Design, Technology and Innovation
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Lecture-20
Research to Innovation Part 1

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Artificial intelligence has gone through a resurgence. You know, in the 1960s to 80s it was a heyday of AI and then now, again we are seeing a resurgence of AI, but a very different avatar. And at that time (it was) highly symbolic manipulation oriented rather than statistics oriented. And so I wrote a program that can actually invent new ideas. And then I stayed in Cambridge for about 10 years, leading its Design Synthesis group and then I came back here and joined IISc, where I now teach since 2001.

Let us take a few examples which I hope will excite you about the kind of things that the students or ex-students do.

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The first one is a chapel, yeah, a flip-flop.

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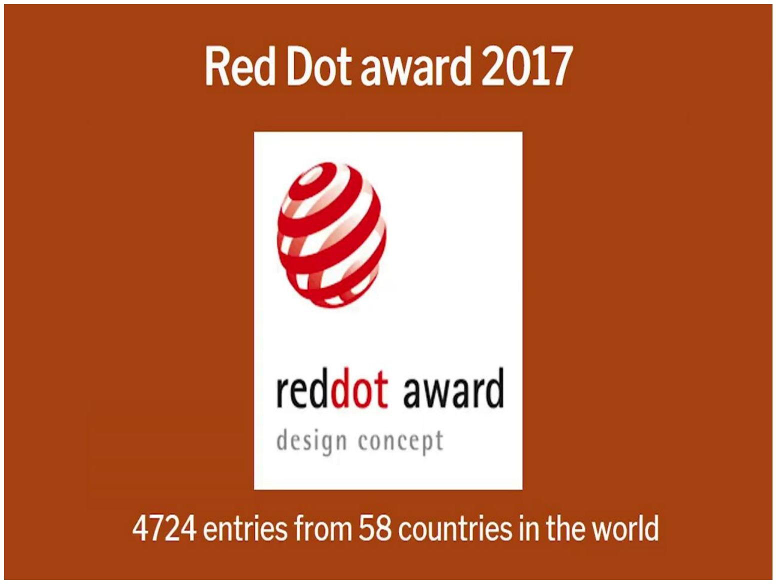
This is Govind Sharma here and Anup Chander;



And in 2017 they received the RedDot award which is sort of the Oscar of design awards for redesigning chappals such that it does splash water.

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You know a major problem with chappals is that if you are in muddy water, you will start getting a nice spray on your back.

This is a slightly different emphasis. It is an invention.

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And this is Mona Sharma, another ex student who is working in a Bangalore based startup. She is the design head.

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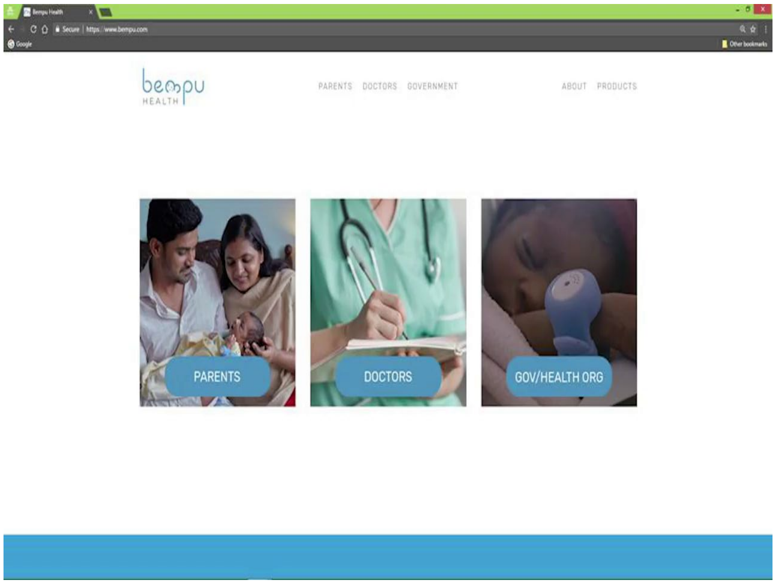

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And her startup, Bempu they, created a wristlet that goes into the hands of babies and just senses temperature and whenever the temperature goes beyond a certain number it will send an alert to the caregiver. Whether it is the mom or whoever else is in charge. And by doing that they actually saved the lives of 25,000 newborns in 15 countries. Why? Because hypothermia, a sudden drop in temperature of babies is a major cause of deaths.

You have to warm them up but how do you know that temperature has gone down? When has temperature gone down?

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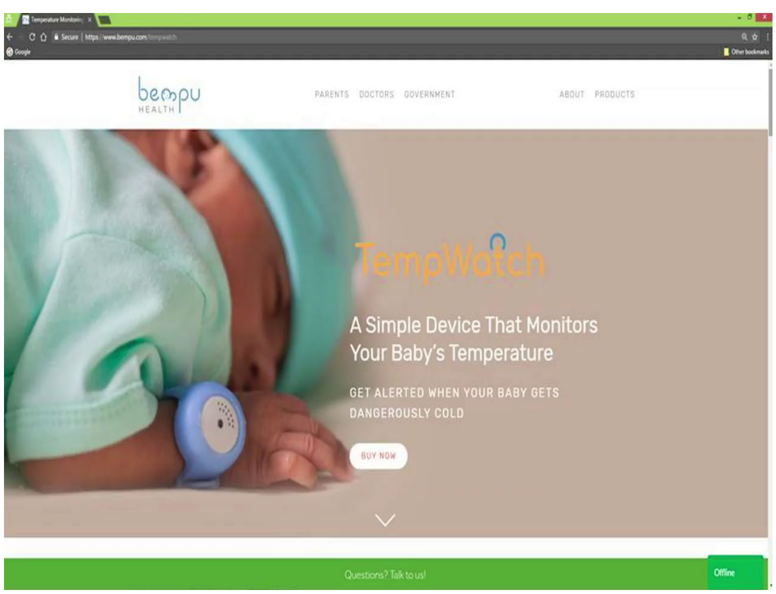

So, it is a very simple invention but very, very effective invention.

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The third one, outstanding industrial design and that is TVS Apache.

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So, this is Arun Kumar Frances, another ex-student who has done the form design for the TVS Apache Akula 310. As you know TVS actually makes BMW bikes in India and this is their first venture into creating a racing bike in the country and of course it had to have a form that matches that. You know of course you can come up with good ideas, nice inventions, brilliant solutions but if it does not go to society then it does not make the change, right?

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So, Sickle Innovations is a startup that was created about 5 years ago by 2 M.Des students: Nikhil Meshram and Nitin Gupta to basically pick cotton from the field. That is a difficult task, not many people are interested in doing and it does not give them enough money to stay in that business and there is a small window during the year in which you pick cotton, you do not pick cotton every day, and that makes it even more challenging to keep some of these people interested in that profession.

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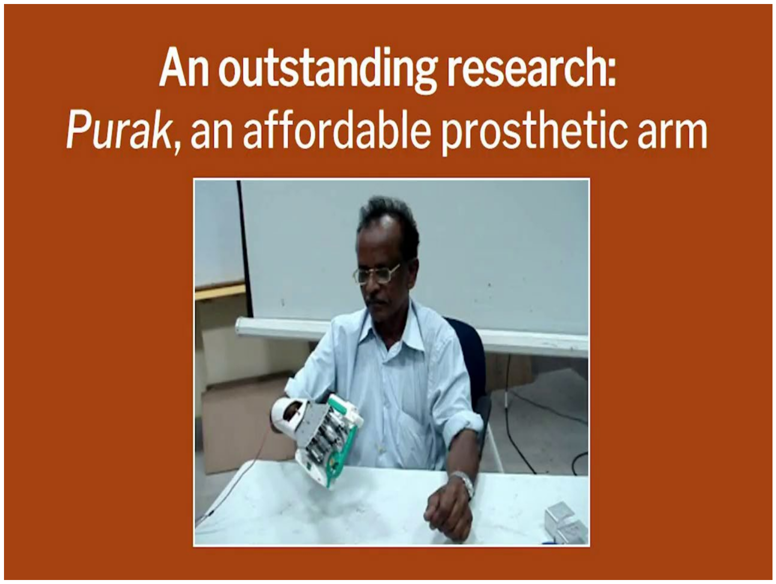

The last example is where the importance of research shows very clearly, and that is Purak. Purak is a prosthetic arm. This is a colleague of mine. His name is Eknathatn and he was one of the finest welders before he lost his forearm and as a result he is unable to do that quality of welding.

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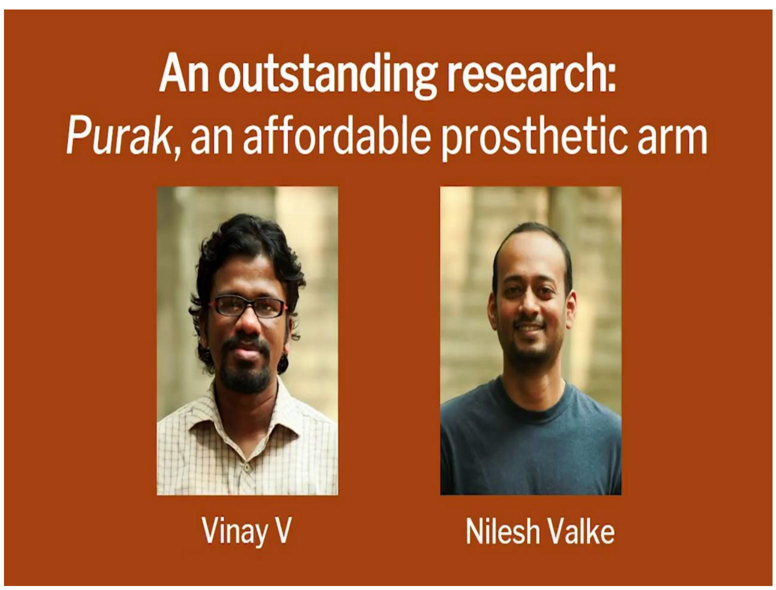

And these two students, Vinay and Nilesh, wanted to bring him back to the workforce so they did a master's project on creating an advanced affordable prosthetic arm.

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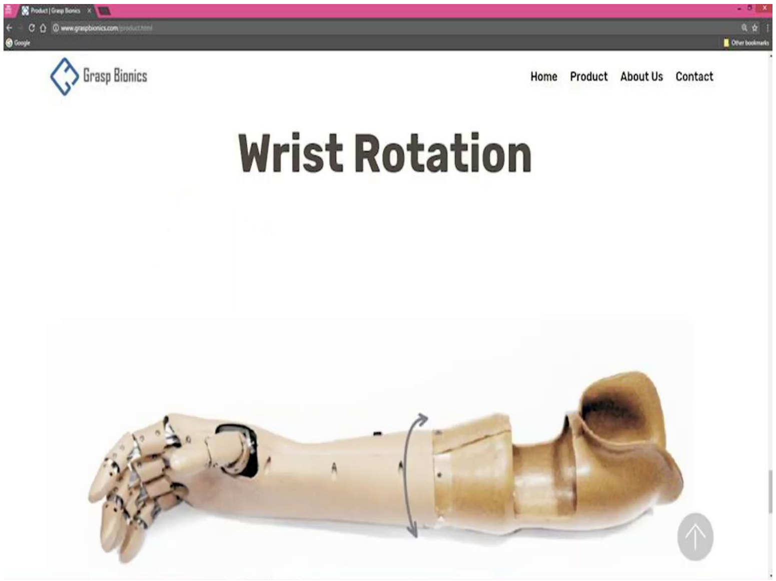

So a prosthetic arm that becomes far more affordable than anything that is available. And at the same time in order to make something so incredibly affordable, you have to really think out of the box and look at technologies beyond just changing the current a little bit. So, for something to be seriously affordable, it has to be also seriously advanced.

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So, they got interested there then by Wellcome Trust, which is a global funding body based in the UK. They gave them another 10 crores to develop this further, with a collaboration with University of Oxford.

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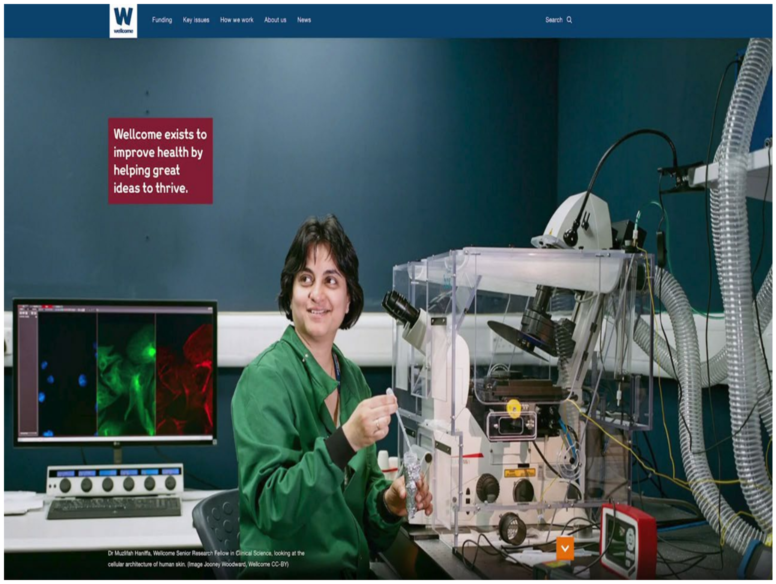

And now they have created a company called Grasp Bionics. This is an example of good research. The way in which you pick something depends on the ‘something’.

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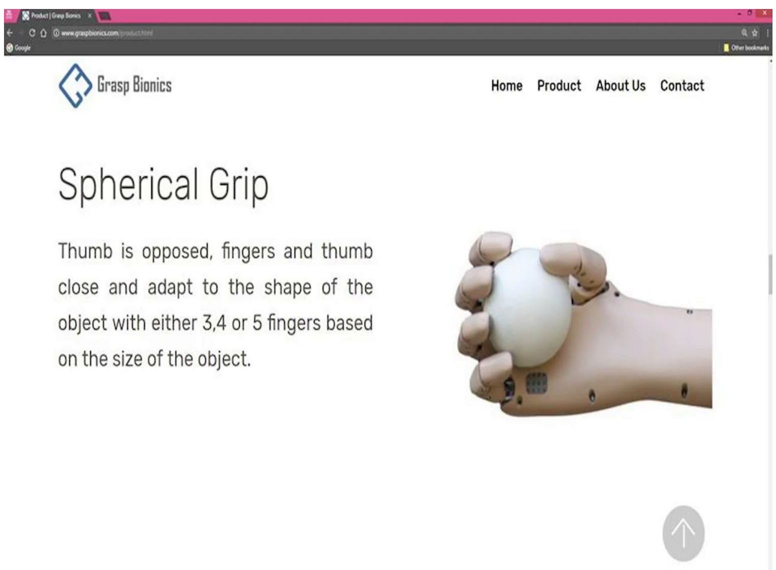

Now imagine a prosthetic arm that has to do that. Giving a flower is very difficult. It's a very soft object.

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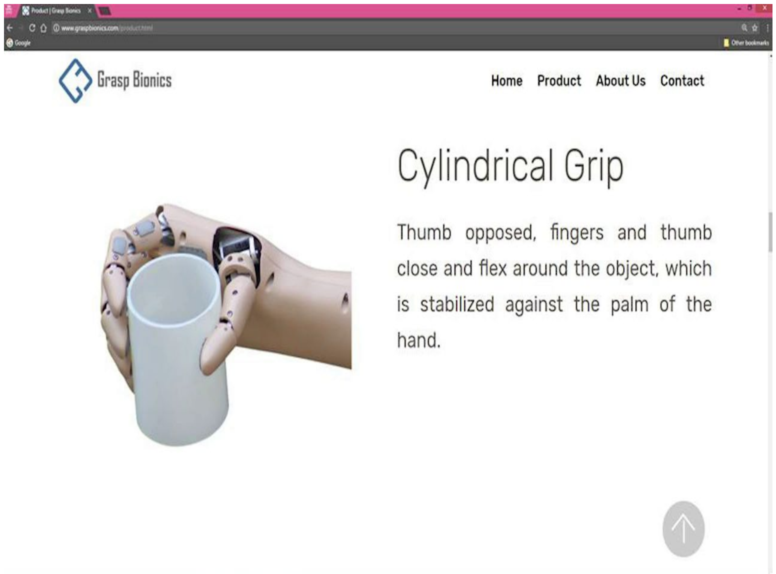

Even more difficult is a very flimsy plastic glass with water and holding it such that the glass does not deform, right? How are you doing it?

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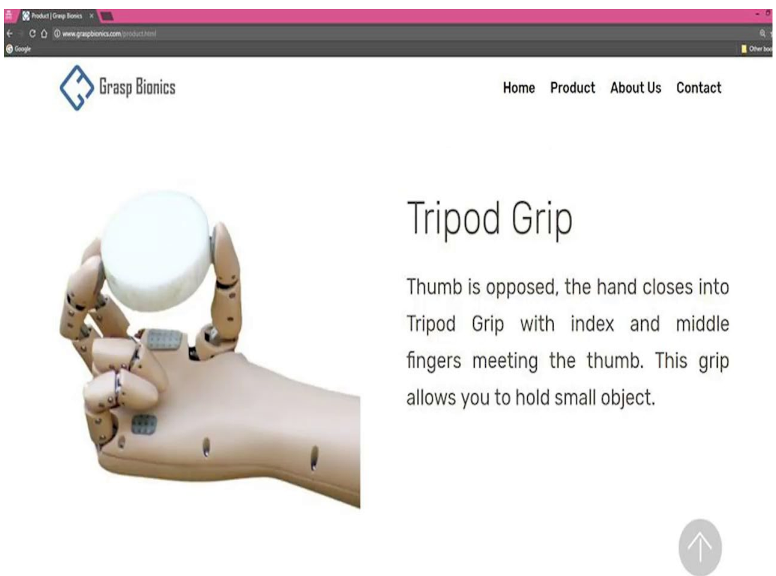

We are doing it with multiple sensors and actuators, right? So what did people do? People said, ‘All right, let us throw as many sensors and actuators and then put some controls around them so that an arbitrarily shaped object with the arbitrary flexibility can be held by multiple fingers’. What happens as a result? You have a very heavy, bulky, complex device that people find very difficult to use. So, it is very difficult to train and also it is very expensive because there are so many actuators and so many sensors. And therefore, you know, these things cost somewhere between 5 and 50 lakhs. So, these students said, ‘Can we do it at 20,000’, and they did that. And how they did that is because of good research.

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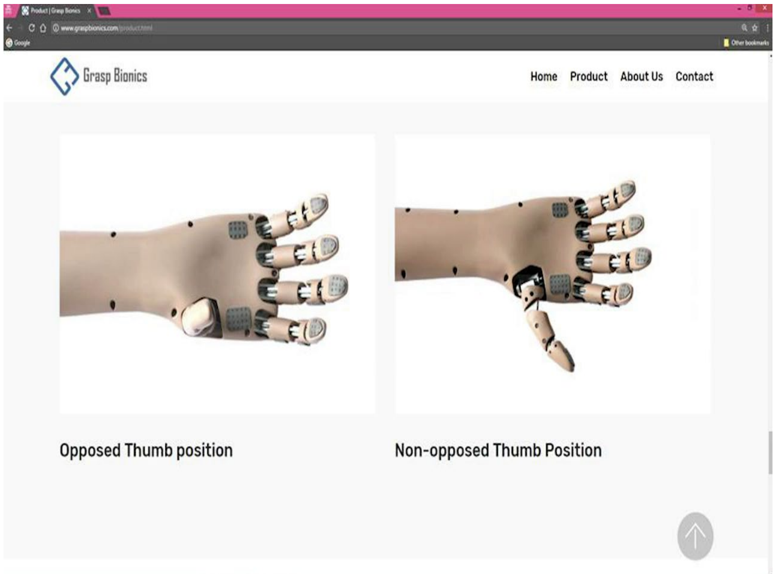

They were able to come up with what is called Under Actuation, where you use a single actuator to operate 5 different fingers in a coordinated manner, so that it wraps around and arbitrarily shaped object and something called bio mechanical sensing whereby the movement in the muscle can be sensed as a signal for it to operate.

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Now what is it that enables somebody to do all of that?

So, to do that we need to understand that there is this thing called Business which is interested in money. It does not matter whether you are doing social innovation, you know, or not, you have to fill your stomach, right? Somebody has to pay you, so there has to be money. So they are doing it for money. They call it Profit, the difference between the price at which they sell and the price at which they did everything else for that object, so that they can sell.

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There is this thing called Society, and what the Society does is that it says, 'I want Value'. What is Value? The Value is not just based on price, right? So, one simple way of looking at it is: What is it that you want? and, What is the price that you pay for it? Right?

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If you take this thing: How does it produce that Value? It produces that Value by either integrating technology or by creating technology. So, if we agree with that, then value is performance by price and profit is price minus cost. What is it that is in control for us as its designers?

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We can actually tweak two things. One is Performance, okay? And the other is Cost. It can be the cost of the environment, it can be the lifecycle cost of a product and so on. Now for this venture to be successful both Business and Society have to agree that we like it. Ok? The Business likes the Profit and the Society likes the Value. If they don't, it's not going to work. It has to be a win-win situation. So, we need to understand the needs of the user, right? And the aspirations of the user and immerse in the user context.

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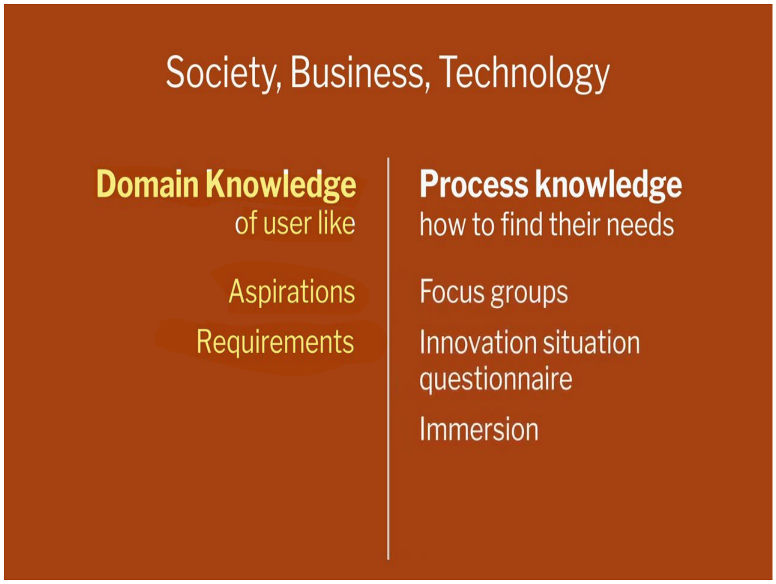

And to do that we need to have two things which I broadly call Domain Knowledge and Process Knowledge.

Domain knowledge means the knowledge of 'What is', Ok? What are the users like? What are their aspirations? And Process Knowledge means, 'How to find that', you know. How to process? How to create this knowledge? Is process knowledge.

Here is the second example. Now there is this disorder called muscular dystrophy. So, there is a protein called dystrophin in our body that is essentially a messenger between the signals that come from the brain and the muscles. So if there is less distortion, there are less, weaker signals that would go to the muscles. The muscles will not operate often and as a result over a period of time the muscles will not remain strong. And this is something that is dominant in younger children, men and it is recessive in women, so women will survive for a long period of time but at a very low quality of life.

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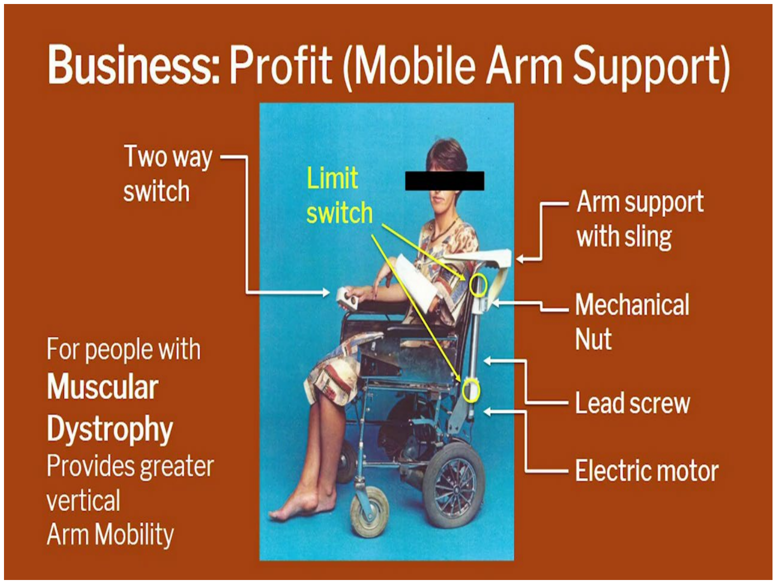

So, one of the things that we did in Cambridge, that I was part of, was to develop a simple device which we called Mobile Arm Support. Now what is Mobile Arm Support? These people would find it very difficult to move their arm up and down, because that requires much more force than going sideways. So, we developed basically a glorified lead screw that you can rotate with a motor here. So, if you have a screw that you can rotate and if there is a nut, the nut will go up and down, if you do not allow it to rotate, and that is all that it had.

So that is the nut, and then here there is an arm. An arm with the sling with enough degree of freedom that the arm can use inertia to move about. And with just that simplified device, and you have just a 2 way switch going up/going down. And 2 limit switches over there and over there, to make sure that the nut does not go out of the lead screw. That is all that it has, as a result it is very inexpensive. So we went to British Muscular Dystrophy Society and they said, ‘Brilliant product’. So we had to do field trials, we’ll talk about piloting later. When we went for field trials, we went, I went with a colleague of mine at the outskirts of London. And there was a lady, recessive lady, so she survived, she was 37, 38, she agreed to be a guinea pig for us. So, she had her wheelchair. So we connected the device there and we said, ‘What would you like to do?' She said, ‘Well, I want to type on my computer’, so we said, ‘Fine, let us go’. And she sat there and there was this keyboard, right? The keyboard was about one and half feet (above the ground). And she put her hand like that and she slid her arm like that. It took less than a second for her fingers to go from one side of the keyboard to the other. She started crying. So we all got very, very worried because normally people would not show their emotions, right? In front of strangers. Anyway she collected herself and we said, ‘Is there anything wrong?’ She said, ‘No no, it is the first time in my life that I saw that I could take my finger from one side of the keyboard to the other in less than 5 minutes’.

So this is the kind of change that you can bring to people's lives, Ok? And only if there is Profit. So what happened was that for 10 years, we could not find a person or a company that was ready to take this as a product and turn that into a business. Why did they not do that?
Because: who are the customers? They are the customers, they are all wheelchair-bound, right? They do not really earn any money. So, the amount of money available for them to do stuff is limited.

This product is what is called a High-Risk product. In case one product fails and somebody gets injured, they will sue the company. And the company will go bust unless the company has taken large insurance to ensure that in such cases somebody will pay for that. And in order to take the large insurance, where are they going to get the money from? They are going to get the money from the same people from whom they are going to sell the product, which means the product price is going to go up.

If the product price goes up and the ability for people to pay is low, this product is not going to sell. Therefore, it is not a business proposition. Therefore, for money many years nothing happened until in 2008 I received a message from a colleague of mine, one of the professor, Ken Wallace. He said, ‘Finally your product is out in the market’. What happened was the Government agreed to pay for the difference, okay? And suddenly it became profitable because the company gets the profit and somebody pays for it, partly paid for the person and partly paid for the government. And then it becomes a value proposition again.

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So, once again you need to have Domain Knowledge: What is the cost of the material? What is the cost of labour? What is the cost of manufacturing? And so on. But you also need to have the Process Knowledge of modeling costs.

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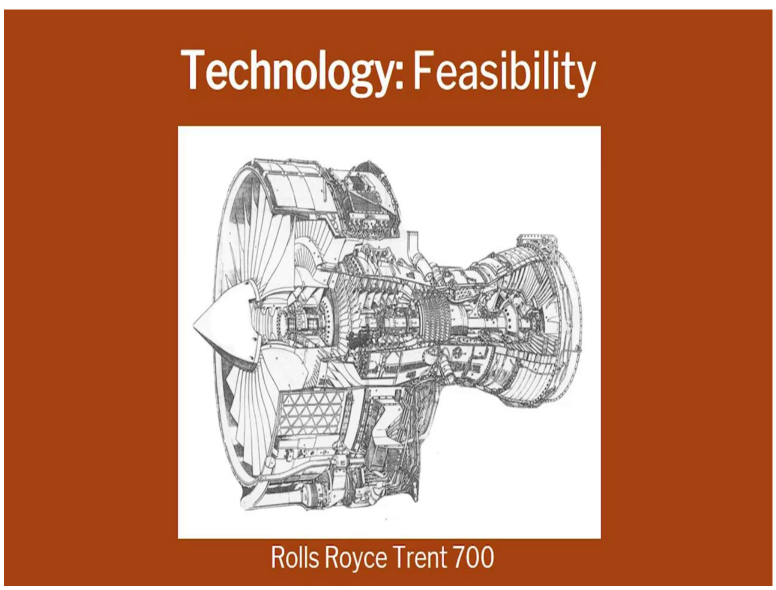

Last but not the least of course is technology. This piece of hardware was so liked by the customers that Rolls-Royce had to stop producing it. Now why do you stop producing something that everybody likes? Because if you do not do that they will not buy your new products.

There is a particular part of it that I would like to talk about, this little piece here, which is called Nose Cone. So, you want to have the Nose Cone so the airflow around that becomes nicely distributed and you do not lose energy much. But it also has side effects.

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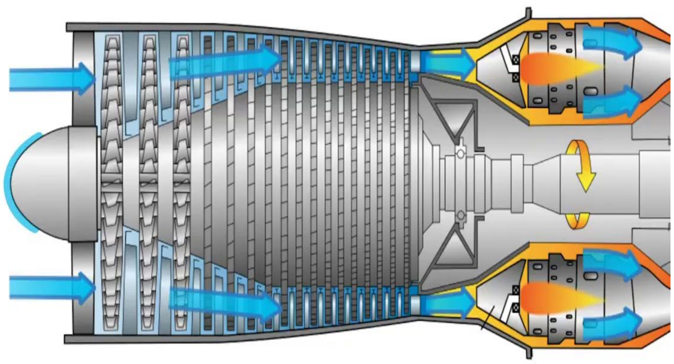

Imagine an aircraft is flying at 1000 kilometres an hour, 30000 feet. The temperature is such that where snow will start forming, and because of the compaction that will happen, because of the air flow, the snow will turn into ice, very brittle, it will break. It will become little bullets that you are shooting at these very expensive, high temperatures. The blades are very tiny here, right? And very big here, because it is getting pressurized. When the air is getting pressurized it requires less space, right? So, those are very expensive blades. There are single crystal blades that operate at a temperature higher than the melting point of the material. Now think about how they do that, there are very interesting technologies to do it.

How do you ensure that they are not shot at with bullets? Right? So this is a problem that engineers and designers have been working for a long time. What did they do?

The first thing that comes to your mind is heat the cone, so that there is no formation of ice. Bad news because if you remember Value is Performance by Price. What is the price of that, you know, heating against -50 degree Celsius?

And then somebody said, 'Why don't we think of this as two pieces where the front piece can be attached with a wiggle motor'. It rotates and then rotates in the opposite direction and it stops.

Now if you have a wiggle motor that you can program at a frequency at which it wiggles such that it is faster than the time that it takes for snow to become ice, snow will never become ice. And therefore, snow will simply break and it will fly into the aircraft engine and nothing will happen because it hardly has any inertia, right? It is fluffy. So it is lower cost, right? So remember Performance by Price. Now we are getting the same performance but you have less price.

Why cannot we make these out of flexible materials. So, if I can keep the front part slightly flexible then what will happen is that the object will vibrate, because there is enough energy around. If it vibrates a little bit that will be enough for preventing formation of cone. And now you have increased the value very substantially, right? You have shifted the problem from the energy domain to material domain, right? Pretty much everything can be done either using material or using energy. The biological systems all push the solutions from the energy domain into the material domain because energy is so expensive for biological systems.

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So, the knowledge of Society: What people value, and so on. And knowledge of Business: What would be sellable, what would stakeholders like. And knowledge of technology: What is possible, must come together and design is the great integrator.

See it is interesting that human beings become more creative when they have less resources. So, deprivation is not a bad thing.

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So, here is an example from Computed Aided Product Design, CAPD.

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So, in this case the deprivation was that you have a hand held hair dryer that you have to design except that you cannot use heating elements, right?

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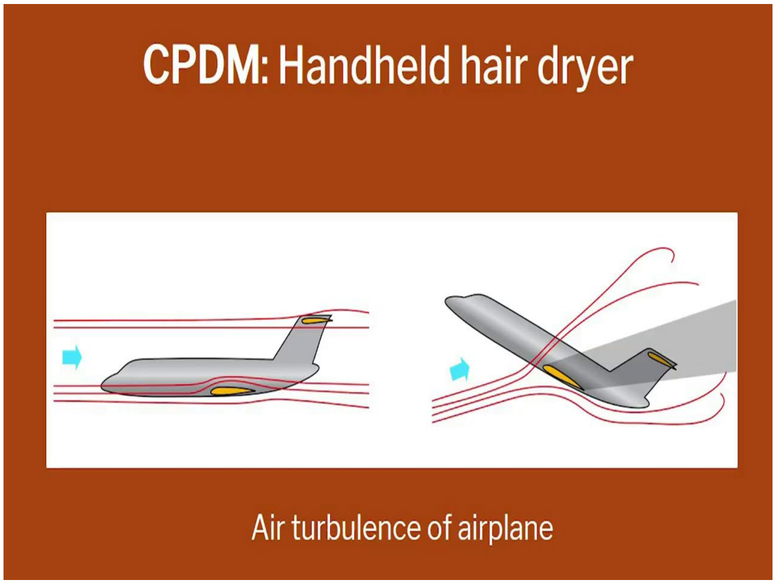

So, what Himanshu (the student) did was he looked at something that aerospace engineers hate and that is turbulence. When you have this wing for example, you want the air to flow nice and smooth on it. That way you reduce or minimise the energy dissipation across the layers and when energy is less dissipated the system is more stable. When there is swirl in the air, there is a greater chance of mixing and as a result of losing energy.

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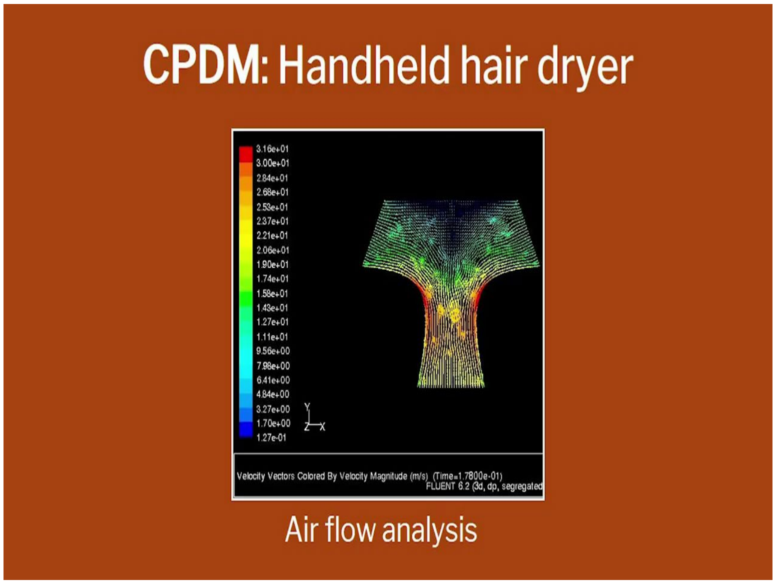

So, basically what they created is a glorified vortex generator. And how did they do that? By bringing in technology.

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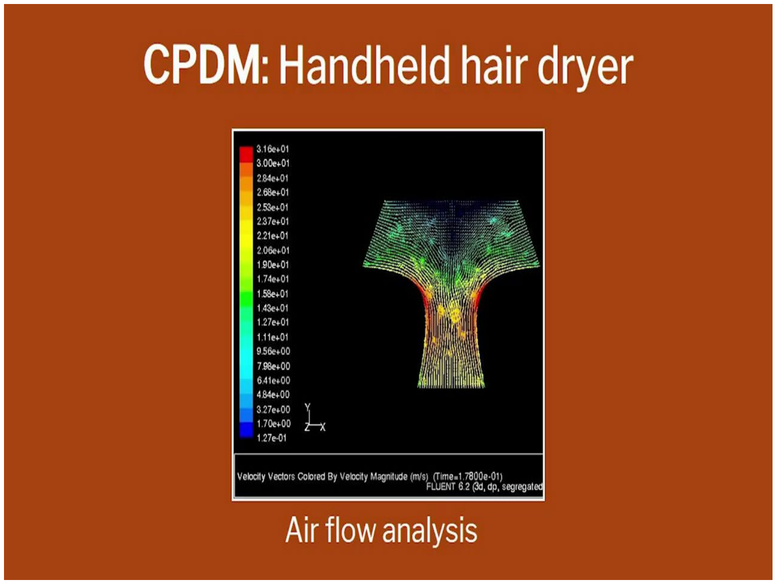

Can you use two fans for example to create two opposing flows of air which will then mix and create these twists. You know, you can use methods and tools to look at the flow and see how it is going to come in and so on. But also you have to say, ‘Ok, what is the message? How is the person going to hold it?

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So, this was something where you can hold it in the middle and you get two spouts of air coming out in order to dry the hair. And of course it should look good and it should be usable. So, usability, aesthetics and functionality must come together.

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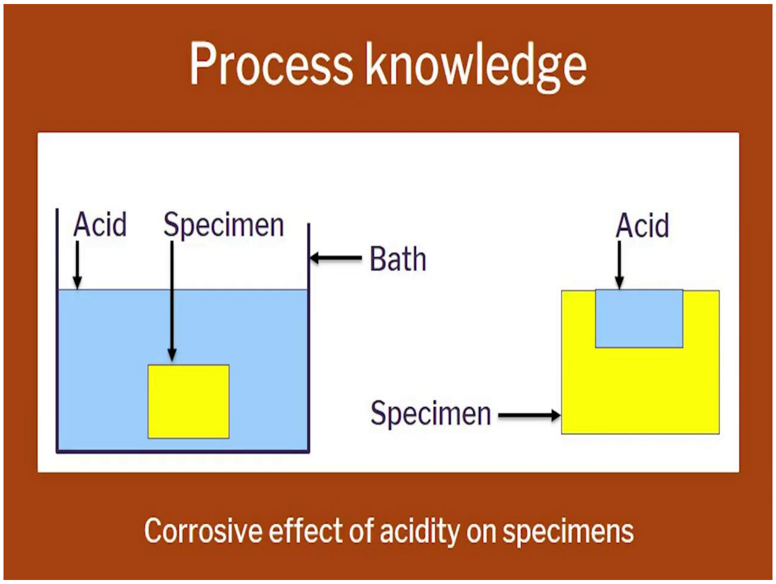

So, this is a sketch for another sensor. In this case it is sensing corrosivity. How corrosive these blue acid is for this yellow specimen.

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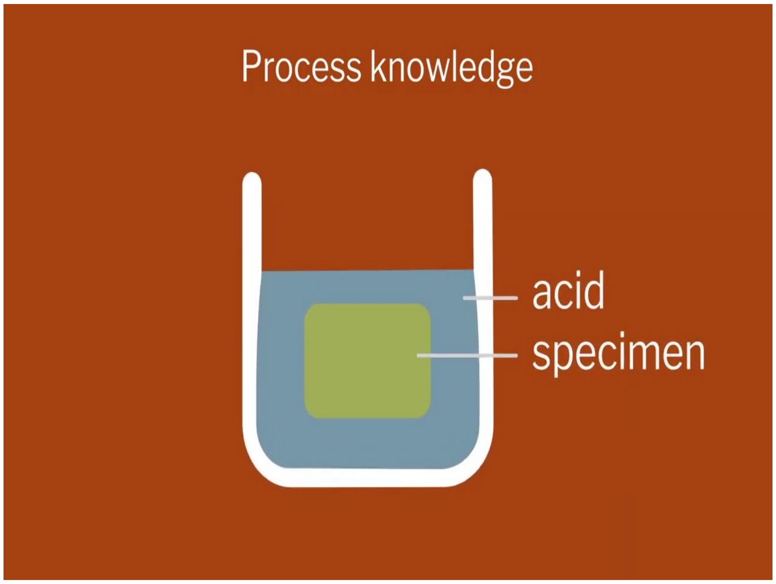

So, what you do is you have a bath, acid bath, and you put the acid there. You take the specimen, you plunge that in. You leave it for a while, for a specified period of time. You take it out and see the difference in size between the original specimen and currents specimen. And it is the difference in size which is an indicator for how corrosive the acid is for that particular material of the specimen.

But the problem is that acid is very democratic and it does not discriminate between the lining of the bath and the specimen. So as a result this very expensive lining also gets corroded away and that leads to a very expensive process of re-lining or throwing it away and creating a new one, so this is a problem.

And there are many solutions that people have suggested in order to overcome that. One of which is of course changing the material of the lining of the bath, right?

But then can we have simpler solutions. This has driven people and this is my personal favorite.

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Turn this specimen into a bath, right? What you do is you make a little hole on the top, a blind one and then you put drops of acid there, leave it for a while and see the difference in size of the hole after a certain amount of time has passed.

So, the question now is that you do not need any further domain knowledge then you already had here in order to create this idea. So, therefore it requires specialist knowledge that something that we can inculcate and it is not domain knowledge.

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So, what do we do to train our students in a structured design process. When you are designing something that is incredibly complex. One example would have been the Trent 700 engine that I showed you, which has something of a million parts, and typically it would require about 5,000 engineers to be, or people to be collaborating with each other, you need to have a process that can symphonise that activity.

Of course if you are working on a technically intensive product then you need to have a technical orientation. You need to have an understanding of the user. We (must) remember, Society was one block, so emotion to the user environment. Understanding them as they understand their problem is very important. Realizability is very important. You know, we are going to talk about piloting and production and so on later on. You know, being able to make and see whether it works, where it works, where it does not and how to change it, is very important.

Therefore learning by doing becomes very important and as I said to you earlier, research can play a significant role in all of that. You need to have the domain knowledge and the process knowledge with which to do it. So here is one process that I want to run through with you and the process has only 4 steps. We start with class clarification. So, that is sort of doing the research.

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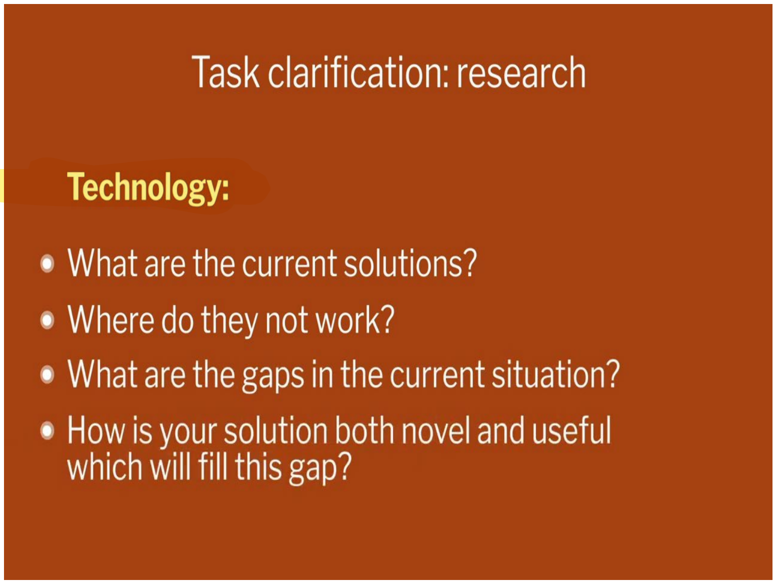

So in the Society you need to ask: Who are your stakeholders, who is going to make it, who is going to consume it, who is going to distribute, market, maintain and, you know, retire. Who are your competitors, what pain would be relieved and what gain would be received if you created a solution.

Technology: what are the current solutions that are there right now, where do they not work, what are the gaps in the current situation that you would have that are both novel, new and also useful.

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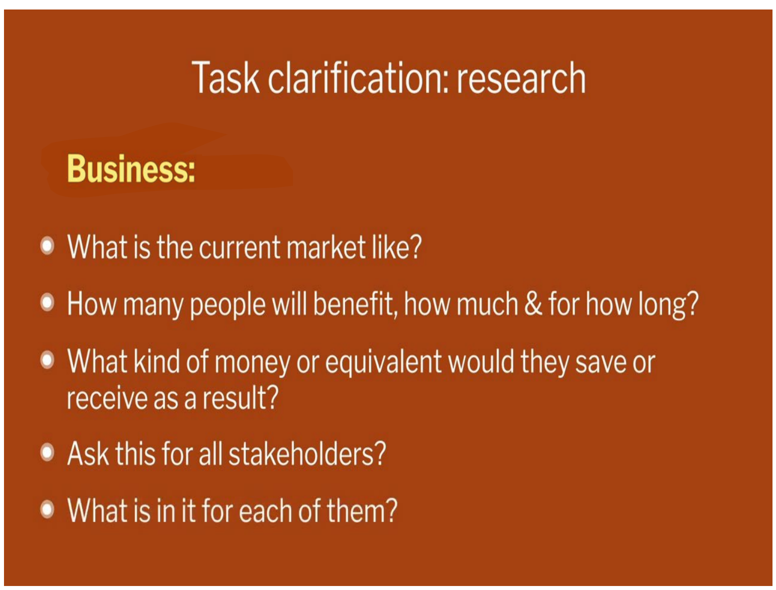

And finally what is the current market like, how many people would benefit if you did that. How much money is there for them to spare on this. What kind of equivalent the money that they will save or receive. And this is something that we need to ask for all stakeholders, not just the people who are going to pay. So, what is in it for each of them. So, basically the question is if you think of the entire process of taking your product from your head to the society, there is somebody who is going to do it, right?

There are multiple somebodies. Are all of them benefitting? If not all of them are benefiting somewhere the chain will break and I will give an example later.

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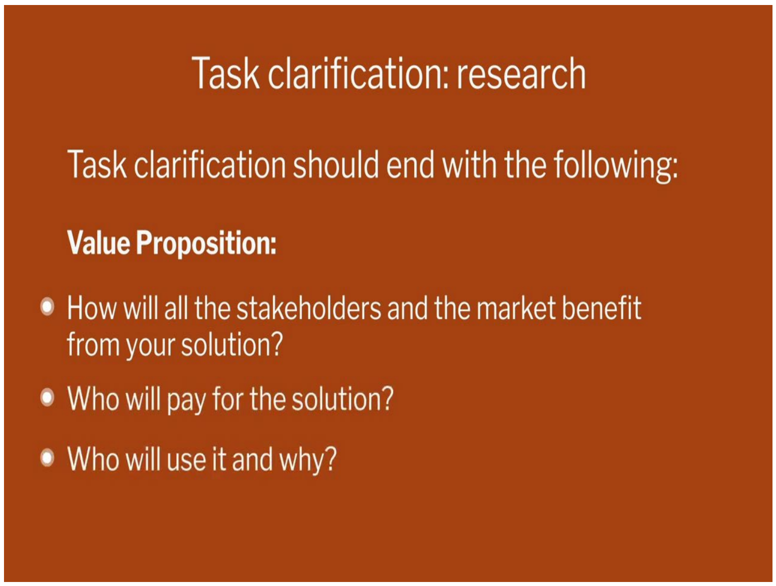

At the end when you have done all of that you should have a Value Proposition. So, you should have an understanding of: How big is the group of people? What kind of people? Who are the stakeholders? How will they benefit from the solution? Who will pay for the solution? Who will use it and so on. And why should they do that? What is the big deal for them?

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Second is a list of intents that your eventual solution must satisfy.

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And third is how important these intents are. If you ask people, 'What do you like?' They will say, 'I like this, I like that, I like this'. They like everything, but if you say, 'Ok which ones are you ready to pay for?' The number will come down dramatically.

So, you need to look at: What are the monetizable needs that are there? Which of them are essential? Which of them would be nice to have?

If you are designing a machine with which you are going to get a certain level of quality of cleaning on the floor then cleaning is essential, right? You cannot compromise that. There may be many other things that can be compromised but not that one.

So, there are some 'Essential' requirements and there are some 'Would Be Nice' requirements ok. It would be great if you can have these 'Would Be Nice' requirements as well but the 'Essential' must possibly be satisfied.

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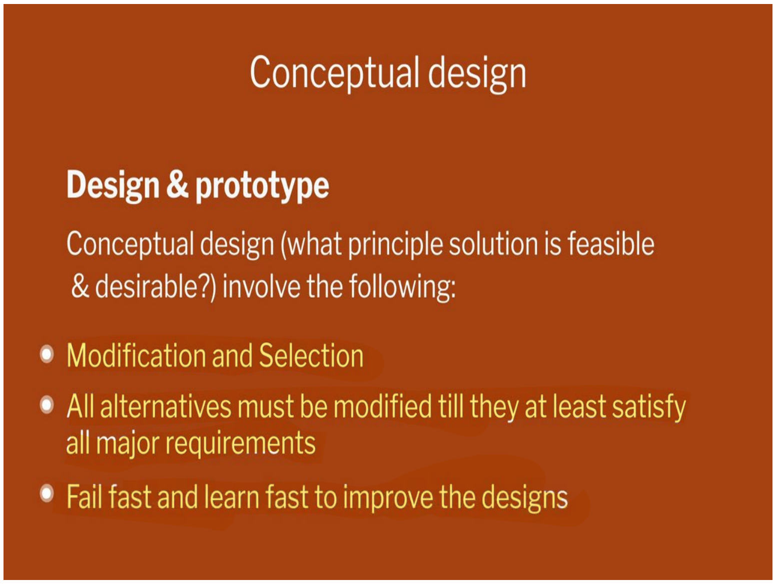

The second part is: Once you have created it, what is the intent of the product or solution going to be? You are then going to design and prototype it which we call Conceptual Design. So, what do you do there, you create multiple, alternative ways of, you know, satisfying those requirements. Normally, you know, you have looked at those examples, right? So, you can heat the cone, or you can put a wiggle motor, or you can just use a material that is more flexible and there are many other possibilities.

The important thing is to bring all these possibilities together, explore them, see which one works better, in what respect and bring them together. And do not get fixated to the first one. Do not have your favorite one. You have to have multiple alternatives and you need to model and evaluate all of them and see: Which one really works? What works? Fix the ones that do not. And eventually bring it to the same level, so you can compare them with each other. And so which one is really the best that I should go for?

And then select the one that satisfies all the major requirements, the one that you cannot do without. And also ensure maximum satisfaction of most of the other ones. We call those requirements that you cannot compromise 'Demands' and those requirements that you can but it will be nice to have 'Wishes'. So, make sure that your solutions satisfy the demands and maximally satisfy the wishes. And one message here is that you should fail fast. It is good to fail actually. The more you fail and learn from it, and the faster you fail, and the cheaper you fail the more knowledgeable you become very quickly. So, fail fast, cheap and learn from it.

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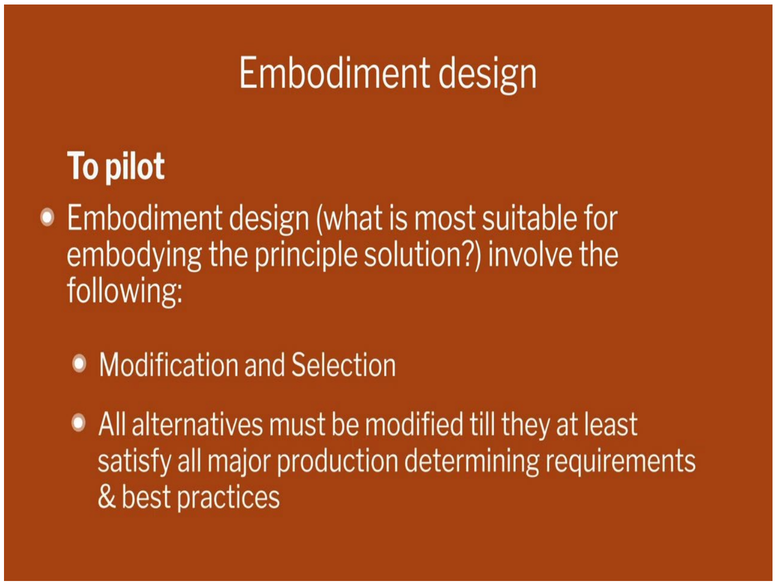

And then what we do is you essentially have come up with a principle that works. So if I take an example from primarily technical functionality, the basic principle on which a chair works is that it is a spring. That is a principle solution, that is looking at the core of what the chair is trying to provide and that is what you figure out. Of course that is not the only one thing to figure out, you have to distribute the load, you know.

The bottom of people are very different, each person's bottom is different and the chair has to cater for all of that. And then once you have done that, you can create a spring in a shape, and there can be zillions of shapes. I can have a chair that has only the backrest and the bottom rest and not the rest of the things, I can have one where there is a support at the bottom, I can have one where there is no backrest also but only resting just the body and so on. So I can have multiple Embodiments: Bodies with which I can embody the principle, right?

So, again you need to do the same thing. You need to look at multiple alternative embodiments now. Should the chair look like this? Should the chair look like that? And so on.

You need to again, model and evaluate the alternatives.
And now your requirements are becoming different. So what you are creating now is a spatial layout rather than the principle. So, you are focusing more on the components and the interfaces.
And you are looking at all kinds of other best practice requirements.
Such as reliability. It must do the same thing over and over again, that is reliability. You know, somebody sits here, goes back, somebody else sits here, goes back, all the time it must support the person, that is reliability.
What is robustness? Each chair is slightly different from each other. However hard you try to make something the same, it is not the same. Over that, however similar you think the environment is, it is not the same, right?

So, if I can vary the parameters with which an object is made, whether it is a size, whether it is a material, whether it is the production process, whether it is the quality of the interfaces with which they are connected to each other, the welding and so on. They are never the same.
So if I can make a lot of variation and yet the object functions, then it is robust.
Challenger was a space shuttle. So Challenger was going up, right? And it's O-ring, one particular ring that, basically a gasket to hold the fuel, that gave in.

The temperature on that particular Friday evening was particularly cold, and as a result the material went beyond the level of brittleness at which the thing gave in. Never happened (before), until that point of time. So, it was not robust enough to survive that range but robustness survived the first 22.

I just want to sensitize you to the fact that there are a whole bunch of requirements that are best practice requirements. You do not write it down, 'It should be maintainable', 'It should be safe'. Of course it should be safe.
So, you have to bring them together so that the part, the material, the implementation, the details are right enough that you will survive. Reasonably survive. And then of course it does not work the first times they keep fixing it until you are with that.

Finally, you know, if you are happy with that then you can go to detailed design. The last of the 4 stages of design, where your intent is to make sure that it is produce-able in large quantities. So, once again your focus has gone from spatial layout to the components, the parts, the specific quality of the materials. So, focus is getting smaller and smaller, so I want you to now, here, focus on the detail of every piece.

Remember the O-ring. O-ring failed. That was a very complex spacecraft. Everything worked alright except one O-ring and why did it fail because it's bitterness was changed to a value which surpassed the temperature on that particular Friday night, so you have to be careful.

Design, Technology and Innovation
Prof. Amaresh Chakrabarti
IDC School of Design
Indian Institute Science Bangalore

Lecture-21
Research to Innovation Part 2

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So, Nitin Gupta became the CEO and the founder of it and it was done under the guidance of Professor Diwaker Sen at CPDM (IISc) when it started.

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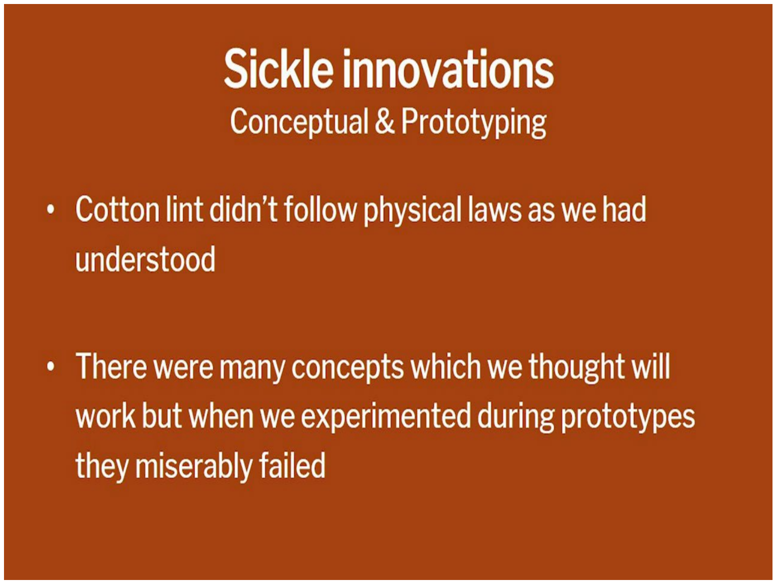

So, lints did not follow physical laws as it was understood, so they tried many things and it worked reasonably well but many times during when they prototyped, it failed miserably. As I said, you know, you have to come up with multiple ideas and fix them as you go along.

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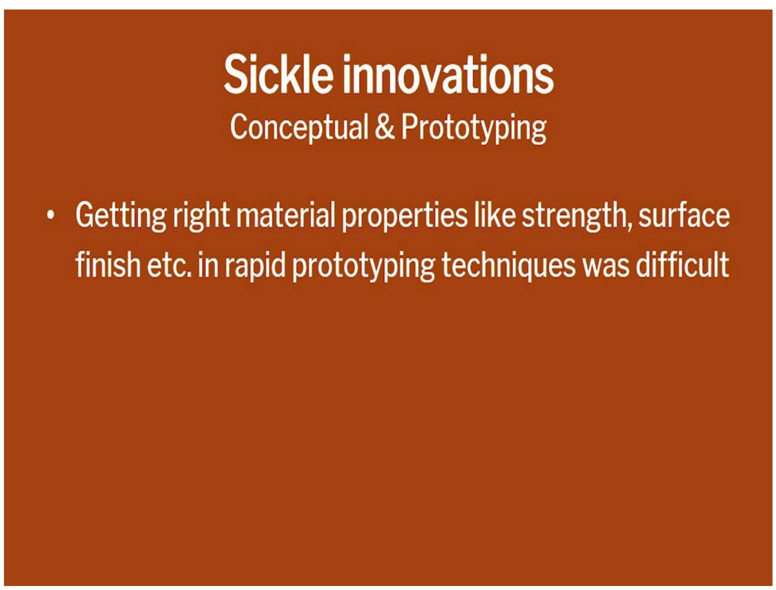

So, getting right material properties like strength, surface finish, and so on was a major challenge. They were using rapid prototyping because they wanted to do it quickly.

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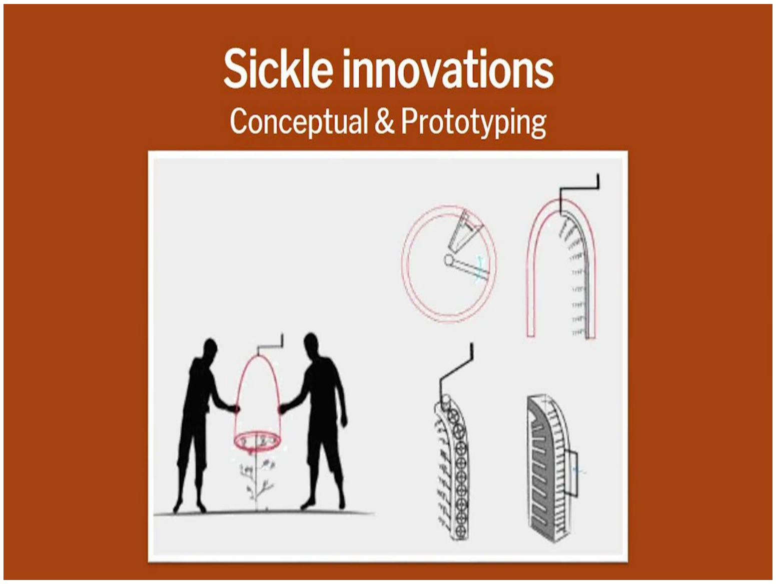

So, they went through the cotton pod, they tried the idea and then they worked through that.

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And here is the device that finally seemed to work. The idea is that I can use the fluid mechanics close to a surface. It creates a small amount of sucking and it can take that cotton out. The problem was that they had a very limited time window in which they have to go and do all these exercises, right?

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Because if you miss it, one year they have to wait. And if there is a modification to be done, what is the time to do that? See you find a problem, you come back, you fix it, you go back to the field by that time the season (for harvesting) is over, so that is the challenge.

The second thing is that tomorrow may not be the same as today. Today is hot, tomorrow is dewy. Once it is dewy there is more moisture in the cotton, its ability to be sucked becomes very different. So, again your design must be robust and works across multiple threads of input.

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So, they had to keep modifying. They had to go and do the piloting. That is Nitin standing there. In the production level, when they wanted to produce enough in large quantities, plastic parts were a big challenge.

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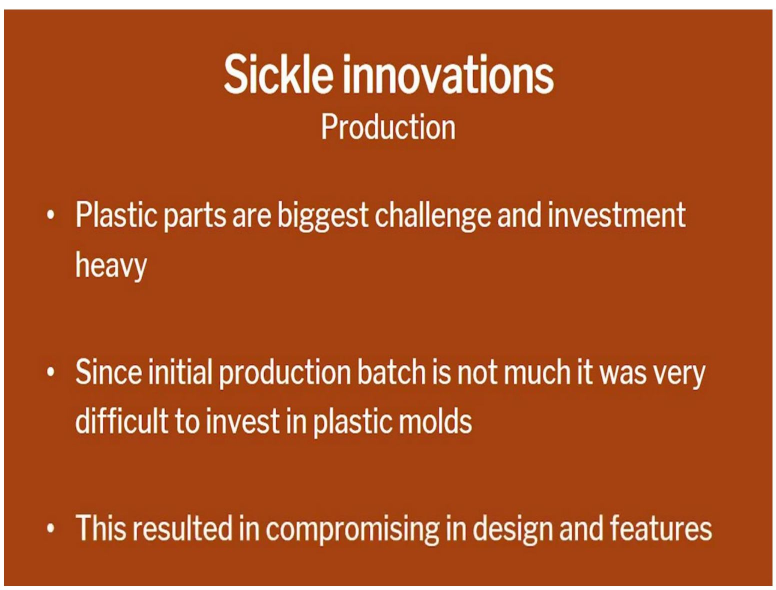

And of course it was investment heavy. Why? Because if you use injection molding, which is a manufacturing process, you have to have molds. Molds are expensive. If you have to change your design every once in a while, you have to have, every once in a while, a different mold and that makes it very investment heavy. So, they had to therefore compromise quality, both design and feature. So it was more or less like that but not quite, and that can make a difference.

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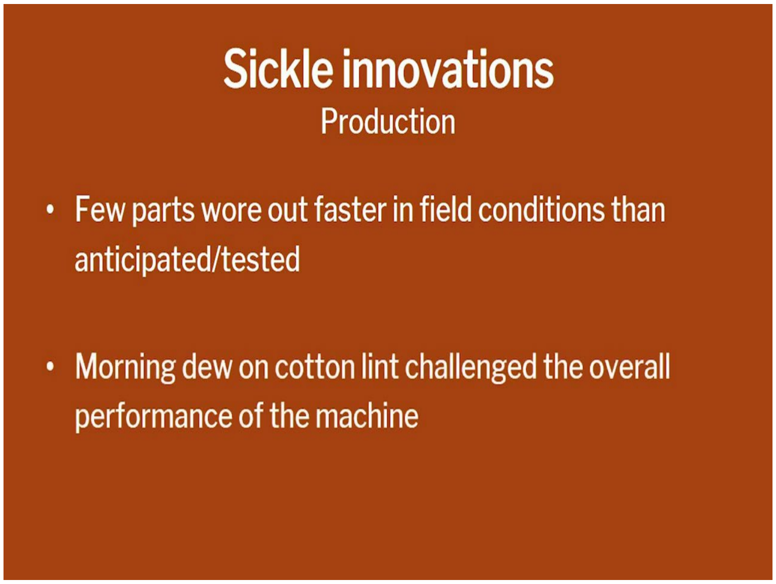

And then there are parts that wore faster than those that were anticipated or during testing in real field conditions. And I said, the dew was there, that would change the overall performance. So, there are many challenges that will come from the field. So the earlier you are in the field. Do not wait for finishing your design, your magnum opus, before going to the field. Go to the field first. Get connected with the people. And then finally it came to business.

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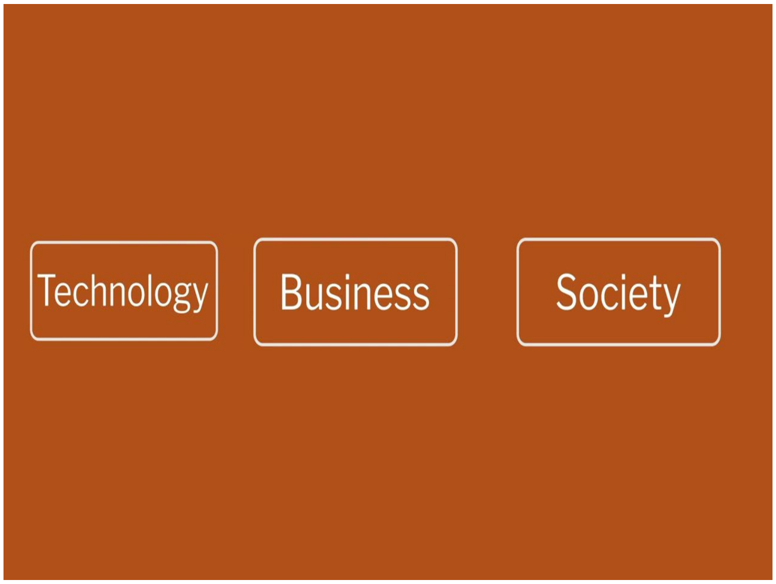

Please remember this is one of those 3 pillars: Society, Technology and Business.

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So, the product did everything that they thought it should do, people should go there, hold the object, it will suck and will go get filled out and all that. It happened. But despite that it did not create success in the market. What happened?

It was not a win-win situation. All the stakeholders must be happy and they were not. It turned out that this machine that they created, that picked cotton from the plant and directly packed it into a bag, was going directly to gaining mills, where they will then get the thread out of the cotton.

So, while they initially thought that they were going to empower the person picking the cotton, they ended up empowering the company that is selling cotton.

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The middle people, middle men, they actually made all the money and not the person at the end. So, because the supply chain was not financially benefiting and the main parts of the supply chain, it did not become market viable. And the product failed. So, it is important to remember that the equation for business is win-win-win-win-win. Everybody must be winning otherwise it is not going to work.

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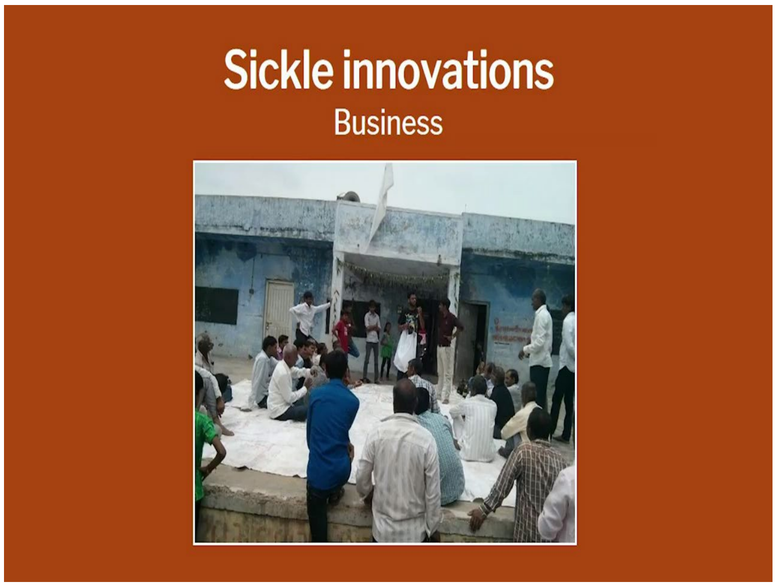

So, this is their business part, you know, they actually tried it. These bags are from the fields and this is the team.

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So, you see the final product there. You see this being picked up here, this chute that is taking it to the bag at the bottom, and then those bags are coming out.

What is interesting is that yes it failed. But what is success? Success is that the company survived. How did they survive?

They moved (ahead) and started looking at picking other things. So, they have mango picking, they have apple picking and they become a picking business, right? And the mango picking and the apple picking is doing exceedingly well and they are getting left-right-center, all kinds of prizes but also more importantly they are making money.

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This is the team that is Nitin.

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That is Vinay Reddy. There they are the main two, sort of, business and technology end of it.

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These are some of the other products that they have created. So, they have all kinds of picking devices. And they use some of the AI and machine learning now in order to see whether the apple is worth picking now, whether the mango is ready for picking now. So, they have a camera up there and so on and they have a wire cutter that can be heated up from here. So, you do not have to do this to cut it.

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So, that is ISBA (Indian STEP & Business Incubator Association) innovative company that is 2018.

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Then Farm Tech Startup 2018.

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Then FICCI business award,

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That is, Modi ji is there,

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picking Nitin as one of the top 35 startups;

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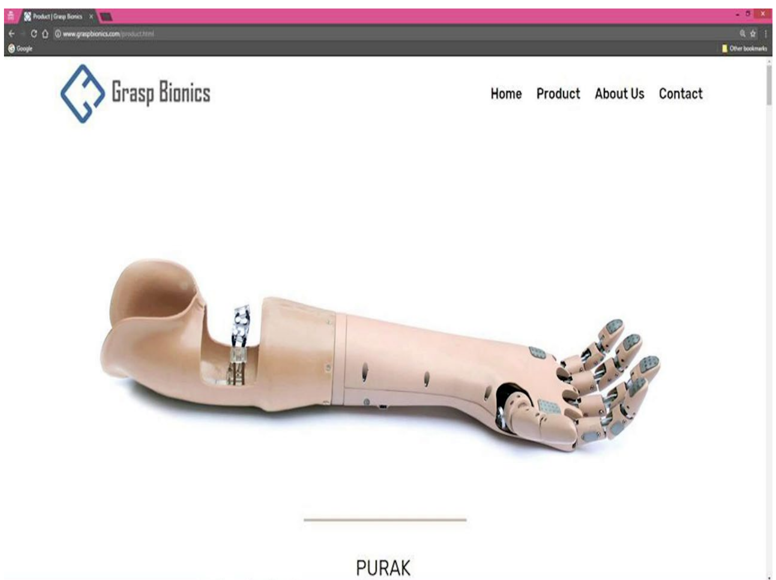

Second example is that of Purak, that prosthetic arm that I talked about. In design their challenge was this high-end function with an affordable solution. And as I shared with you, you know, the challenge was, 'Can I minimize the number of actuators?' Because if I can minimize the number of actuators, I will also minimize the number of sensors, I will also minimize the number of controllers. So, basically the whole thing gets minimized.

And the second challenge was in the prototyping, getting the right manufacturing processes. You know, the same manner that presumably may be brilliant for making 200 parts but terrible for making one remember, injection molding is a classic example, right? So, actually one problem that you should look at or some of you should look at is: How do I create a mold that can be changed into another mold, and that can be changing yet another mold. Molding is a major challenge where the cost is involved.

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The third one is in the production. How can we create a low volume, low cost production process? See the problem is, not everything is like a PCB or a computer chip and so on, which is coming out in millions. Your market is small in size. You will sell probably 20 in one month if you are doing well. And then the question is: How do I create low volume, high quality numbers at very competitive cost. So, therefore low volume, low-cost production processes become a challenge and that is the case for them, right? Not everybody is a lower army amputee, so you get a small volume.

And the fourth point is, How do I price my product? If I make it too expensive nobody buys. If I make it too low I do not make enough profit. So, what is that sweet spot. And how do I penetrate the rural market? There is a large number of people who can benefit, that can be done. So, those are the challenges that they are facing right now.

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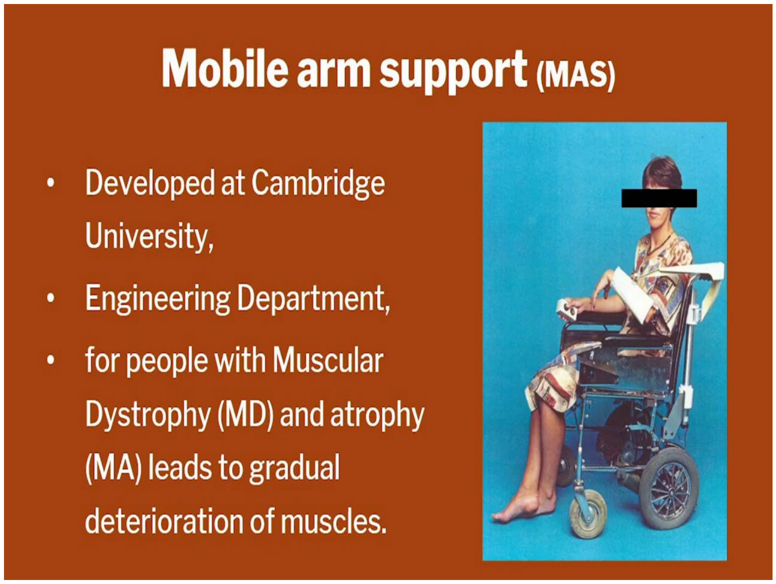

Third example is going back to that Mobile Arm Support project where I want to spend a particular amount of time on only one part of the production level, so the detail design. I want to show how complex it is and therefore how important it is to pay attention to detail.

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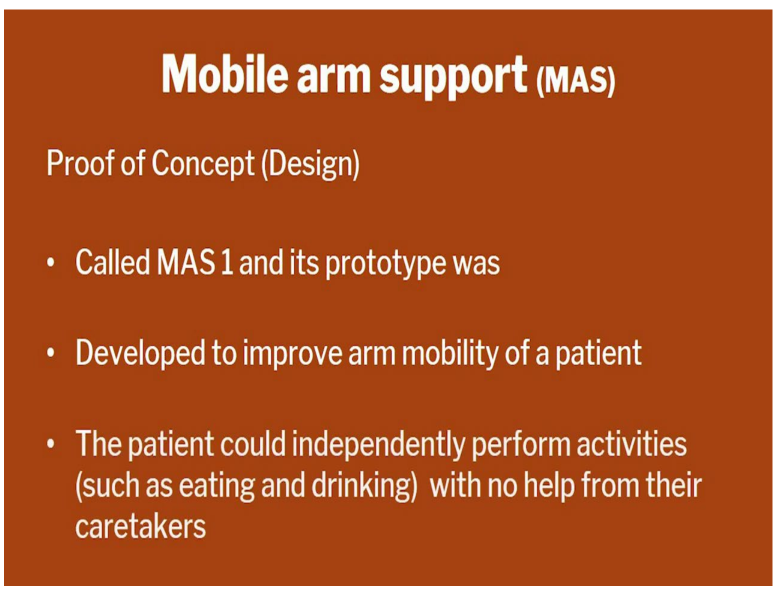

What did we do? We went through two different cycles. First we created a proof-of-concept or design or prototype. We call it MAS 1 that was focused on only a certain group of people that would be fine, who would be agreeable, to testing the device. So that they could perform activities, such as eating and drinking, for which they are currently dependent on others.

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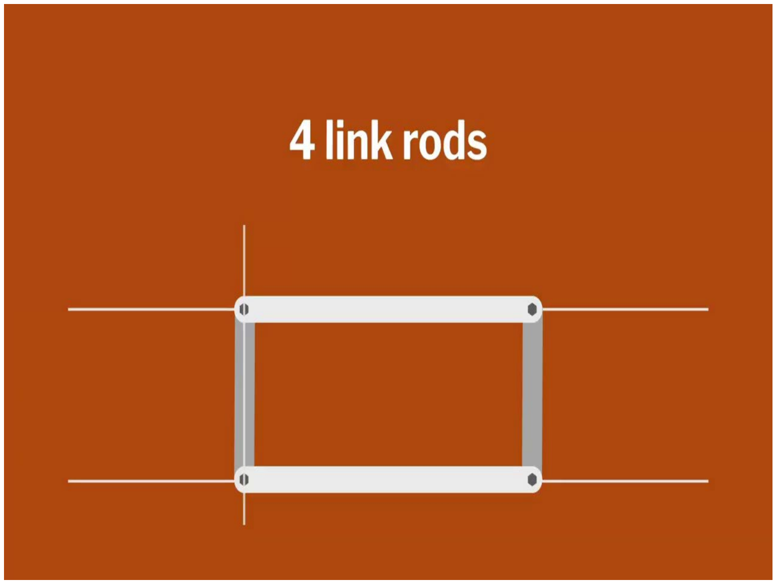

And then what did we come up with? We essentially came up with a 4 bar linkage. You know, when you have a 4 bar linkage, what happens is that the two bars remain parallel to each other. So, if I have a 4 bar linkage, imagine this is a 4 bar linkage, right? 1, 2, 3 and 4. If I take this line and if I rotate this line, these two bars still remain parallel to each other. So, I can use that principle in order to move something up and down while retaining the orientation. And that is the advantage of using 4 bar mechanics.

So, you can use multiple 4 bar mechanisms and so that you can give the degree of freedom here, I can use one 4 bar mechanism and connect another 4 bar mechanism with a rotational joint and then I can keep them in parallel to each other.

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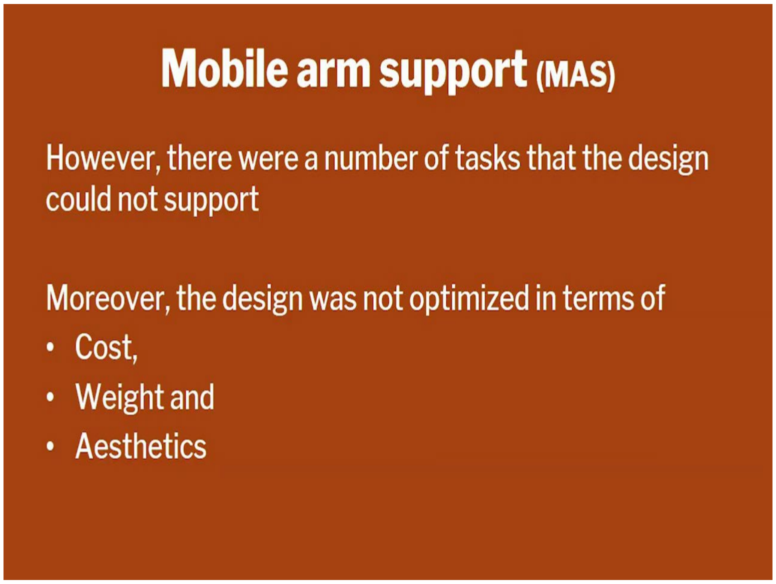

It is not optimized with respect to cost weight and aesthetic.

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Therefore we went from the pilot into a MAS II, a second prototype. Second design where improved functionality can cover larger areas and cost and weight are more optimized. So, this new design had a more sculptured surface, it had a polar coordinate oriented motion and it also had all kinds of other things, so that the arm is more comfortably possible to be used. I want to focus on only one part. Now that part is very interesting. When you go from pilot to production, what happens? Your volume (here, volume is referred to the number of products) increases, right? Now when you want to increase the volume, you have to have more of these mobile dystrophy sufferers to be brought into the realm of your product. Now the more the number of people, the more the number of wheelchairs. And therefore the more the variety of wheelchairs, right? All the designers have put all their creativity and created very different wheelchairs.

What is it that you do so that you become universally fitable? So therefore I am only focusing on that part. I am not talking about the Mobile Arm Support at all.

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Only how to connect that to different kinds of wheelchairs, right? So, you have the wheelchair, this is just one wheelchair and it happens to have a rod there at that certain angle. And I have to fix it to that rod, let's say. But my actuator must remain vertical because if it is at an angle it is not going to work properly, right? So, therefore it must be adjustable. And how do I do that? Another wheelchair may have the rod somewhere here, it may have a slightly different size. So, we have to deal with those, right? What they decided, the team decided is that we are going to have an intermediate bracket.

First time when we did the piloting we had a bunch of people who had the same wheelchair, so, therefore we created one design for everybody. Now we had to create a design, it may still be one design only, but it must now be applicable to multiple types of wheelchair. So, it has to connect to the wheelchair and to the actuator, right?

This is the actuator, the Arm Support and this is the wheelchair. So then we decided, the team decided we are going to have a bracket and then the actuator will connect to that bracket.

Wheelchair will connect to the bracket, the actuator will connect to the bracket. The bracket becomes like an intermediary element.

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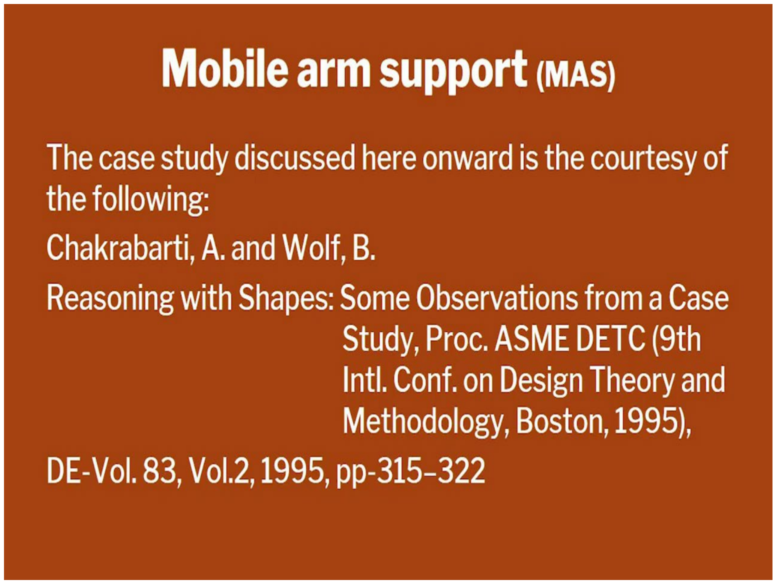

This study was published in one of the American Society of Mechanical Engineers Design Engineering Technical Conferences. A very good student of mine, Wholker who is from University of Darmstadt was the student who actually did the study. So, therefore I have a very detailed report of this and I thought this would be brilliant to share with you.

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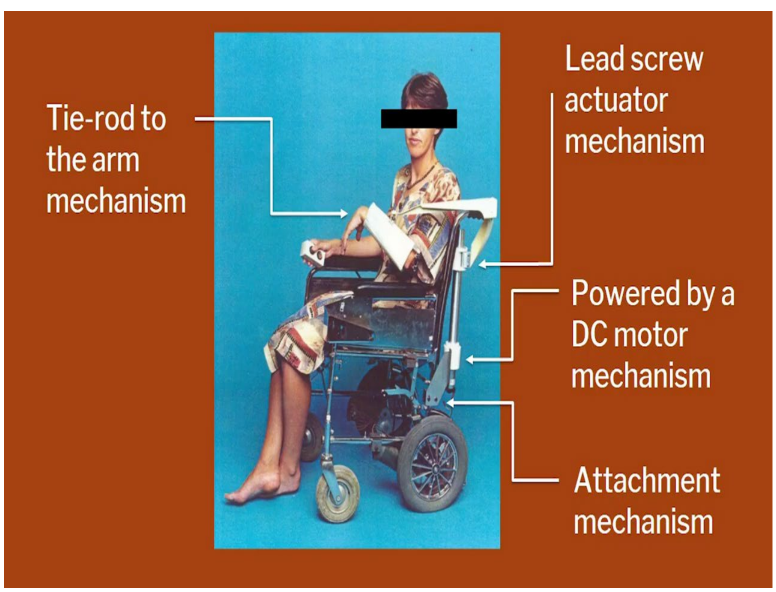

There is a leadscrew actuator, powered by a DC motor gearbox that connects and provides the power to the vertical motion. And then there is an attachment that attaches the actuator arm support assembly to the wheelchair.

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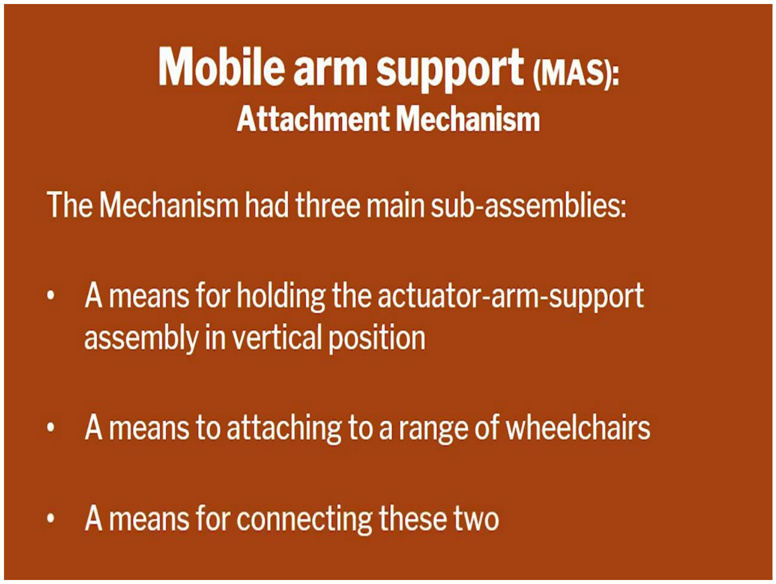

We need to have a way of holding the actuator arm support in a vertical position. It must remain vertical. Attachment to a range of wheelchairs which can have different, you know, orientation and so on and a means of connecting the two, right?

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So, we looked at a bunch of wheelchairs. What did we find? We found that there are no common attachment points. The only commonalities are that they are tubular frames. They are only common elements.

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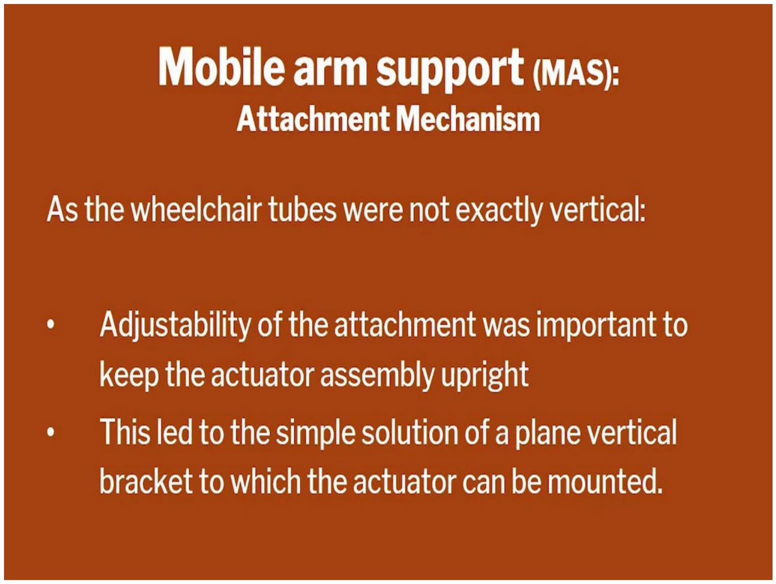

But these tubular frames have at least one vertical site that you can use. So, we decided on a vertical bracket. Therefore the problem became changed now of how to connect a vertical bracket to the actuator mechanism. Now with respect to that component we are now designing components, because we are in the detailed design stage.

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The component must cost low, it must be easy to dismantle without loss of adjustment and it's angle of actuator axis should be possible to adjust. The number of parts should be low. Why? Because it’s roughly proportional to the cost. Design should be discreet, it should merge into the rest of the design and it should be fitting to many wheelchairs.

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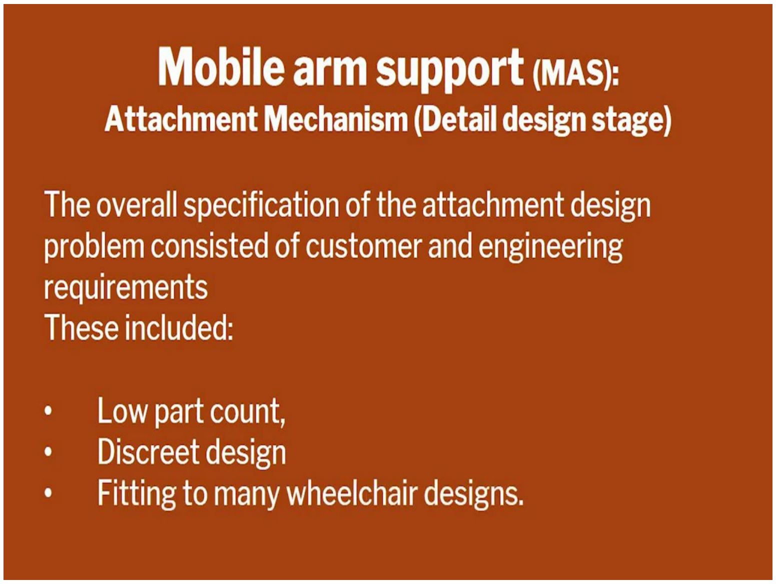

Easy to install, cheap, pleasing aesthetics and so on;

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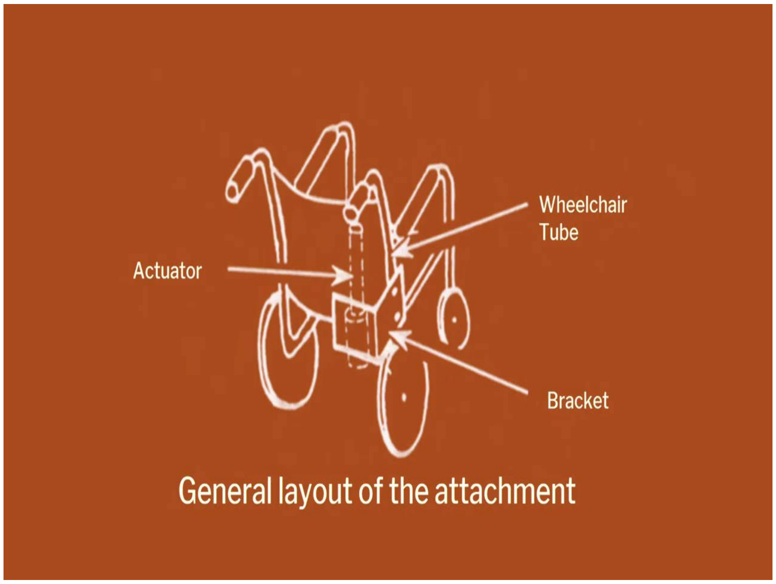

So, back to that diagram again, the bracket is already there. We are trying to connect these assemblies to that bracket.

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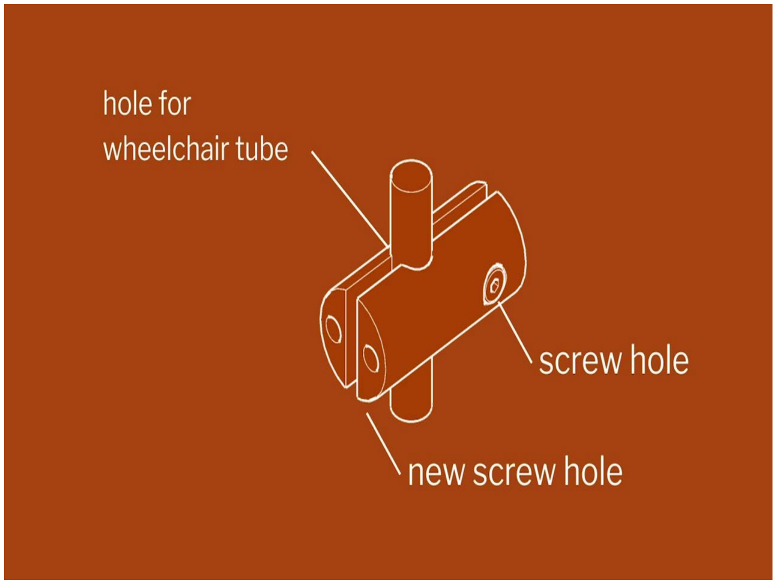

So, we are on the vertical plane and we are connecting the tube. So this is what comes from MAS 1. The hole for the wheelchair tube, where the wheelchair tube will be there, and the hole for the tube that holds the actuator assembly.

So, basically what you do is you, you open these two pieces, you get into the wheelchair tube, it wraps around that here, that's the wheelchair tube. Then you get the other mount support, hold it, somebody else takes the screw and puts it there and tightens it. That is it, done. But for a very specific support.

Now we are going to have to attach it to a plane, right? Which means we need to have screws on that plane so we can connect it to the bracket. You have two screw lines so you get the bracket, you put that there, you put those two screws there and it is attached to the bracket. Here is the Arm Support assembly and you put another screw and tighten it, and it is ready.

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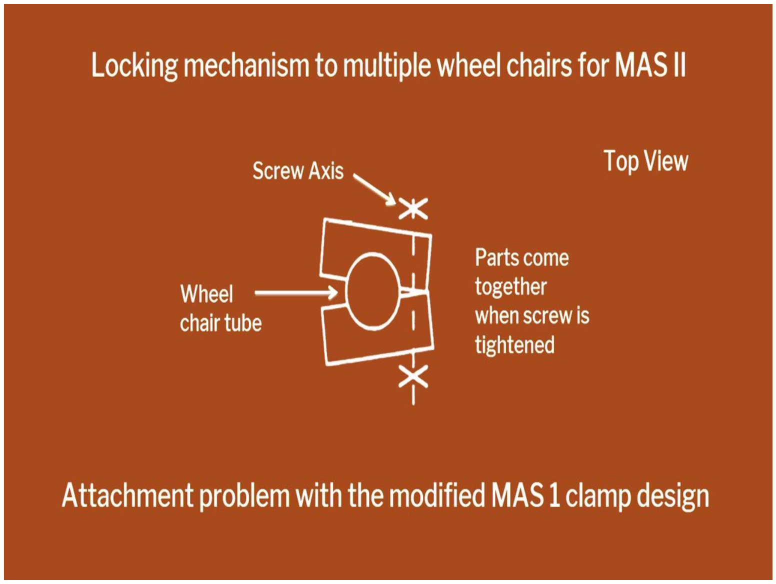

This is the top view of the Arm Support, right? This is where the bracket is. If I tighten here what happens? It forks. These two elements here, and here where there are two screws, they should form a plane. They are no longer a plane. So, it is not going to work over a period of time, the whole thing is going to collapse. So, then you can think of another solution instead of putting one screw to tighten it. You have two screws one on this side and one on that side and you adjust that such that these two planes remain on a single plane. Ok, that is going to be a nightmare for adjustment. But assuming that you are so good at adjusting that you can do it, the problem is that there are also other two screws coming from the side, that is holding it against the bracket. These two are going to interfere with each other or make the parts sufficiently weak that over a period of time your robustness and reliability is going to go out of the window.

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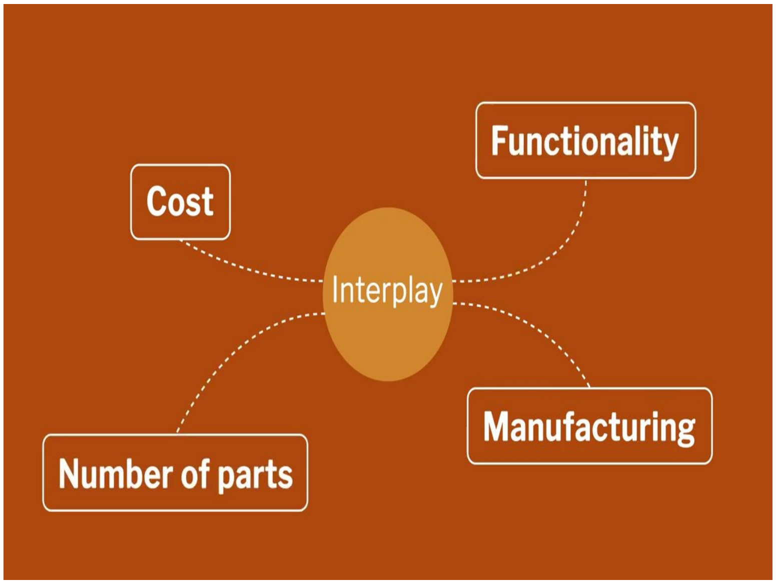

So, what I want you to appreciate is that the interplay between cost, manufacturing, number of parts, functionality. It is not one or the other. It is one and other. And that is an interesting challenge for you.

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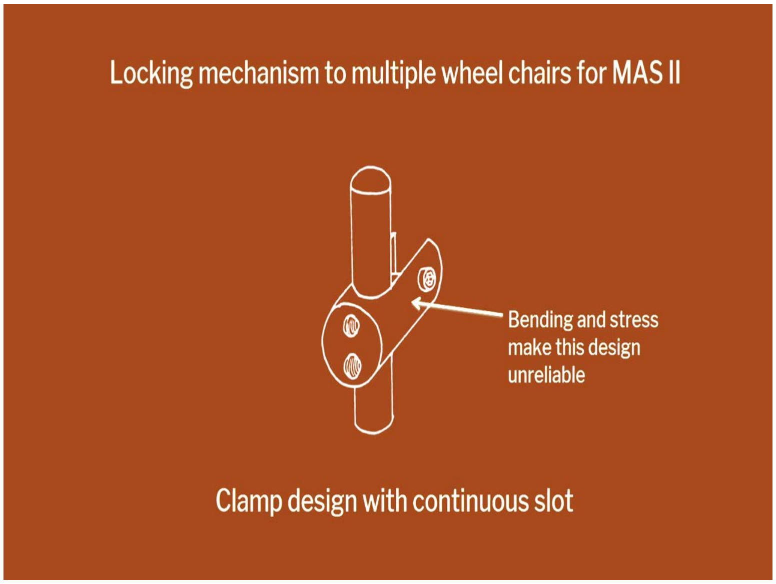

And one way to deal with this is that we are going to have this whole thing as a single part. The problem is happening because there are two parts and we have to keep these two planes on the same plane.

Can I make the whole thing a single plane? Because it is a single part, I can attach the actuator assembly to that and the plane and I can use, you know, the assembly can come from one side. It is a continuous slot, so you can push it in and it is slightly bigger in size.

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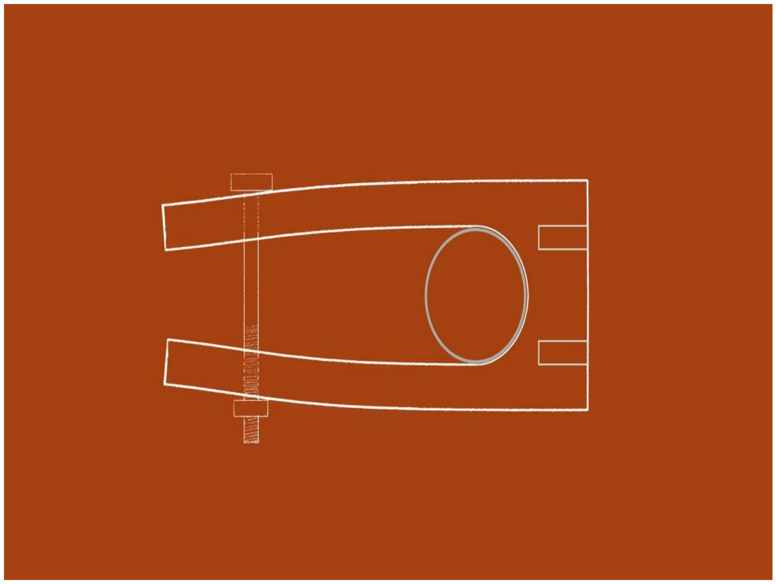

And then I can have the screw to tighten it. But the bad news here is that this part is going to have a lot of bending and that is not good.

First of all it is much harder for you to tighten it because you have to work hard on that bending and this screw has to go through a lot of stress and that is bad news. So over a period of time this is not going to remain a robust and reliable design.

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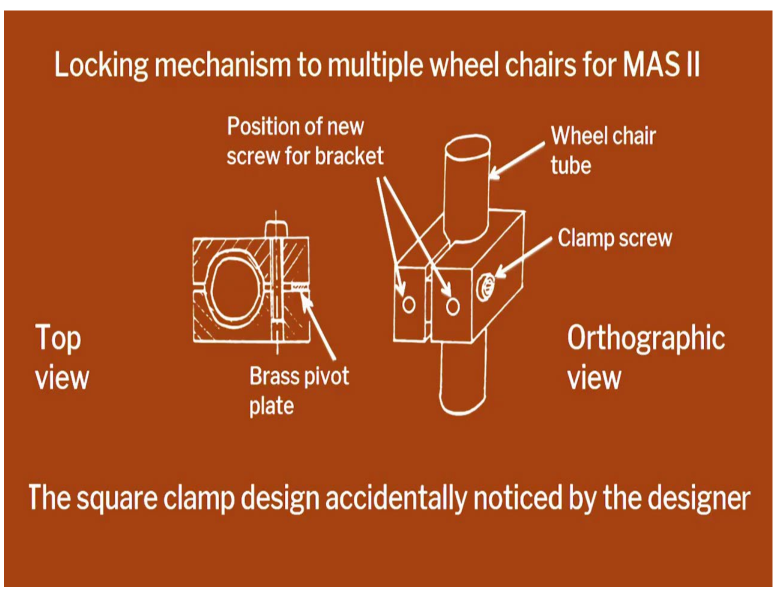

are going to attach, that is for the bracket. The difference between the earlier design and this is the following: that here your pivot is not a single point. Your pivot is a plane, so if your pivot is a plane and there is a brass pivot. So if I open it I see that there is a plane here. Then what I can do is I can put two screws here and I can attach that to the bracket. And I can use this screw to tighten it, the only thing that you have to ensure here is that this is not a full circle.

So, if I take a block, and make a through hole, and if I cut it into two, and if I put it together, then I am not going to clamp anything. It is going to support each other. So, therefore I have to take a thin portion out of it, so that it can do this. And then I can tighten, and it goes on and clamps the object.

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Now look at the manufacturing. How are you going to do that? Let's take a block and you cut a hole and you cut it into half. Let us say that you are using something like a CNC milling, right? So, how does CNC milling happen? Does anybody know?

So basically you have a cutter like that, right? A cylinder that goes round like that, it rotates like that, like that. So when it does that it takes the material out at the bottom.

So, I can take a portion of this and leave a little bit of this at the end. And then those two points can become your plane pivot. I can have two element pivots. One here and one here. It will still sit together and provide me with a nice stable plane on this side, right? And then you have a screw here and the screw here to hold it with the bracket. And here the attachment mechanism will come and using this screw I can tighten it.

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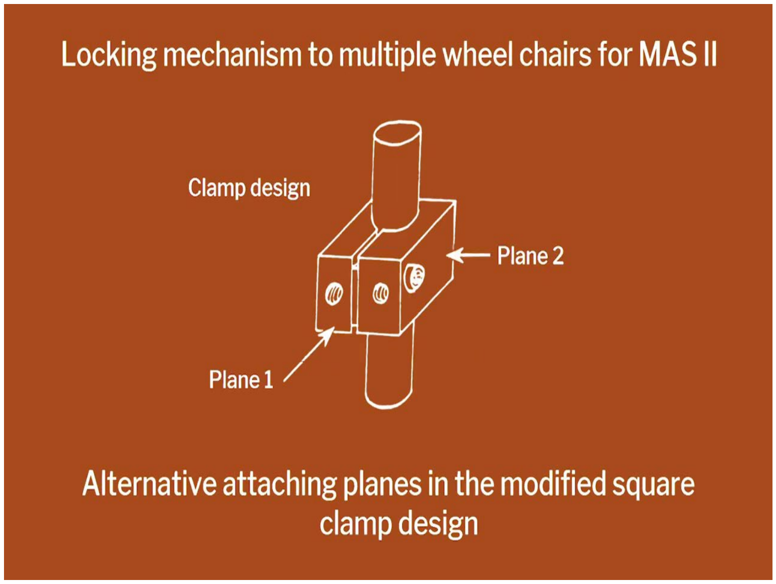

So, now I have these two attaching to this plane, attaching to the bracket, and this plane where I can put this screw and tighten it to clamp it. But then this is a rectangle. Originally, we put the two screws here because it was a circular object, and in that circular object that was the only plane available. The end of the cylinder was the only plane, but this is a rectangular object. I have more planes. I can put my bracket here. Therefore this whole struggle that we are going through of making sure that these two planes have to be on the same plane can now be dispelled with. If I do that I do not need these two screws.

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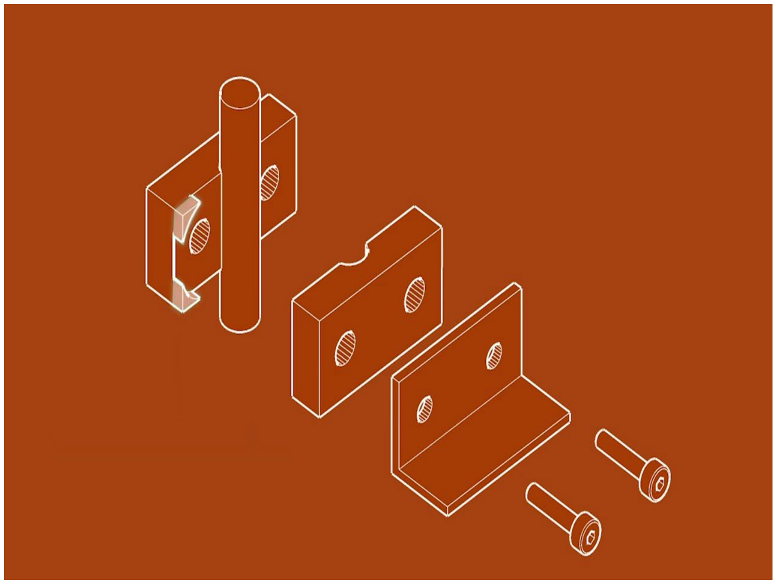

I can put the screws on this side and therefore those screws can do double function. One is they can attach to the bracket and two, they can clamp the mechanism. So in other words, my number of parts goes down. Good news. So, this becomes your design: So you have this plane where the bracket is fixed, these two screws with which we can tight. And both these screws are Allen screws, let us say, which means that this is a hexagonal head in the middle. So, I can then operate with a single tool which is good rather than multiple tools because then my cost of tooling is less, my cost of training somebody to use the tool is less.

One problem is that it is a big chunk of metal. Why should I waste so much material? Can I reduce the weight of this object? The team said, ‘Ok, what we can do now is that, can I potentially use a tube and then cut that tube into two, and of course cut a little bit more. Remember, you have to do this. But that is still a lot of cutting.

I have to take a whole tube, I have to put it in a jig, I have to make sure it is parallel and I have to cut it properly, right? Can I not use standard parts? So they said, ‘Yes we can. We have channel sections. We can buy sections that look like this.’ So, can I pick two of these and put them back-to-back, hold it properly, take a thin material out in the middle and then make the hole. And now it is ready for working, right? And now I have reduced the number of parts and also standardized.

The more you standardize the better because if I am producing that part in millions, my quality is going to be better than if you are making 3. So, therefore we should take advantage wherever possible.

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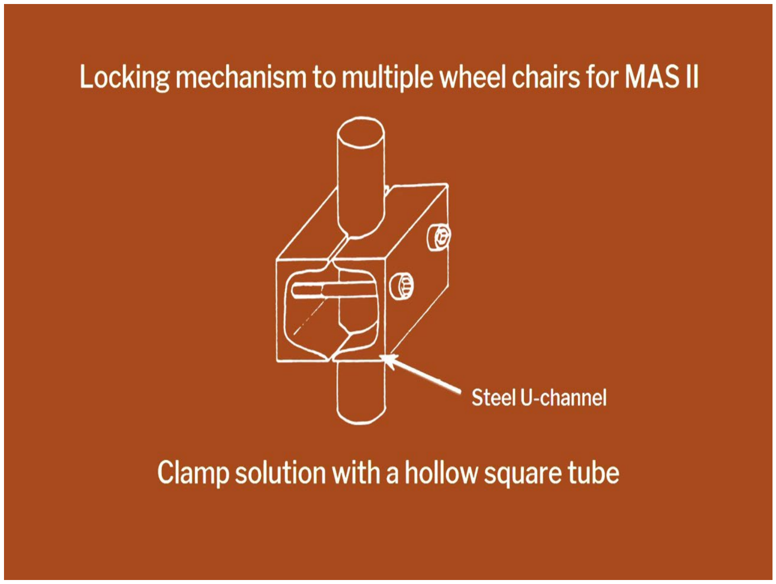
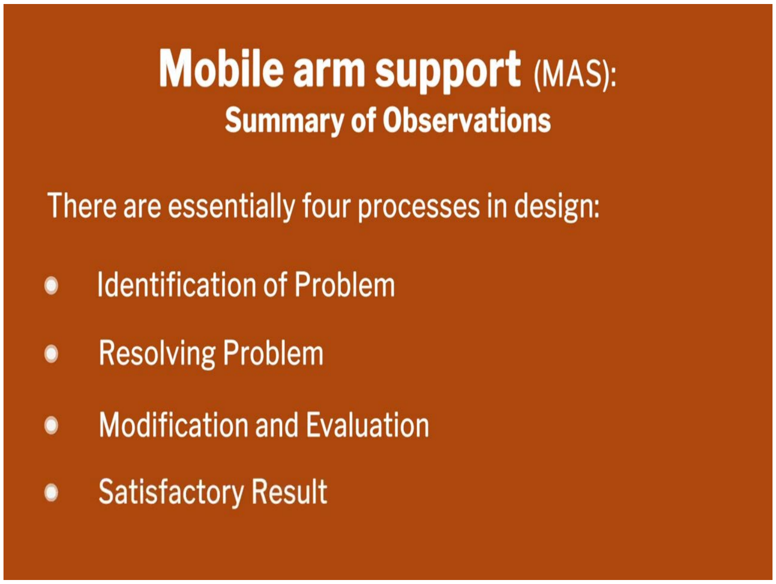


Finally that is the design. You have one channel section, one channel section. And that can come from the same material, right? So, I can take a single stock and keep cutting and then turn it around, make the cut and I am ready. And then you connect it with two screws so your number of parts has dramatically come down, your weight has come down, your reliability and robustness has gone up. And that is the final design.

What is it that you learned from this study of a single part? It is effectively just one very simple case study. One is that we actually apply, we look at the problem one at a time. We say, 'Ok, how do I reduce part? How do I reduce the weight? How do I make sure that it gets clamped?' And when you do that you create new problems. The process is very simple, it is actually identifying the problem and solving the problem.



And to do that you have to go through these 4 stages. You do that almost unconsciously but I want to make it explicit. You identify problems, you come up with ways to resolve the problem, you model and evaluate the problem and this process goes on until you are satisfied or you are completely dissatisfied, that you give up.

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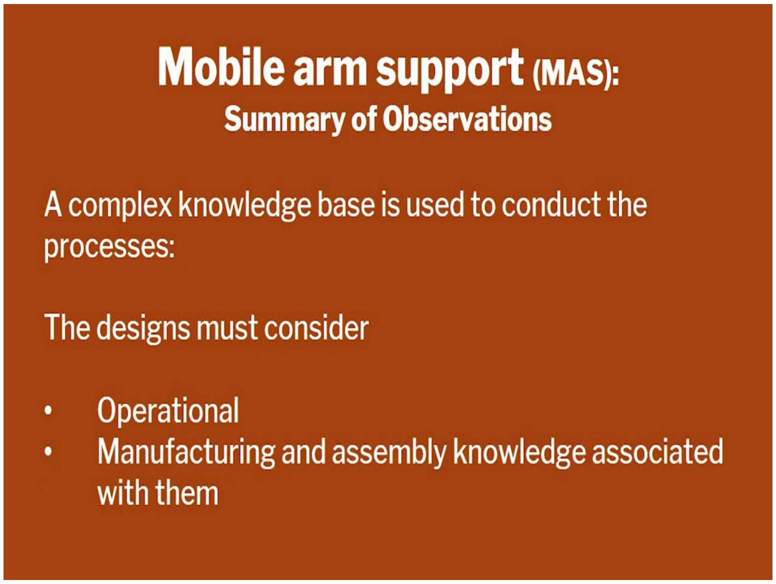

And this requires knowledge from Functional, Behavioral, Structural, Operational, Manufacturing, Assembly. It's kind of a complete package. So, I want you to therefore learn all of them in an integrated manner, that is important.

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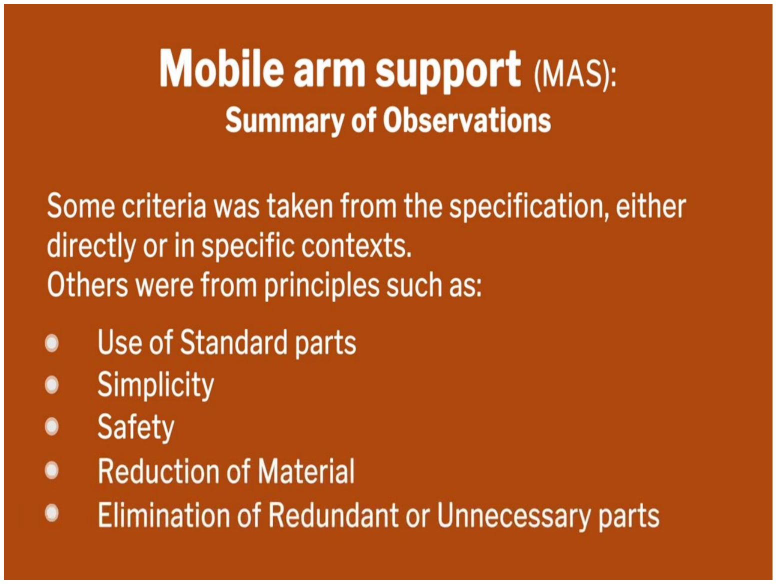

And remember the importance of standard parts, remember that there are certain things that are considered 'Common Sense'. Common sense is the most uncommon sense actually. And therefore you should look at those principles and guidelines of embodiment, ok? Simplicity, safety, reduction of material, elimination of redundant or unnecessary parts. Individually it is very easy to say this, 'Yeah everybody understands'. But collectively you need to ensure that you apply them.

When you are evaluating you do not evaluate with respect to one criterion and another alternative with respect to another criterion and say, 'Therefore this one is better'. You have not used the same standard for both, right? You think, 'This looks better and that functions better, therefore I am going to choose this one because it looks better'. Make sure that you use the same set of criteria for evaluating, ok?

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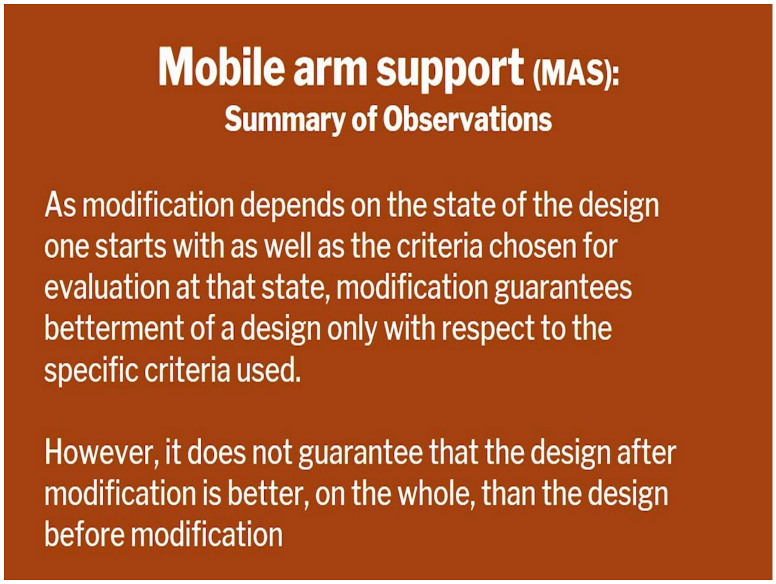

Selection, interestingly enough, when you're operating at that microscopic level, is very much dependent on your level of satisfaction. And if your level of satisfaction is low, you are going to come up with a low quality product. But it is also dependent on your knowledge and your deadlines, ok? Given a lot of time you can do better, but there is always deadline. So you have to ensure that your satisfaction level is high enough and still commensurate with the amount of time that is available.

Remember, that every time you make modifications, only that particular problem's solution is becoming better, not necessarily other ones. You have probably already designed well, now you modified it for some other purpose, the earlier design became worse. So, keep an eye on whether your earlier modifications are getting affected. Finally I want to again emphasize the importance of the business angle, ok? Ultimately you want it to go out to the society.

It is not just an exercise in intellectual adventure. As I said, only this became possible when somebody was ready to pay for it.

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So, make sure that you bring it right up front of the design process. And the time of task clarification itself, you talk, you discuss, you think about business. And then at the end you validate. In the beginning you make sure you take into account, at the end you validate that. Our vision is to, of course excel in design and manufacturing. Why? Because you want to have people who can go out and develop Systemically Complex, Technological Intensive, Socially Impactful solutions that are Functional, Aesthetic, Usable and Sustainable.

Now I deliberately used the word systemic complex. Now when you are thinking about a problem you normally are focused on that point, right? Here is something that I want to reduce the weight. You should not create a new problem, overall your number of problems should go down, or the overall intensity of problems should go down. And that is what is called a Systemic Complex. For example, I can make a car very cheap at the time of buying at the cost of making it very expensive for the rest of its life. That is 'Shifting Cost', it is not really 'Reducing Cost'.

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We have two programs. One is a master's in design program. About 25 students per year, two years, engineers and architects and of course B.Des. And then we train them in technical, aesthetic, ergonomics, and so on, aspects where we expect that in their final year project, they are able to create working prototypes with visual aesthetic appeal, and about 30 to 50% of them get patents. The other part is of course the PhD and M.Sc program in Design and Manufacturing research. We have labs like, labs on creativity, sustainability and so on.

We have of course, we have pioneered a formal Ph.D program in the country, but also we have started M.Tech in Smart Manufacturing from this year. Professor Chakravarty and we are very strongly connected. It's that both of us have one of the first Design Innovation Centers, DIC's ok? That is funded by the MHRD, Government of India. Also the NDIN the (National Design Innovation Network) which we lead, like the open design school is led by IDC we are again very strongly connected.

And there is this INDO-US Center of Excellence Sustainable Manufacturing, Berkeley and so on. This is by the way one of my labs. It is called Ideas labs. So it is the first design observatory in India, where we basically have cameras and other devices with which you actually see people how they design and we try to learn the way they design whether that is good or bad, or where we can improve, where we can learn from them because they do it well. Where you can maybe teach them later on and develop tools and methods with which to improve their performance. And that is it. Thank you.

You have tremendous power to change people's lives. Use it, that is my most important message, yeah? Forget everything I have said, but change people's lives, all right.