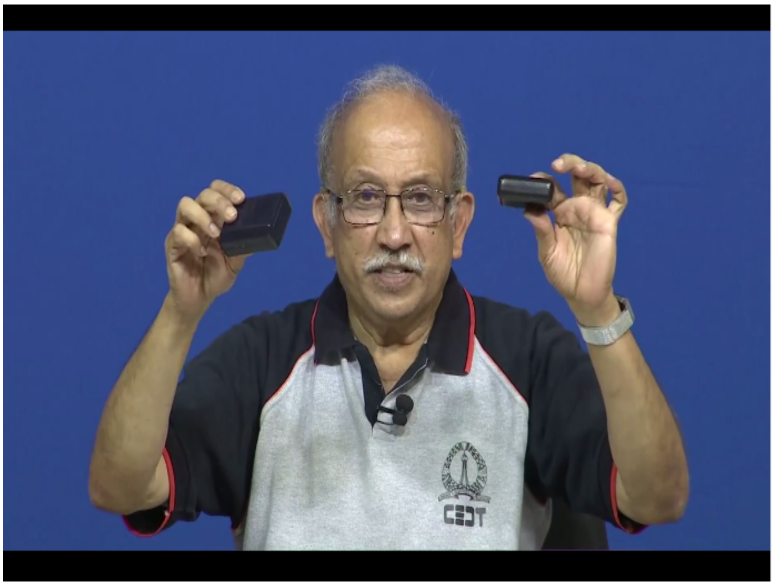

All you need to do is if you have two things here, you see here I have two boxes okay, both of them are meant for my hearing aids. It is much, much smaller, this is a little bigger. So there is a place here for you know once when they thought of it know they made place for batteries to be placed here and then these you know hearing aids nicely sit in this.

Now subsequently when things became smaller and smaller, they found out it is much easier to have something which is very simple and this is actually taken from a headphone’s thing from Samsung. So you see here, it is slightly transparent also. So if I keep it here and shine something on it I can make out if it is there inside, very, very small, easy handling, put it in the pocket, but then easy way it is also fall out, I will ignore that.

When things become small, this touchy feeling we have no option to you see here that is what now it is a tangible.

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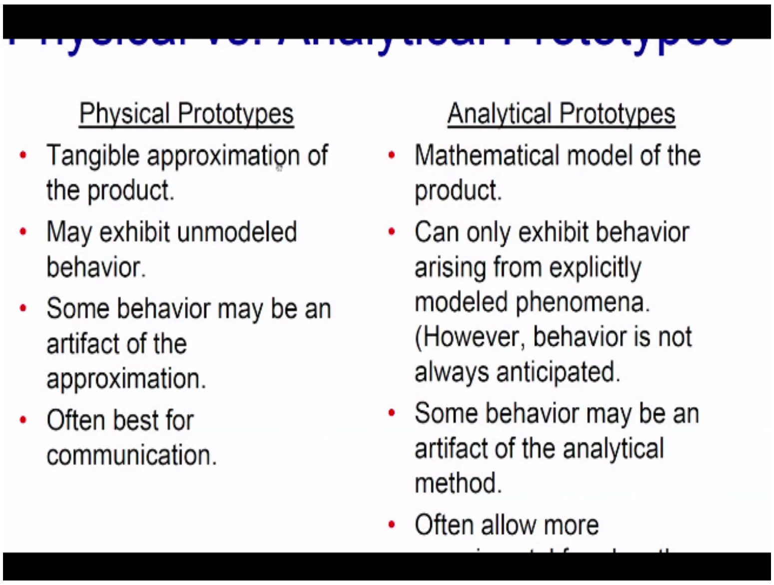

How do you touch approximation of the product and may exhibit unmodeled behaviour? You see here in this case unmodeled behaviour means something not as per the intended thing. One of the simple thing I can talk of it is, if I have shown you this whole what to say anything which we need to write any pen or anything now how well does it balance itself.

Does it have something which center of gravity shifts and there is a key here and another is some behaviour maybe this is what you call this is the pro and then the cons. Behaviour maybe an artifact of the approximation if you make things because of this.

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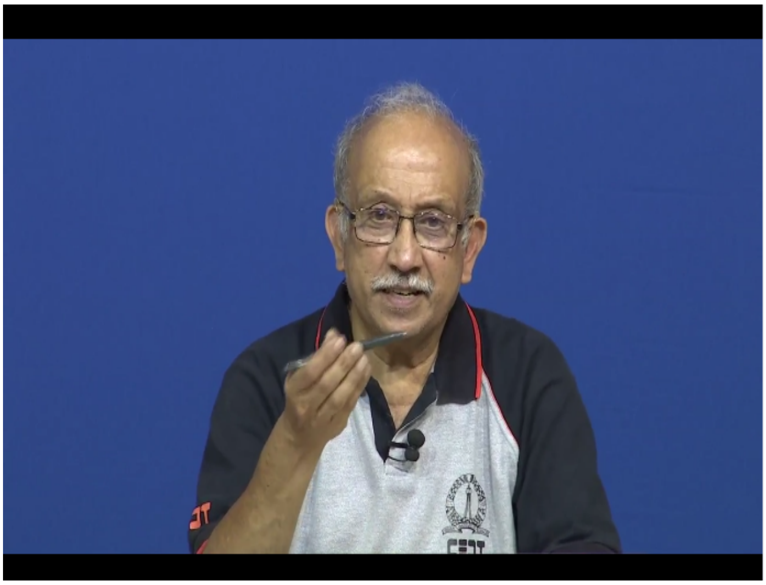

You see here, the way it behaves, how do I clamp it, do I hold it like this and you see there is something here at the tip in this case now this is a stylus, this tip helps me in what you call doing things and the other side they have given a dummy thing, both for the purpose of I can point here nothing will happen. If this whole thing were to be made in 3D printing now life would have been absolutely easy.

Only problem or anything is how well is it balanced, should the weight be a little to the back or should the weight be a little to the front and then how do things shift. This is where physical prototypes are getting better.

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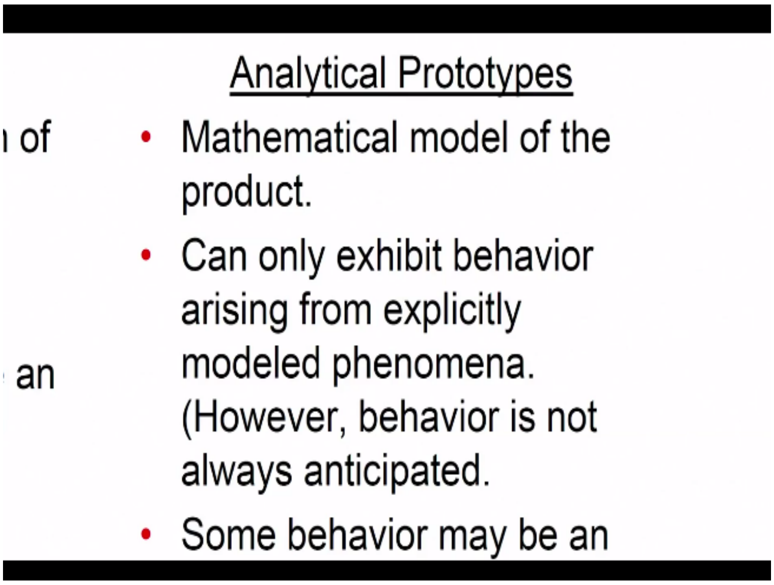

Now when we come to this analytical prototypes, typically it is a mathematical model. So one of the mathematical modeling is that let us say if you have a flow, how well does water flow out of something? So reasonable example is I am sure you people have gone around seeing in the shops now, suddenly glass's back, for tumblers for any other modeling things and all that know there is a nice way in which you can hold a glass tumbler.

It does not look like plastic, all that things saying something breaks. Hence, use plastic since we are going out of fashion and if you have glass, it can be cleaned and last forever, brings you back to the good old milk bottles which are familiar. Suddenly, the milk bottle is everybody's attention. Here we have now mathematical model of the product simplest thing we talk about is if you know the volume and then if you know the thickness you know actually how much can we hold.

In case of the imperial and American thing, we have things like the gallon, the quad, the pint and so on. In case of our metric, invariably use the liter and something part of it like typically all our what you call cups and all that are about a small cup is about 100 milliliters, a very large cup is 200, something in between is 150 ml. Now if I have a mathematical model, it is a question of playing around with the diameter, height and the wall thickness. So anything I want if I want to make a 100 ml cup, I can make it. The same model is valid.

And if I have anything else, let us say instead of being straight if that is a taper, the cups can be stacked. Oh you have a handle, something can we do such that the handle also can be used attractively. Then, how do we stack them? Supposing, we have this cup now, you need to pack it. For packing, how will do you pack 6 of them in a box or 2 of them in a box? How do you make a merchandising device with a display thing?

This is where rapid prototyping helps immensely. You can make the cup and you can keep one over the other for packing or we can keep them side by side or we make them diagonally meaning imagine if this were the cross section of a cup.

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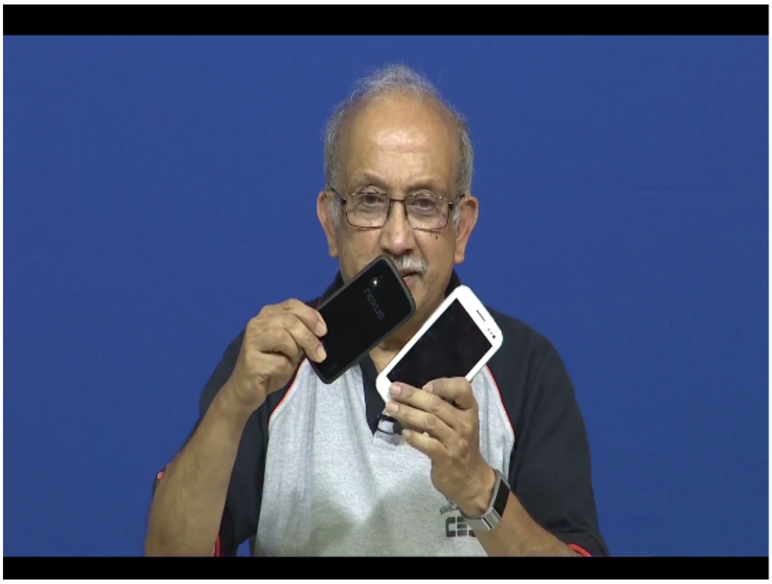

How about stacking them like this, do they look better? Like this or one over the other, one in front of the other. All these combinations if you have a model.

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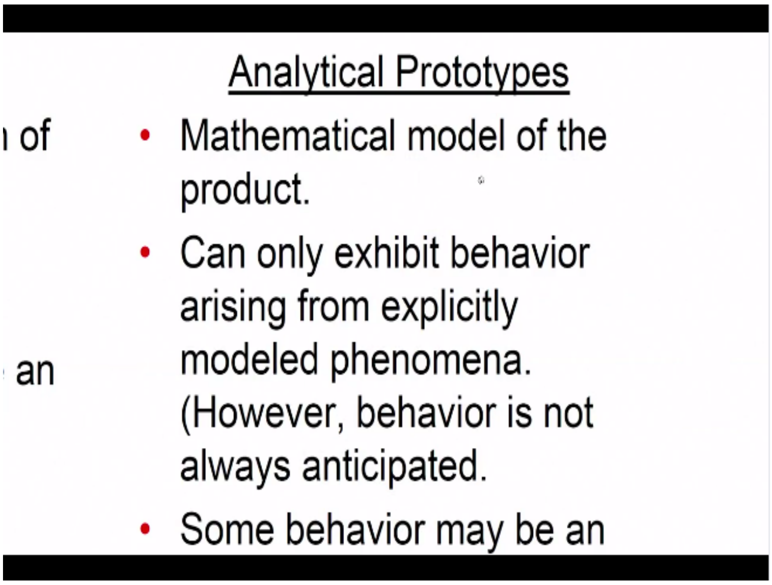

In this case, analytical has been used exclusively to talk about something which is a mathematical model saying you have set of variables, which are (()) (15:09) number of variables and then you also have a set of eventual out comes of it. For example, I have given you the very crude simple example of a cup, which has a diameter and then height by which the volume can be calculated.

Using that we can also calculate the weight of the thing, how much material and then I have also mentioned to you that if we give a small taper we can see how well they are stacked. Then, analytical prototypes have the disadvantage or limitation saying can exhibit behaviour arising explicitly from modeled phenomena, good.

So we have two liquids in a container, one of them is water, you know how well water behaves and then water has been modeled so well in fact there are so many things like Prandtl number and we all know there is something called viscosity. We also know that something which is a density and we know surface tension and how well water will pour out of something, quite okay, does honey flow as well we know very well, yes and no.

Then what about petrol, does petrol flow out of a can as we assume? No, you would have found out in a very surprising way if you take a can of petrol and pour, there is invariably a leakage outside. The same thing if we use water, there is not a leakage about it. I will let it go at the moment but then I would like to say this behaviour often know it helps us. If it is modeled well, it will help us.

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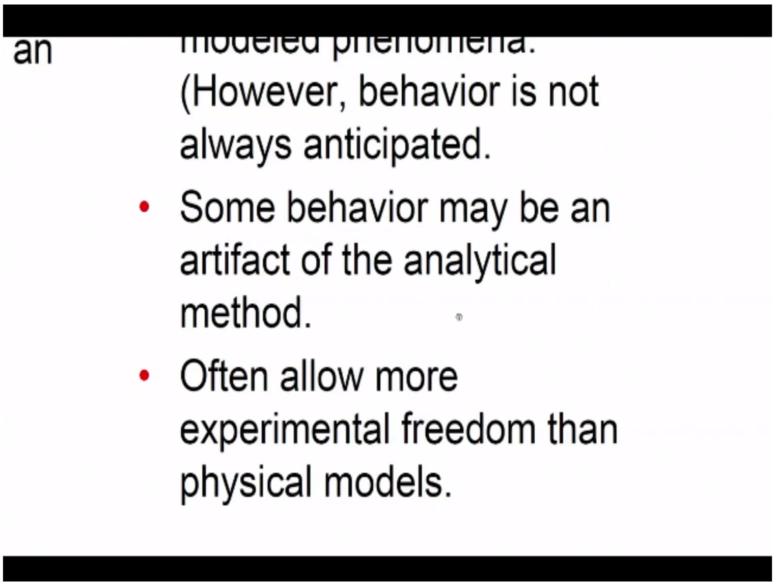

Some behaviour may be an artifact of the analytical method meaning the analytical model may vary in a narrow range. If you go beyond that are combination things will go beyond that and then you see the most important thing at the bottom. I need to enlarge it and show you often allow more experimental freedom than physical models. We just need to play around things very easily.

If you have a geometric idea about how well something opens, so if you can show me this sir.

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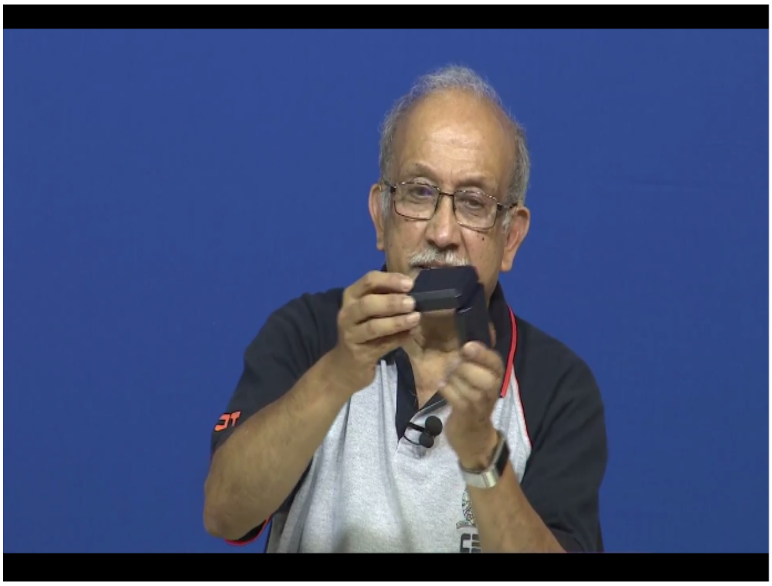

See here I have a box here and you see it here opens like this, beyond this there has been intentionally some stopper has been provided here. So if I have a CAD model of it, I know where it stops, how much it goes, how much gap it is and how well things close like this. See this, this is a clear advantage of if it is a fully mathematical model how much of force is required, how well it is closed.

So I am sure all of you have seen an automobile the back hatch. So if you open the hatch then two supports there, how much of force is required, how well do you model the support saying when it is fully open it should not fall down and then after a certain point it should close shut, it should not you know dangle outside easily. So we have a hatch which is fully open like this when it is down here.

And then if you know this and then the weight of the device and the shape, we can easily we have the two gas filled what you call sockets or bur it is just a support seen that. Now so if I have proper combination of a mathematical model and combination of a physical model, physical model is what you see and a CAD model it is very easy for us now to come off with the dimensions of the gas-filled stopper, you see one of the things which are very common in your experience.

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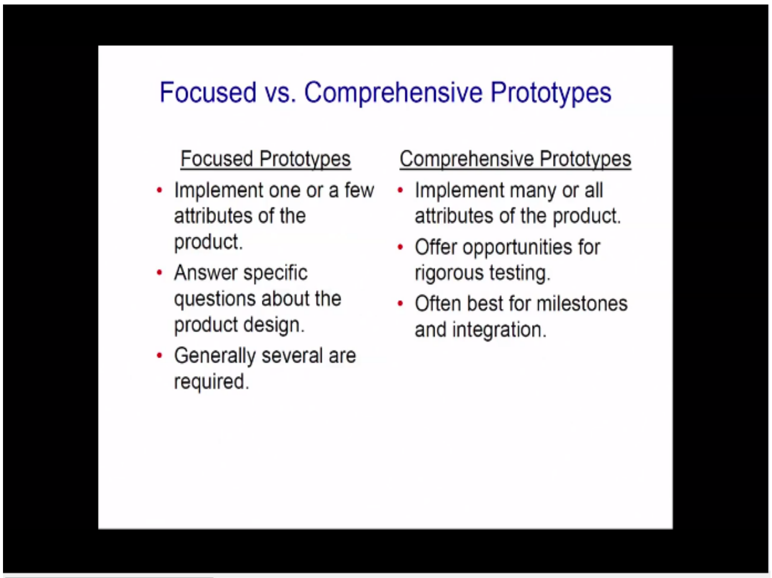

Now let me go to the next slide. This I am sure you would have tried as an engineer and more out of curiosity and there are two types of things, one of them is a simple focused prototype. I have given you an example of a hinge, how well does the hinge open. So a focused prototype will talk about one specific question about the product saying how well does a car door open and advantage for us is we can easily show someone how well our idea is going to be advantage.

It is very easy, very simple and generally several are required; however, no issue about it. Comprehensive prototype implement many or all attributes of the product. So how well does so I have again this pointer, so if everything know it has a small switch here and so on, many or all the attributes of the products can be checked, similarly opportunities for rigorous testing including what will happen if it dropped. How well does it slide into a cover?

So we have these issues of saying often best for milestones and integration. I will try to a sample. I hope I have brought it along today.

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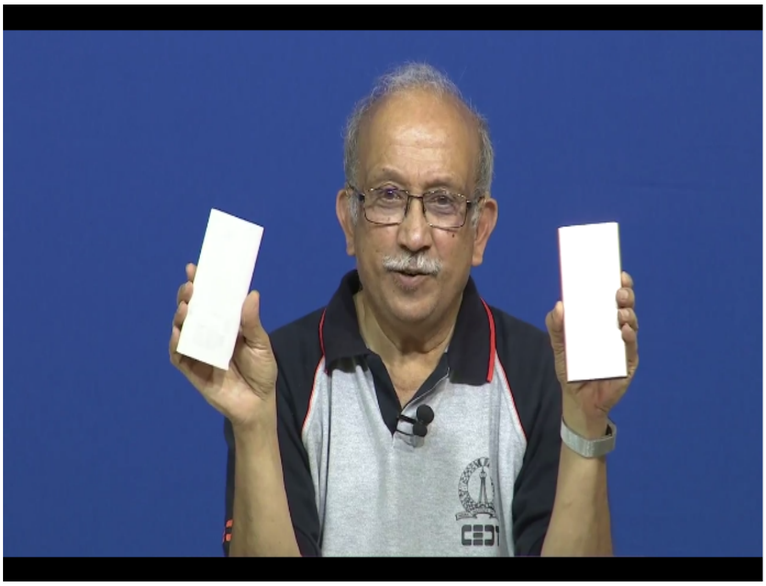

I think you know what these are, both are backup batteries also called some storage or I do not know what is the name that is given to it saying you can charge it. This one has probably good old you know lithium ion or nickel metal hydride thing, so it is a little thick, it is big and some number like you know 1000 milliampere hours is written and this one is the same one except that it has thinner lithium polymer batteries similar to what you already have in your phone.

So we have here you have seen this know, advantage is if I now make a physical model of it and I will show you what all is inside very, very easy for them to what you call somebody to make all the necessary electronics. Where do you keep the charging devices, discharging devices and do you have a switch and can you now make a pouch. If you make a pouch when I open it, I can use it. When I close it, it keeps getting charged.

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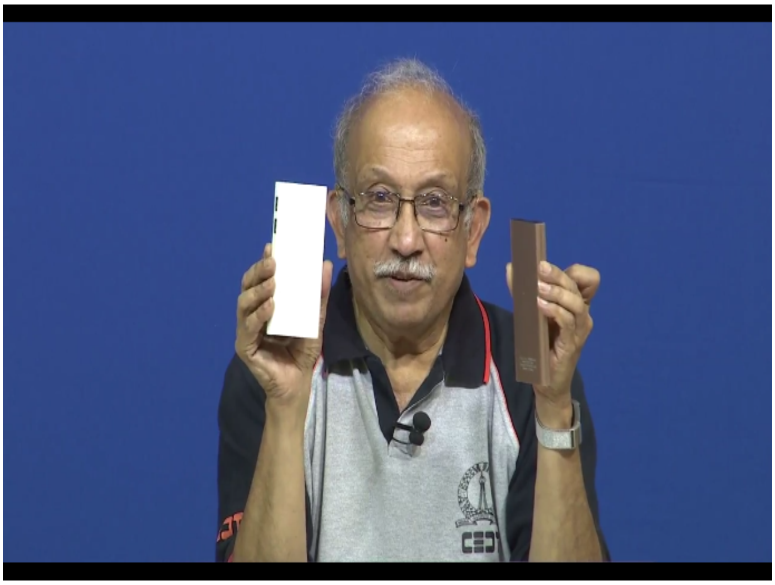

You see here it is very easy for me if I have a prototype of it and this is an actual model. This is an actual model absolutely I mean not model, it is just a working unit from the thing, such things like this now can easily be made out of 3D printing. It is very easy and then you have noticed here, they have put a little bit of graphics here. Then, they have put a switch also here while in contrast know this does not have any such things.

It is intentionally made thin because as I told you, you push it into a pouch and there are various switches and all given here including a charging thing and all. So obviously this has a place, this has a place.

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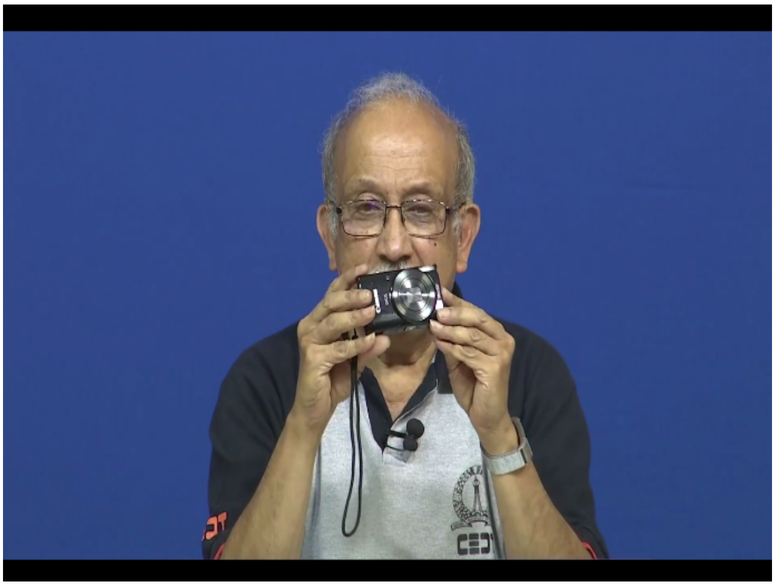

Now I will come to more interesting and very common place thing. I am sure at some point or other all of you had enjoyed using this camera. Imagine the amount of care that has gone in making this. It is so tiny and it has everything. I am surprised it says that 10x zoom and it has 15 megapixels what you call thing inside and all that and then it has obviously known place for me to put the shutter release button.

And then I have a shuttle what you call knob here and then I have everything. Right now, I will switch it off and I will come to very critical thing saying the small thing is a place for the battery. Somebody has thought about all these things. So if you were to have, it is an expensive piece. This thing I think I have paid probably equivalent of 200 dollars, it is around 15000 rupees long ago.

This is about 3 years old and that time it is. Right now I think it is may be around 50 dollars same thing you can get but you say a lot of thing has gone into saying this thin battery goes inside. Now comes the other option saying what if I run out of batteries? Is it not logical that I make something which works with rechargeable cells outside? The movement you say rechargeable cells outside; we can talk about the double A or triple A.

Double A unfortunately big, it is the whole you know form factor becomes big. So what instead they have decided is let us stick with the small what you call small cells. See in this, this is one of the very, very common thing which is used in all the cameras.

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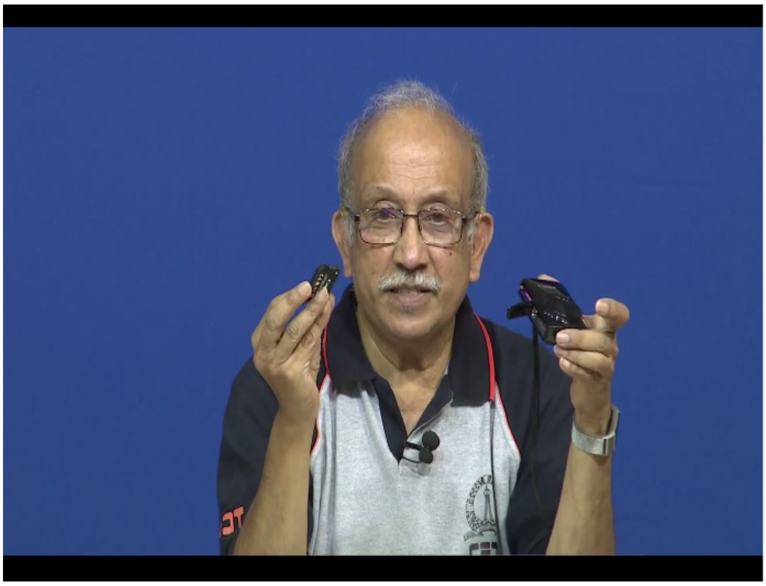

This is the lithium ion cell saying why cannot we instead have a charger for this which works directly from 230 volts or also it works from your car charger or in the unlike clickers if you have an adapter it is possible for you to take any of these things, have it charge this and in one of them the OTG cable from the mobile can charge this. Now we come to a very important thing saying if the mobile is around you need this at all which is true.

Now these days' people do not bother to carry this around except that the quality and all is good all this is.

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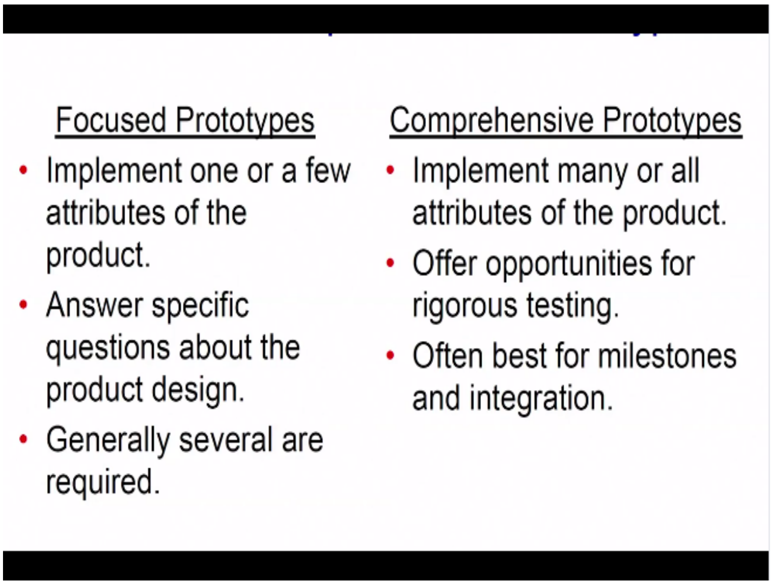

Now if you look back at my slide best for milestones and integration saying how well can we integrate all these features into the product?

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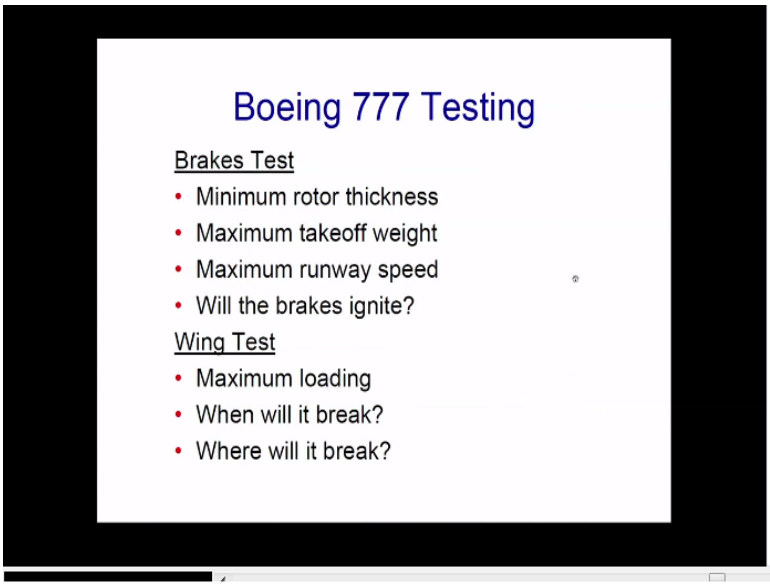

So I said what you call I would like to thank and acknowledge the original author of this. You have seen this. Somebody has to check all this stuff know. So in this case both the combination of mathematical as well as physical models are done, little scary to think of maximum loading, when will it break, where will it break and behaviour is almost predictable, very rare for anything it really goes off.

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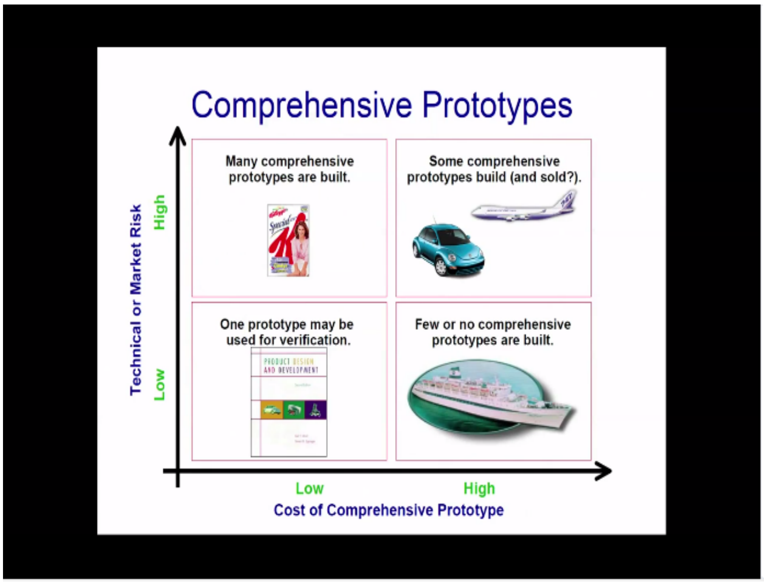

So we have technical or market risk on this you know cost of comprehensive prototype. So you see here, you can read the matrix yourself. When the market risk is what you call low and cost is low, this book itself know in this case it is not about so much about the contents because contents are well known.

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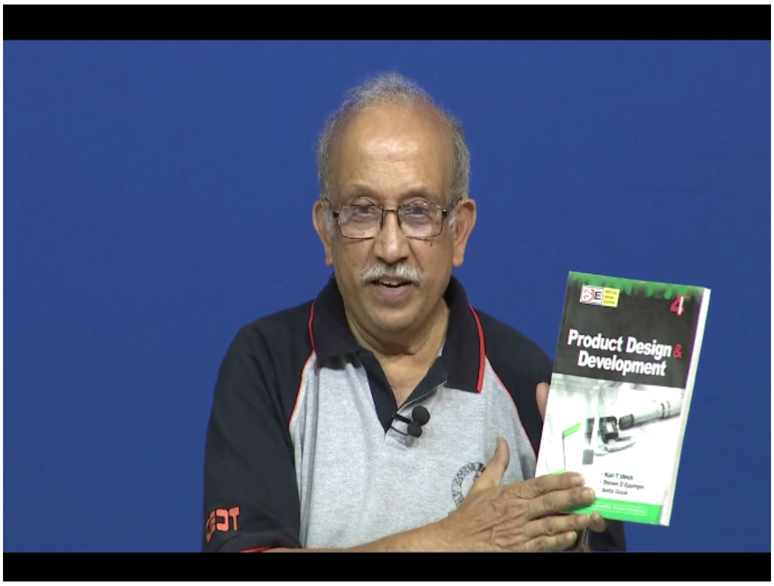

It is more about the format, picture how well it is. This is widely used in graphics and you know professional thing that is why books designed well, sell well and then after we open inside even very, very carefully somebody has chosen all these things carefully. Incidentally, this is a low cost edition, it costs a lot less and not in color but they all colored original hardbound editions know.

They are expensive but they have also gone through extensive testing. The other extreme we have high technical risk versus cost of comprehensive prototype. So probably the development cost know is probably equally shared by the developer and the customer. So now you see here, we have this packaging which incidentally know like where for a lot of packaging testing, the cost of building a prototype is not big.

You just need to put a cardboard and then what you call put it and even the content inside saying how well do the cereals behave. So we have fantastic things about it know of course in this case, it looks like saying it is a special what you call cereal which will make you know people to call more healthy but even the behaviour of the cereal that is you keep it in a box and then if you pour it, how does it crackle. Secondly, how much of taste testing is important.

In you know parts of the world, we have a very complex taste. For us normally sugar and salt, the combinations are very different from what other what you call regions behave but the thing is duplicating a few hundred numbers meaning take a what you call few hundred kilograms of the material and reformulate it is relatively easy because the market risk if you do a mistake and you can sell your product, it is a waste.

And you go to the other side, technical or other thing, there is a beautiful ocean liner here, it is extreme one know. This one is an ocean liner, so I do not know whether you know people say few are comprehensive know prototypes are build it. It is not really true meaning for the what you call all the superstructure probably no prototypes are build but individual small parts are built, cabin layouts and all.

And more than that if you see the design of this hall and the total volume displacement and the various weights and various safety features, all these things full comprehensive prototype is not built but small models are made. You too would have seen in hydraulic slabs; you will have this what you call ship structure probably scale down 1:1000 or 1: 10,000. It is kept in you know what you call water stream.

And it shows how well it behaves even waves and all can be shipped including we have here one chimney. So a full comprehensive 1:1 prototype is not built but small things are built here and obviously you cannot build a prototype of a huge ship or an aircraft carrier or anything but they are extensions of earlier technology as such you know not a big deal.

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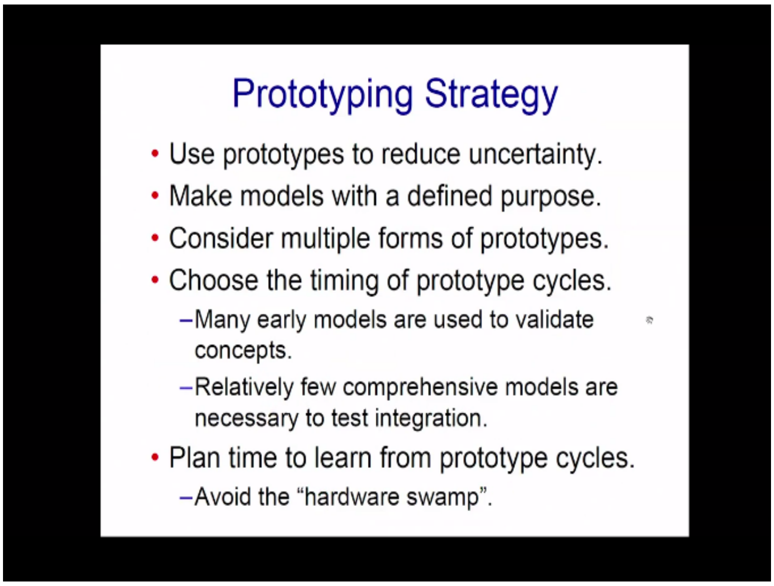

Here we come to the crux of the whole thing how rapid prototyping and especially 3D printing has become very, very important because it is part of the prototyping strategy. Prototypes invariably avoid surprises in the final product and in the market. The marketing group will use it because you know how well they use that experience as the product and in the opposite side, the formulators in the case foods and all that and various other people know use it how well the thing behaves at all.

So a prototype at all stages know reduce uncertainty or reduces surprise in the final thing and here exactly know are you making it for purposes of the market or you meaning end user or you making it for the cost point of you or anything and you see here now defined purpose you decide. So my those what you call battery banks where do you use it? Do you carry it with you, what should be the weight and so on?

And multiple forms of prototypes saying is that going to be made in the final materials or is it going to be mockup, painted, look like the original. So if I have time next time know probably I will try to introduce some of the you know small things we have. I am sure you also would have seen food on display at the entrance of a restaurant. They are all mockups that are presented there saying this food is going to look like this inviting.

And you know what to call it, so you will call what you call a vegetable a vegetable and maybe as good as it could and finally what is the portion size you are likely to get for the price you pay. If you pay 100 dollars I mean 10 dollars you know what you will get and similarly for us if you pay 100 rupees we know what we will get. So these are all display food items for the case outside which we do not need it.

I will try to introduce the pictures later and you see here early models are used to validate concepts. Next slide from University of Cambridge I will show you that will show you these things. Relatively, few comprehensive models are necessary to test integration. Full comprehensive models know are very rarely required because if you see the inside space and all that know you probably will just be working with the inside items.

Plan time to learn from prototype cycles. Avoid the hardware swamp saying once you get into the what you call quick send saying this hardware is fixed, we are in for it absolutely there is nothing you can do about it.

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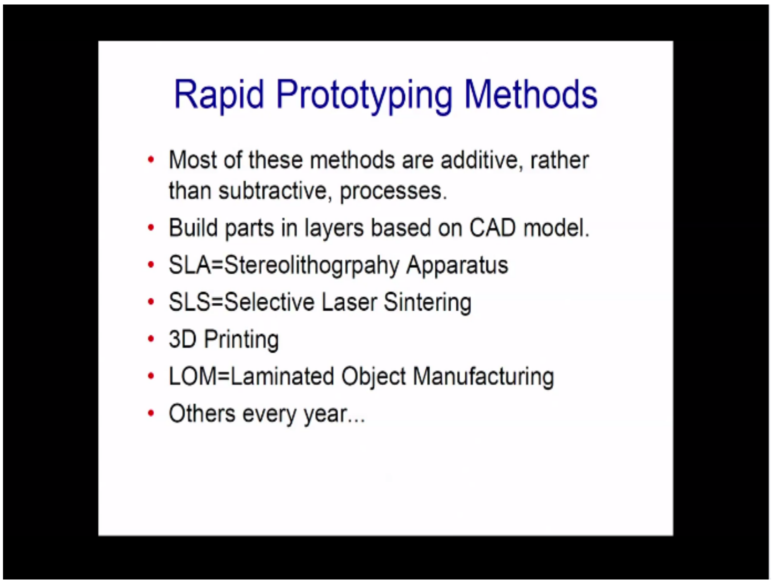

Now this is probably you should have I mean I am sure you will be wondering sir why did you not get to rapid prototyping first or I am eager I want 3D printing. So before we get to 3D printing and before you know why some of the 3D printing problems you should know why all these prototyping is required. So in the most of the rapid prototyping model now loosely called 3D printing, most of these methods are additive rather than subtractive process.

Often you see here 3D printing, lot of them are there, 3D printing is only one of them like that. So you have molten plastic which will go on you know building things and then you have eventually your prototype. So you can make parts in layers based on a CAD model. If it is a 3D solid model, you know how to make it and if it is what you call surface model you know how it is going to behave.

Then, we have all this selective laser sintering and all which will come back to the thing. In passing, I will show you what these things are then laminated object manufacturing and so many are coming up every year.

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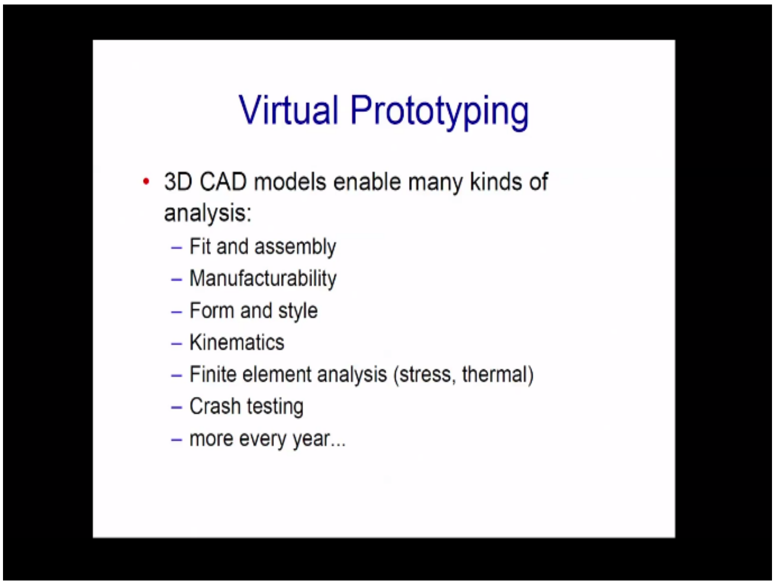

So hopefully so we have this 3D CAD models which enable many, many kinds of analysis. This is where we have the advantage of you can use the same model for other what you call one of the thing is how well do two parts assemble together, you just snap fit how is it. Then manufacturability, can we manufacture them. Then as I said form and style, I was what you call emphasizing to you about the where does battery banks work, feel in the hand and how the mobiles feel in the hand.

Kinematics means how do things open, how much of things to this thing and then method of finite differences and all meant for physical stress and thermal stress. How are things going to hit hot? Then, again crash testing, so I am sure now some of us we feel how important safety is and occasionally they will show you perfectly good looking cars being crashed into stationary walls.

And beautiful expressions they are called being totaled all in a matter of seconds and then we have those dummies.

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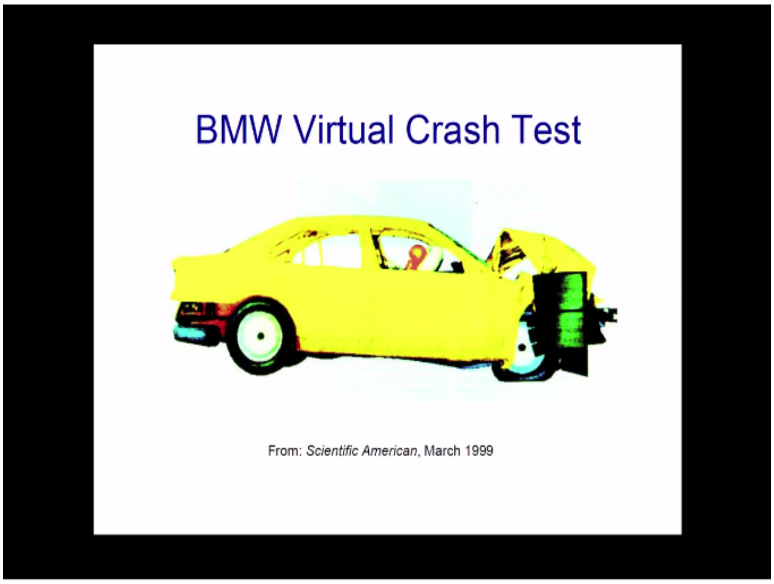

You have here, it is old, you have seen that, 20 years old. We have a virtual crash test. This whole thing is just a simulated mathematical model just about the turn of the what you call in the 1940 automobile bumpers were thick, heavy and big and chrome. Suddenly, they found out if actually have a chrome bumper like this you may be passing and all the shock into the remaining thing and hurting the unfortunate occupants.

No more are rigid bumpers made, all the bumpers are crush. So during the impact, lot of the impact energy is taken by the crush of the various items that are inside. While it is dramatic here even things like if you say your Styrofoam or thermocol expanded polystyrene UPS packing material, you see it is not a solid, it is usually there will be small ribs, whatever is need should be packed into a small space.

So if these have to be protected, it will be kept into if there are enough cavities and in between there are walls which in case something falls, those things crush and nothing happens to this device. So the device comes to be safe. So whenever you buy such things is very unlikely that your lever has any damage anywhere and all this item because they are I mean what you call packed well.

And the packing is partly by physical testing and now it is almost a CAD model. If you have a CAD model, it will show you where all, if you were to drop the whole box into a corner, if you have to drop it on to a corner how well does it roll and fall and we have all I think you have seen about you know the cat falls on all the four feet all the time. How does it do, well I think last 5 or 10 years the modeling was done into a solid saying somewhere in the mid ray of it is flexible, so it is able to give a curve and then rotate itself and land on the things.

And then in case you have bread which is buttered on one side, so Murphy's Law or I do not know who found it, I am sure all of us found. When it falls, it falls with the bread with the buttered side down. Now one of the wags, if you say the cartoons know has put one of this what you call bread with the thing tied it to a cat and he now you want us to figure out which weight is so I leave it for you.

I am of the belief that first of all it is a waste to both cat as well as the bread. I am in a buttered toast and secondly the cat is wise enough it will land on its legs and probably it is you know wiggle and you know do everything to spill your test and probably it will throw away the toast, leave it. So we have here the virtual crash test.

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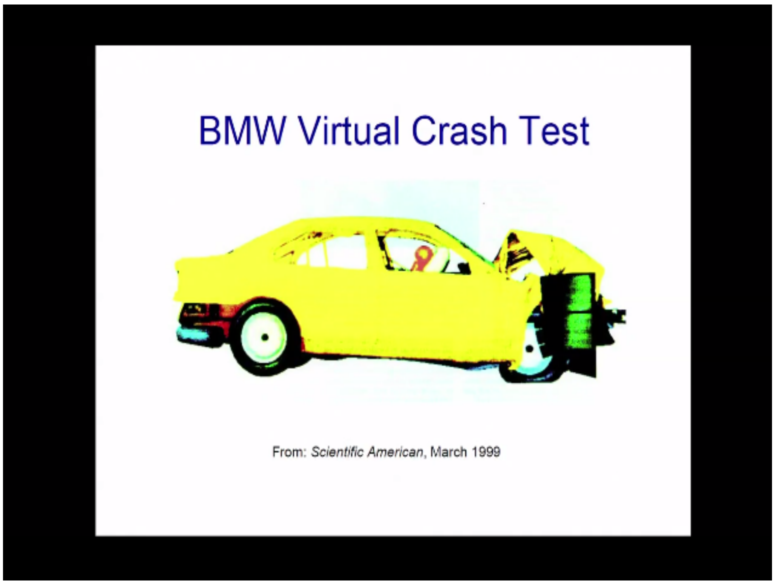

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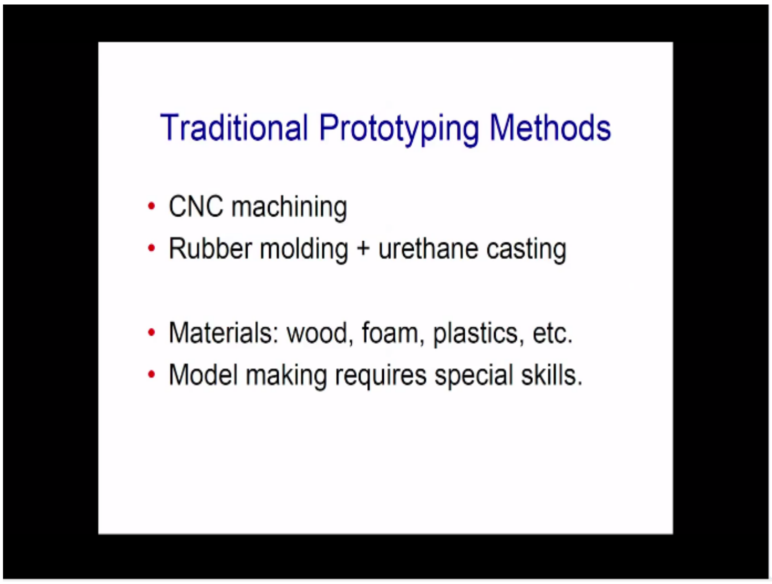

Traditional prototyping were easiest to do CNC machining out of a solid and the solid can be solid metal like you can have aluminium or it can be made out of other plastics and we had this also. Rubber molding and urethane casting saying if you make a positive model, it is possible for you to convert it into a negative and then try to pour materials inside. So traditionally people were taking wood and carving it.

And even wood when used in CNC machining if you use a proper what you call cutter, it is possible for you to make something of any shape, same thing is out of foam, is foam can be any rigid form and very peculiarly polymethacrylate foam, one white substance was used by industrial design people to make beautiful, unbelievable models. Really, really unbelievable models and after the painting and all that you cannot make out what it is.

Then, we have all these plastics means you can take polystyrene or you can make PVC or you can make anything and then try to do CNC machining or cutting and this need not be what you call explained to you model making, there are highly skilled model makers and these people make models for industrial prototypes and also for architecture and sometimes when the photograph is made and presented to you, you will be thinking that is real.

This is how the actual thing looks, so what you call I have come to the end of this session.

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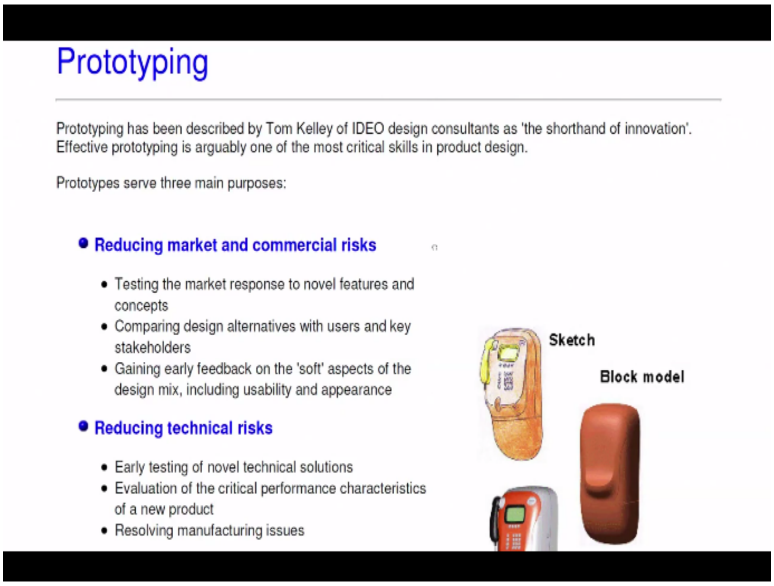

I will just try to this has been taken from the University of Cambridge, better product design resources which comprehensively covers what has been what you call put in the other one. So I will continue this in the next session. So thank you.