Physical Modelling for Electronics Enclosures Using Rapid Prototyping

Prof. N. V. Chalapathi Rao
Department of Electronics Systems Engineering
Indian Institute of Science - Bangalore

Lecture – 03
Physical Simulation

Hello, so I am back, I will try to continue where I left off, one more time please bear with me and how do you say, we have to have the sequence, we cannot break the sequence and say, I want 3d printing, if we are very curious about 3D printing kindly look up the Internet and beyond the picture of the Deodar, then several I know, assemble yourself what you called machines including one of their successful what you called MakerBot.

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If you want to actually make things like this, it needs a little more understanding, it is not easy, meaning, something about why do you deserve a prototype like this.

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And finally, if you are to make some complicated thing like this, you have seen this, it is a beauty probably, some of the scale models you know, cost a lot of money and these are the ones that triggered the child in you, so there people who collect it and then, I just want to just say know, see there is everything including this and there is rotating thing and then you see there is a cowling and the cowling is fixed to the body.

And then, so this spring mass and then they steerable variable mass, I am sorry, this is there and then this and then if you see carefully, how the back wheel can be removed with the disk in place, the calibre is still mounted on the body, the disk will come out of it and if you see this alignment of the drive chain is not disturbed, see know, alignment of the drive chain will not be disturbed.

So, I will keep it here, you have seen this, so I can remove this wheel, all these retailing are best done, if you have a prototype, while these belong to this class, I will show you a another example, is a little expensive.

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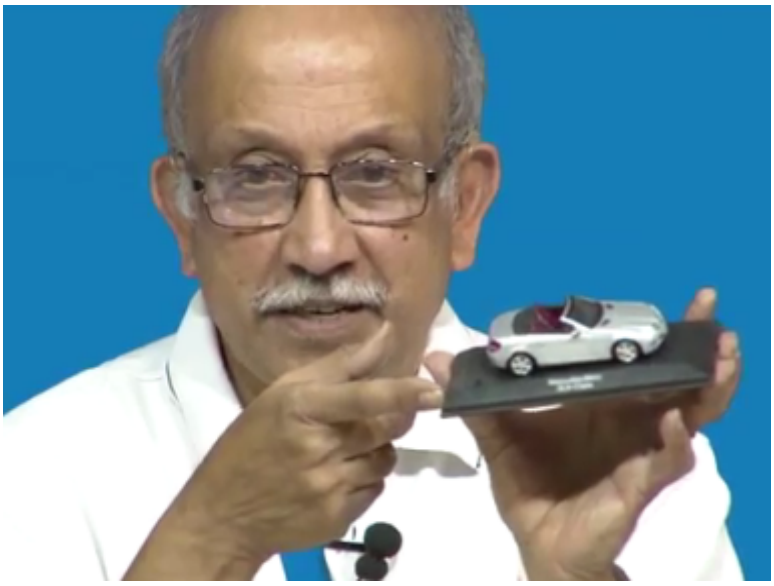

It is a Mercedes-Benz SLK, this actually a collectible item, so I have been to there, what you call their museum and then I know, we pay a lot of money, I paid I think nearly 30 mark for this and I do not show it to anybody, I am happy, this is as an occasion I could show you, things like this, which are not really functional can easily be printed using a rapid prototyping typically, simple 3D printing.

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Now, when we come to other items, you see here, you see this small beauty, this is a small cup, it is a barely the size of my lip, okay, so these things are little novelty items and then to see how well they sell, people do use the things what I am telling you, the various types of what you call

techniques and in the case of ceramics, these days even 3D printing of ceramic is possible, okay. Now, let me get back to the display here, kindly if you can see the monitor display.

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Yeah, see this is taken from University of Cambridge, good design, what you call, resources which were available but for a while it is out, so if you can read it for yourself here, you see here on the top it says, instead of my peculiarly accented voice maybe you should read prototyping is a short hand of innovation, short hand you know, know very quickly people write what the other person is talking.

Then they can what you call transfer it back to full-fledged typed, type set fonts show it to the committing sense on, then what people wanted to say and all that know, everything is later on the minutes are; how do you say, there a prudent passed around like that so, the word shorthand also you know, it is a, what you call allegorical representation of innovation and then it is now please be with me.

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One of the important thing which you keep on implying or you know what you call explicitly saying is that the prototype serves mainly market and commercial risks, so unless you show somebody what it is and you have a focus group, which is strained to think a little beyond what they do already meaning, if you again go back to crossing the challenge, these are all early adopters and there is a gap.

And then the laggards and all, the regular main people will come here say, focus group come what you call can be used as a test group for every new concept that is about to be generated. I think you have already showed you about the mobile camera, camera is okay, we are all happy and then we all know about the selfie camera suddenly, we have the cameras now with 2, I am sorry, a mobile with 2 cameras at the back.

For a long time, I used to think it is for stereo that 2 close together to say it is for stereo, so I think you know what it is, something called it is used for the depth of control which is also little related to I mean, sorry for this thing; control of depth and a little related to stereo because a slightly you know, there will be a slight shift of the material and things will be there and also called the bokeh effect and all that the things which are behind can be made into nice coloured spaces, orioles of colour.

So, if you just show somebody, saying how do you want a camera, it will with the same thing else, if somebody had asked a horse carriage user, what is the improvement you would want in your carriage, I think he will ask for more horses, which I think I have gone through earlier and you know how to store the tailpipe emissions, we have not fully solve the tailpipe emissions but then we know now an automobile is something else.

So, coming back to my, what you call presentation rather that presentation from the design Council, first thing is market and commercial risks can be dramatically reduced, okay, market and commercial risks, okay. Testing market response to novel features and concepts, you have seen this know, a lot of time people may not understand what they feature is, if you just talk about it or listed down as a set of attributes.

Right now, I use the word saying if you have a camera with; I mean a mobile with 2 lenses, at the back you can have control and the depth of field and also the bokeh effect, so the word sound make sense but I will show you actually pictures taken with it know suddenly, you will say, ah this is good, may be a useful feature. Similarly, several other things know, saying, why do we require face recognition and so on, I will leave it.

Comparing design alternatives with users and key stakeholders, this seems to be very, very important in critical thing. A lot of times because it is easy to add, features are added to the products which are rarely used at all, so I were very funny witty write up by none other than Jeremy Clarkson saying, see all the gadgetry on my desk, it does not seem to help in any way.

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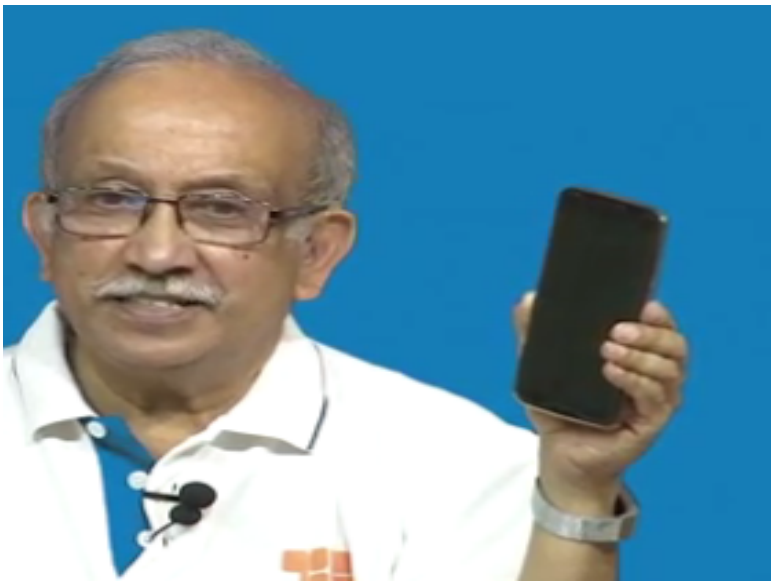

So, for him it does not help, probably if there is a way of product differentiation saying people who do not want those things or you know do not need them people want them are visible, it is good, so now right now you know, fortunately for us the age of the app has come, so you can put any app you like, if you do not want the things, they can just you know, secretly disappeared, you can do whatever you want with it.

Comparing design alternatives with users and key stake holders, design alternatives; this is not just the shape, it is not about the shape or things like this you know, these things can probably be known, somebody can you know even sketch it and show it, there is no issue about this at all, sketching it, design alternatives is often trade-off between the features, I can add this features at a small additional cost.

How do people think of the additional feature saying, putting a little extra money can I now move into the next aspiration lifestyle, so that is where it is known and then related to the other thing is other stakeholders like that if I add a feature, it is not going to cost any money but if I delete a feature, we are not saving anything either, so as well I give it or if you must add certain things it may very, very, very expensive.

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Then early feedback on the soft aspects of the design mix including usability and appearance, see here I am sure some of you are very familiar with it, the very fact that it is all held together by a cellophane tape shows that it is used and it is a little flimsy to send this know, there is a; I mean there is a problem probably, it fell and you know it knocked itself off and so on, these are all where the prototyping helps.

Now, how well it nestles in the hand, see here they have given a small projection, how does it feel, usability and appearance, it looks convenient and unobtrusive. The same feature is also available here but somehow to me it is not the same not about the same but using this, I have a tremendous amount of control on this including, it also has; see, I am shaking the what you call laser into that it will damage it.

But I just want to say maybe you can see here, there is a beautiful laser shining there in their front that is typically one of those bokeh effects. Now, it is very convenient you know I am not distracting my hand in a very funny way which happens occasionally with this. Here, very peculiarly, they have angled it little, so even if I to hold it a little like this you know, it will fall in an intuitive way in the same, I think it is easier okay.

It follows the same thing here, though I need not twisted, if I just operated like this know, typically at the height with where the audience is sitting, easily they are able to make this, this is

the actually starting point of any of your prototyping saying, first asked the customer and when you asked the customer, you also make a prototype and if you present it to the customer, he will be able to now take a decision.

So, early feedback on the soft aspects of the design mix including usability and appearance, we will get, this is where looks like a rapid prototyping and then in that specifically 3D printing seems to give the designers a head start over the others. If you have the file made first time, many times you want you can change it.

Any small things like that if you are to make this, a block model are using even clay and all that you know it stuff not easy to make a block model. 3D CAD model easy now, the same model can be used for printing and the same model can be used for all other downstream activities. We come to testing of novel technical solutions, so typically you have an LCD here, so I think all of us had this problem know.

You have an LCD screen, now should it be lighted or not, so we have a little problem sometimes, backlighting helps, sometimes back lighting does not help at all and the other extreme is; if you see the E-book readers, so you have the traditional normal display which is available on most of the what you call tablet type of a devises, 7 inch tablets but when Kindle came first when Kindle came suddenly, E Ink became popular.

Even when the power fails, like my stain here, the stain will not go away, same thing with the E Ink, when the power fails or when it is switched of nothing happens, it is just that you have a white background and that something is printed and given except when the power goes off, later on, after it got accepted in the market they have come to the paper white saying it is not enough, background should be black and you know something comes you know, dark, I mean the bright letters that is the strains eye, why not in reverse but no wasting of paper, so that E Ink concept was a tremendous success.

And only the display in E Ink, whether the product is a success that is separate things, people have moved on, now I have a Kindle app on this, I use the Kindle app for this thing, coming

back; evaluation of the critical performance and characteristics of a new product, this is where technical risks you know, suddenly there should not be a surprise from how far should this be able to control the display.

And secondly, what is a minimum power that is required for this circuitry that is where know, performance characteristics come probably, I could have included it in this pen also, so we have a what you call, very smart board there by which you know, if I write something and happen and then probably and this one has a small; what you call, I do not know what you call it know, a small switch here, so I can press switch, something happens.

I dare not risk it, I may end the session, so and then it has something now, why not have a LED, I mean, sorry, a laser pointer in this such things are available but not somehow know there were never picked up, you write from one side and then you turn it over, you can point there, alternatively, you write here and then, here itself there is something comes and you can point on the screen, not very popular.

And in fact, I have a display here, which shows I mean one of my students are worked on it, you can see it, I have brought that also along, very important thing here is finally, whether you like it or not manufacturing is a reality and while our level of abstraction is improved, manufacturing is not able to catch up with a designer's enthusiasm and what you call level of thinking ahead and asking for you know, making products with their.

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So, there is always the issue about how to solve the problem, so that is where rapid prototyping helps. Now, supporting brainstorming and creative exercises enables studying and refining of difficult features, demonstrate the viability of new principles, communicating concepts and alternatives within the team, this seems to be the best, you see here, we also made it in 1988 exactly, 30 years back made something here.

This is something which you can hold in the hand and but the displays are little bigger, so it was possible, these days you know, you can just print it, making a printing like this you know it is easier.

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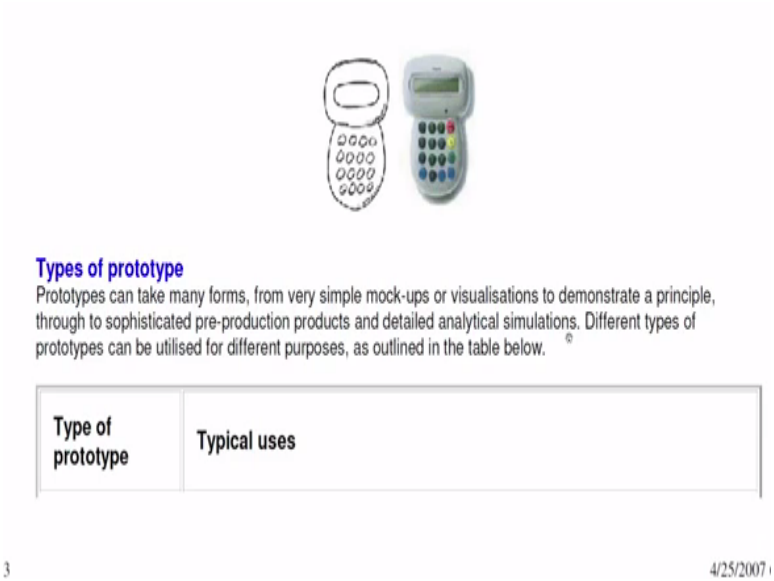

So, prototypes can take many forms from very simple mock ups or visualisation to demonstrate a principle to sophisticated preproduction products and detailed analytical simulations. So, preproduction products are what very easily can be made by rapid prototyping, analytical simulations are what can be now done by all sorts of mathematical models.

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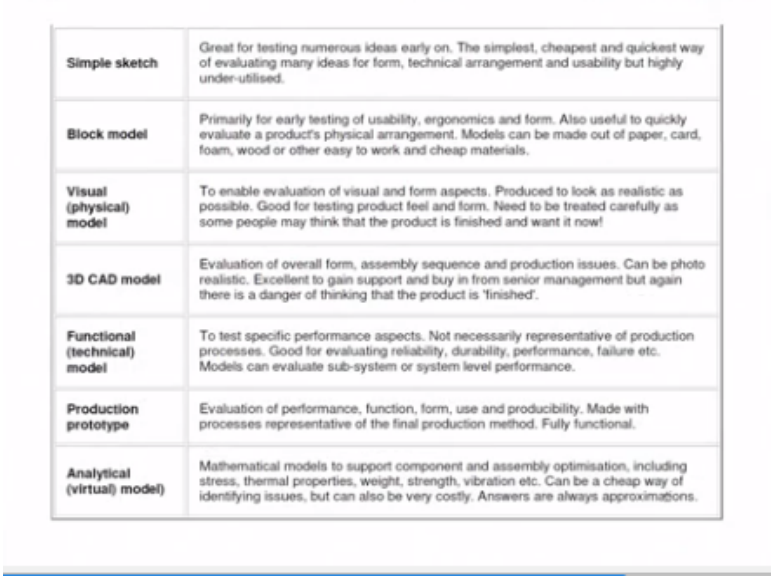

Simple sketch	Great for testing numerous ideas early on. The simplest, cheapest and quickest way of evaluating many ideas for form, technical arrangement and usability but highly under-utilised.
Block model	Primarily for early testing of usability, ergonomics and form. Also useful to quickly evaluate a product's physical arrangement. Models can be made out of paper, card, foam, wood or other easy to work and cheap materials.
Visual (physical) model	To enable evaluation of visual and form aspects. Produced to look as realistic as possible. Good for testing product feel and form. Need to be treated carefully as some people may think that the product is finished and want it now!
3D CAD model	Evaluation of overall form, assembly sequence and production issues. Can be photo realistic. Excellent to gain support and buy in from senior management but again there is a danger of thinking that the product is 'finished'.
Functional (technical) model	To test specific performance aspects. Not necessarily representative of production processes. Good for evaluating reliability, durability, performance, failure etc. Models can evaluate sub-system or system level performance.
Production prototype	Evaluation of performance, function, form, use and producibility. Made with processes representative of the final production method. Fully functional.
Analytical (virtual) model	Mathematical models to support component and assembly optimisation, including stress, thermal properties, weight, strength, vibration etc. Can be a cheap way of identifying issues, but can also be very costly. Answers are always approximations.

So, we can start with a simple sketch; great for testing numerous ideas early on so, even if you want to go for the other thing that is that concept of a rapid prototyping, you need to have even cheaper; cheaper than printing, cheaper than anything cheapest and quickest way to evaluating many ideas for form, technical, I mean for what you call, assembly, usability and not utilised often.

But next time, when you got a designer's desk, you notice he has probably stop talking like me, when I go to a shop, I do not further you know, waste my time on describing buy things, I take my mobile show them something an equivalent product taken from the; probably, online thing and immediately he says, yes sir, what is shown there costs a lot of money, he has shown a picture of an imported what you call sink trap.

Imported sink trap if you want, it will cost you a lot of money, a good trap probably, cost you around 20 dollars, which is equivalent to Rs.1000, however something which does about the same work I can give you for a few 100 rupees, so my business is done again that is what I said

know, when you are talking with people and you do not have the Internet to show pictures, easiest for you is to sketch.

And next block model; for early testing of usability, ergonomics and form useful to quickly evaluated products physical arrangement, models can be made out of paper, card, foam, wood or other easy to work and cheap material, so as I have one solid presentation may be after this, I will give you a chance to see, it taken from the mazda car saying how the mazda car full-scale mock-up has been made where uses all these things.

Since it is open source, I want you to watch it, physical model; to enable evaluation of visual and form aspects produced to look as realistic as possible, good for testing product feel and form, need to be treated carefully may think the product is finish and wanted it now, this is there, we have had it once, we made a table top okay, again coming back, we made a table top fax machine, so it has an interesting form meaning it is a little more than a A4 size wider.

If A4 is 210, this is probably around 250mm, thin; very thin, comes down and then there is a beautiful tapered base like this okay looking at it, I leave it on the table and then in case any fax comes, I get a beep, I take my A4 or any available paper in it, it gets printed in, comes out. Similarly, if we take any written material push it on top and it faxed out, everybody who is side wanted one, you understand.

We did a little bit of you know, magic with all the lights and mirrors and smoke saying it was wired it up inside using parts from another probably, a printer and the little bit of trick, already the image was stored inside, there is a big monster's computer sitting on the table, what I shown on top is only the mock-up, so when you put a paper, another pre-printed paper used to be ejected out of it not part of this mechanism, people believe that we are actually making it.

It is like that the currency duplicating trick where you have 2 rollers, roller above and roller below and then you keep a what you call, some unit may be 100 rupee note, you turn the thing and the other side it becomes 500 rupee note, I think all of you have seen it little like this, so the

advantage of it is, people unless you are very careful and tell them know, people may think that the products has finish and wanted it now.

Whenever a magician gives you one of those what you call, currency converters, you will want it, saying, I wish I had one because normally, I am not having too much money, I wish I keep money in the pocket take it out and I get this thing, this is the thing with all these prototypes. Now, 3D CAD model; evaluation of overall form assembly sequence and production issues can be photorealistic, excellent to gain support and buy in from senior management, danger of thinking that product is finished.

This happens to all of us when we are conned into buying apartments, if you see any of the apartments, all of them seem to be made by 3Ds max, there is a swimming pool and my God, tell me what not is there and in India, somehow if it has an ambience of a western country including skin colour, including hair colour and cars; big cars and leisurely lifestyle, people buy it, only at the bottom left corner it says, artist's rendering.

And they forget to mention, it is from the 3Ds max or Maya or anything at all, things are so real, little advantage and disadvantages that model, if it was extracted from a full project including layout, how much of ground or plot size they have, how much of setbacks they have and how much it is a lot of it will be very close to what you get, though you would not get all that what you see but you will get the most of what you see.

So, we are not wrong and you can also select, which were the Sun is, which were; wherever it is known, whether you want to be on the roadside, you are want to be quiet side and so on, so this is where this 3D CAD modelling, okay can be photorealistic, so photo rendering is now possible in most of the 3D packages. Functional, test specific performance aspects not necessarily representative of production, good for evaluating reliability, durability, performance, failure.

Models can evaluate subsystem or system level performance, so we have here a production prototype, evaluation of performance, function form, use and producability made with this processes representative of the final production method, so the issue being there, it is a fully

functional model and sometimes things like how to package that how do you put it into box and how does it to do.

And then secondly, in case you are organising for mass production, how do the machines handle all these items, can you make; in the case of printed circuit boards usually panels come in almost a half metre size, so can you make more of them, can you make all of them on one panel or use a different process all these know can easily be sorted out on this in a production prototype and if it can be open because it is a self-opening thing.

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I need do not do anything on its own, it is falling apart, so instead I will show you here, see here, when I open it, I have these things, how does it slide and how big or small or all the small catches undercuts and so on and how well do these things nestle here, I have a small wireless dongle, dongle goes in here automatically it does and then I also have a small cell here, now comes to thing, now complicated by having the charging wire, does not need it.

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Because once you will put the battery inside, I am sorry, the cell inside, it will last for a long time and anytime the more of these things you put like in a small USB, I think it is called a micro USB socket, it only leads to more under liability in this because very rarely you charge and chance of damaging it are high and there has not been a compromise, everything is mentioned here, it's have a small switch over to reset it.

And also to pair it and then I have a power switch here to switch it off and I am finished, so all this plus, I have 2 more switches here, I do not know what is the purpose. One is to blank the display probably one is to advance it, then there is something here and then if, on the other side, there is a smart board I can even use it like a mouse, I can select various things and so on, unwanted features but still their built in.

Now, coming back to reading this presentation, we will note here, same time; mathematical models to support component and assembly optimisation including stress, thermal properties, weight, strength, vibration etc. can be cheap, it does not sound well know, semantically it has a little negative thing in an inexpensive way of identifying issues but can be costly meaning, somebody has to spend a lot of time in what you call, getting things.

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In a small locus thing like this it does not matter but when people are able to simply show me this and people are ready to pay money for; now the current thing know, wearable fitness band, so you see here I have a beautiful fitness band, which has my God, I do not know what all are there see that there is at the back, there are some sensors and there is something and then I just need to put it and then it has a very peculiar magnetic thing here, you understand.

So, even in the unlikely case, it gets locked off know, the next round if I do it just hooks up and then I do not lose it at all, is that useful or it is not useful, I do not know but to me at the time when I bought it, it looks useful, it cost a lot of money, in India, it is expensive but then you see here know the way these things are attached to each other, this is all the physical thing. Now, the mathematical models know, talk about how long that the battery lasts, how stronger these things.

And what should; where can we optimise the weight saying, can we remove unwanted material from this and if you give a simulation run somewhere else you know, how well the products can be made, so using the same core, their products which start from around 1000 rupees and go up to 15, 000 rupees all by the same manufacturer okay and of course, we know Apple and all have even more, these thing in which there is a watch and all that not very popular.

It is popular for people are serious and do enjoy it but though I have it know, I somehow feel this is unobtrusive and it is small and I do not want it to be coupled to my phone or to my hearing aid

but then for everything in this if a mathematical model is made and it is existing in the background, it can always be put to good use later, you need to make it once and then after that things move on without any problem.

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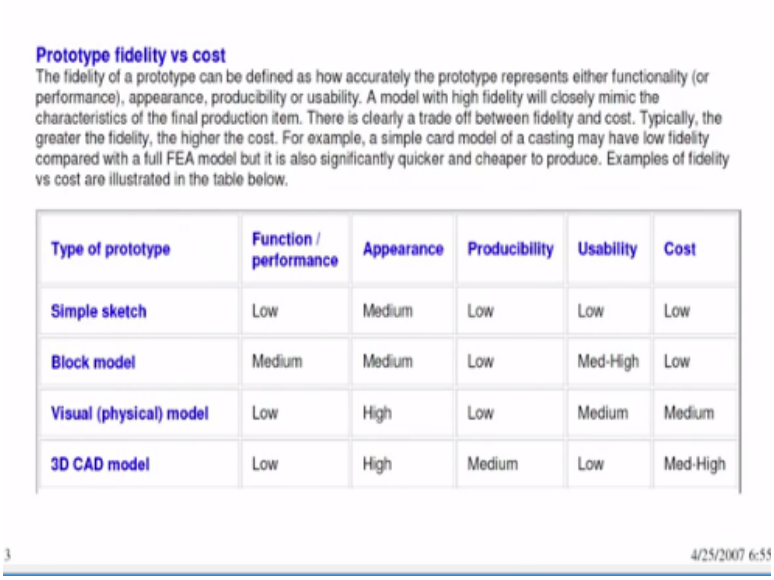

Prototype fidelity vs cost

The fidelity of a prototype can be defined as how accurately the prototype represents either functionality (or performance), appearance, producibility or usability. A model with high fidelity will closely mimic the characteristics of the final production item. There is clearly a trade off between fidelity and cost. Typically, the greater the fidelity, the higher the cost. For example, a simple card model of a casting may have low fidelity compared with a full FEA model but it is also significantly quicker and cheaper to produce. Examples of fidelity vs cost are illustrated in the table below.

Type of prototype	Function / performance	Appearance	Producibility	Usability	Cost
Simple sketch	Low	Medium	Low	Low	Low
Block model	Medium	Medium	Low	Med-High	Low
Visual (physical) model	Low	High	Low	Medium	Medium
3D CAD model	Low	High	Medium	Low	Med-High

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Good, at this point know, they use the word fidelity, occasionally people use the word granularity and then I will say, amount of detailing know, can be defined as accurately prototype represents either functionality or performance, appearance, producabilty or usability. A model with high fidelity will closely mimic the characteristics of the final production item; there is clearly a trade-off between fidelity and cost.

Typically, the greater the fidelity the higher the cost obvious, a simple card model of a casting may have very low detailing compared with the full finite element analysis model but quicker and cheaper to produce, so we continue to have combinations of both, in real life designers do not wait even for the rapid prototyping you know the part to come that is where desktop printers have become popular, just like you have a desktop, what you have to be called DTP know, desktop publishing.

And now, you have the beautifully desktop 3D printing, you put the printer and then you press the button make anything and then slowly you know, it comes out, this is ice cream season for us now, we are just entering into the summer, so if you want to make a new ice cream scoop make a

model, press a button and you can use it but imagine suddenly, somebody has given you an ice cream and then you want to have a spoon with it, make your own spoon, do everything, just print.

And then, you give me the ice cream, I make the spoon and I eat and probably, I will give you a small scoop and keep the cup. Now, examples of fidelity; for example, simple sketch function is low but cost is also low, you can produce anything what is sketched cannot be produced at all. A block model function is medium, appearance medium, same thing here know, price is low, usability; medium to high.

Visual, physical model again, you read it for yourself depending on the detail, producabilty can be high but you cannot do anything with the 3D CAD model unless you practice and learn how to use these things.

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Functional (technical) model	High	Low	Medium	Medium	High
Production prototype	High	High	High	High	High
Analytical (virtual) model)	High	Low	Low	Low	Varies

Yeah 3D CAD model, we have an medium high, next page comes to full technical model, same thing again in the last know, the prices are high and the production prototype on every aspect, it is good except price is extremely high not at all easy. If you want to simulate something which is made in plastic where you know you have snaps and most dreaded is the living hinge, you understand know, something which has a living hinge application it is stuff making a production prototype is stuff.

You still have to probably get a hinge from another part make a lot of you know adjustments and included within the thickness, it works absolutely no problem and finally, analytical virtual model depending on the amount of detail varies.

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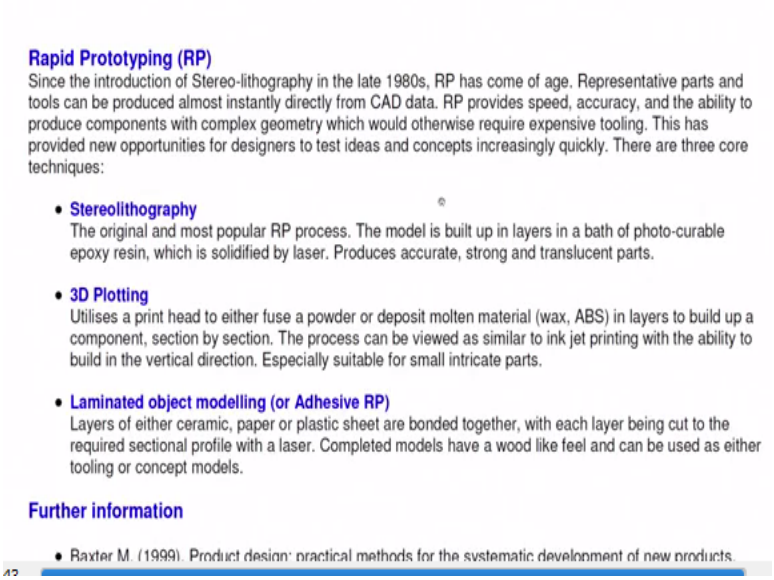

This is where we come to the crux of the problem, so I will just take a break and continue with the next session.