Design, Technology and Innovation
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Lecture-21
Research to Innovation Part 2

So here are some examples, ok? I am going to take various details of 3 examples. First example is that company (which) created that cotton-picking, cotton productivity enhancement tool. The idea is that people will go to a piece, a pod of cotton, lint I think it is called and then they will get this device and the devices suck the cotton into it, and there is a conduit through which the cotton will directly go to a pack at the bottom. And eventually, you know, one once this person has finished the work, there is already a bag full of good quality cotton sitting there. All you need to do is wrap it and send it across right.

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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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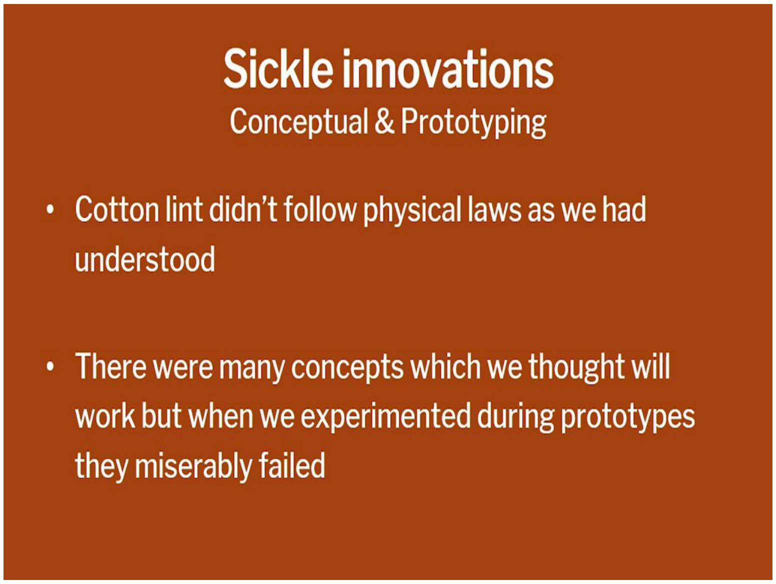

So, lints did not follow physical laws as it was understood, so they tried many things and it worked reasonably well but many times during when they prototyped, it failed miserably. As I said, you know, you have to come up with multiple ideas and fix them as you go along.

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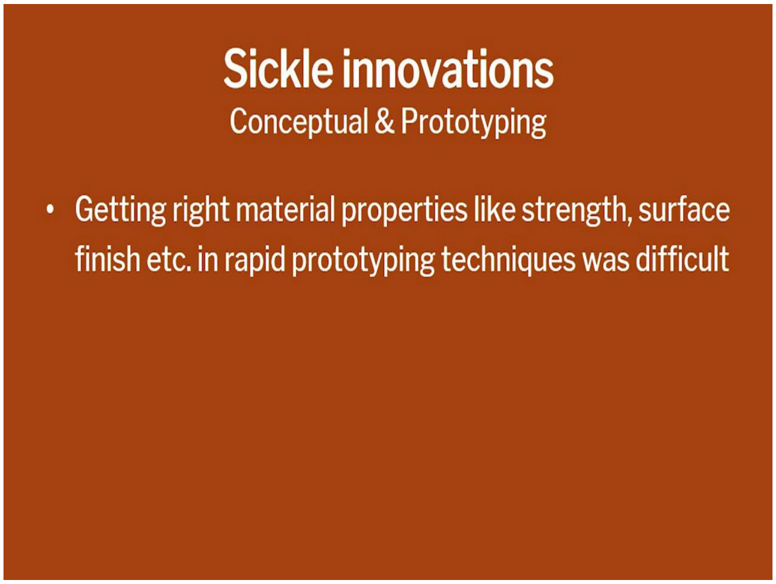

So, getting right material properties like strength, surface finish, and so on was a major challenge. They were using rapid prototyping because they wanted to do it quickly.

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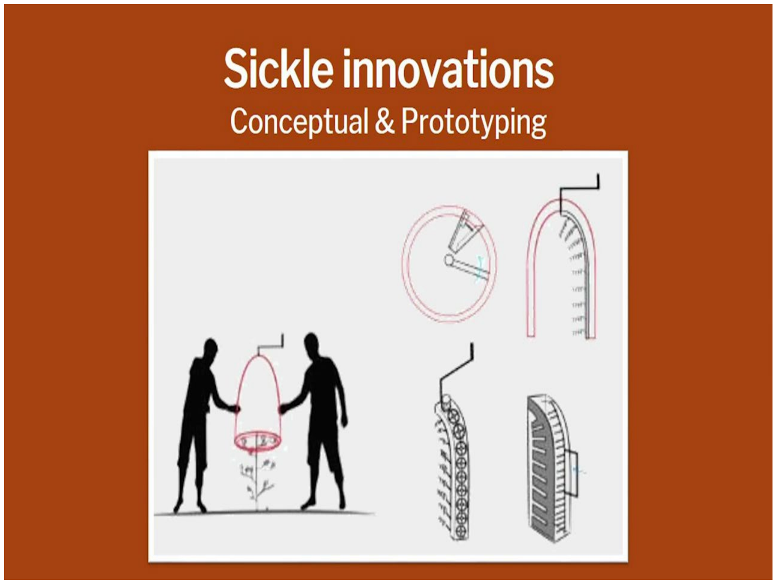

So, they went through the cotton pod, they tried the idea and then they worked through that.

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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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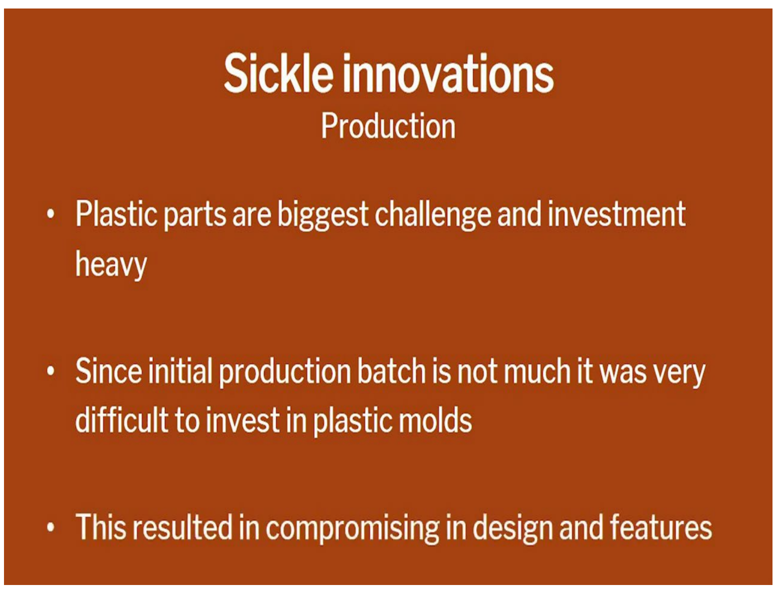

And of course it was investment heavy. Why? Because if you use injection molding, which is a manufacturing process, you have to have molds. Molds are expensive. If you have to change your design every once in a while, you have to have, every once in a while, a different mold and that makes it very investment 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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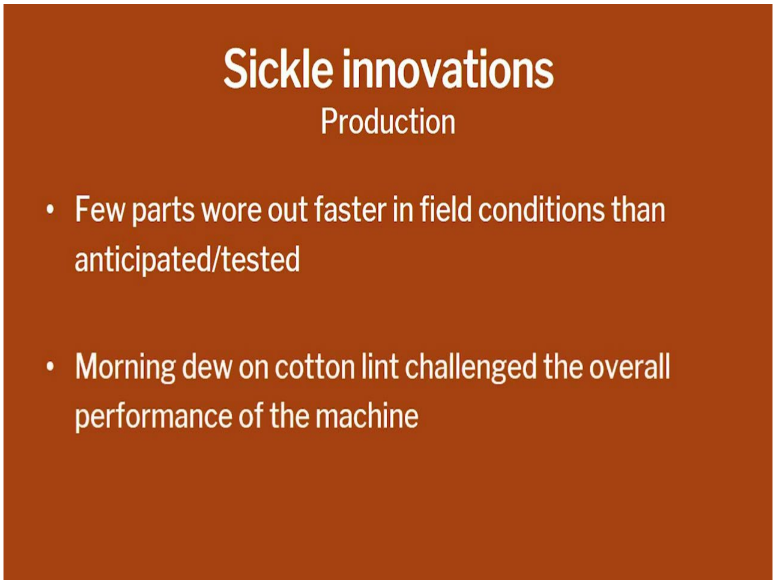

And then there are parts that wore faster than those that were anticipated or during testing in real field conditions. And I said, the dew was there, that would change the overall performance. So, there are many challenges that will come from the field. So the earlier you are in the field. Do not wait 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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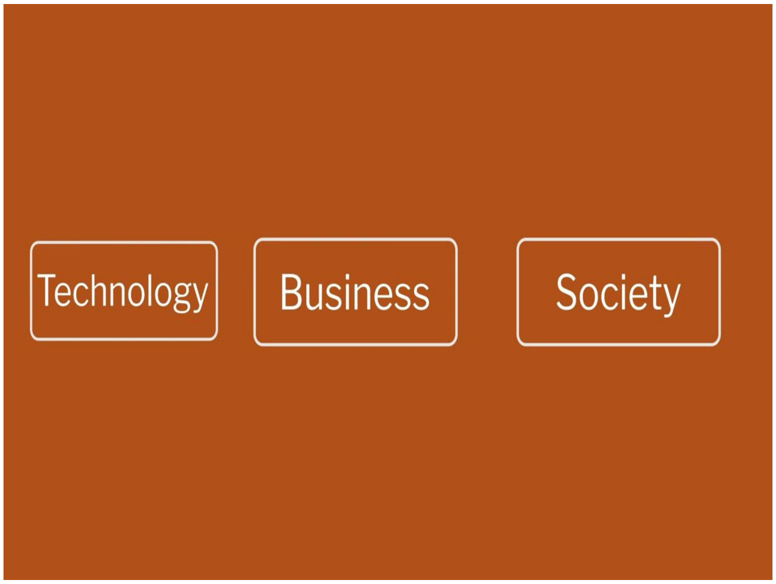

Please remember this is one of those 3 pillars: Society, Technology and Business.

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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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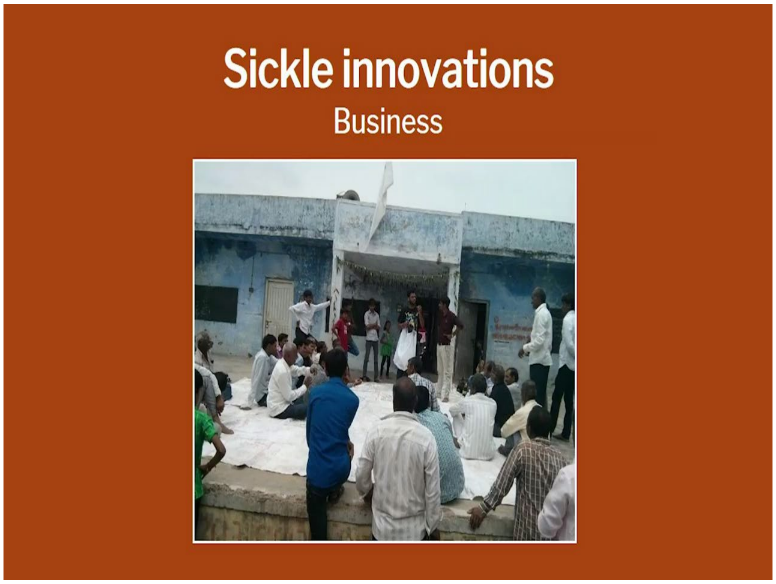

So, this is their business part, you know, they actually tried it. These bags are from the fields and this is the team.

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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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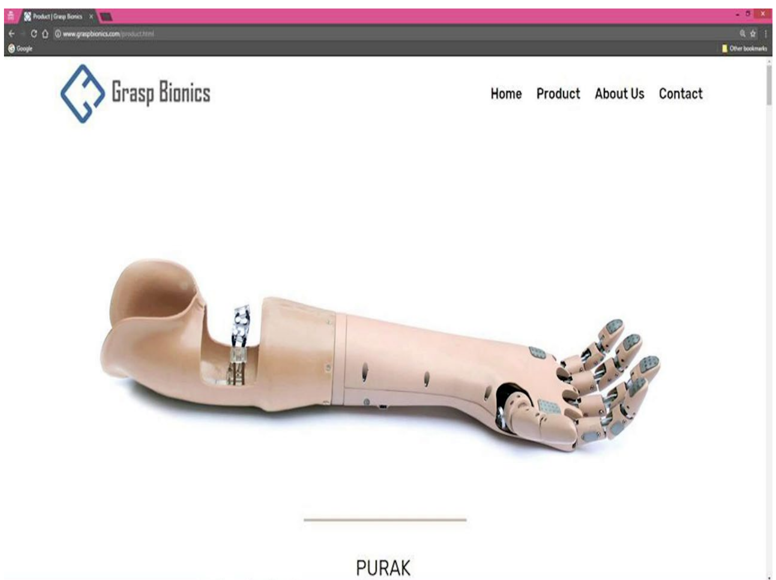

Second example is that of Purak, that prosthetic arm that I talked about. In design their challenge was this high-end function with an affordable solution. And as I shared with you, you know, the challenge was, 'Can I minimize the number of actuators?' Because if I can minimize the number of actuators,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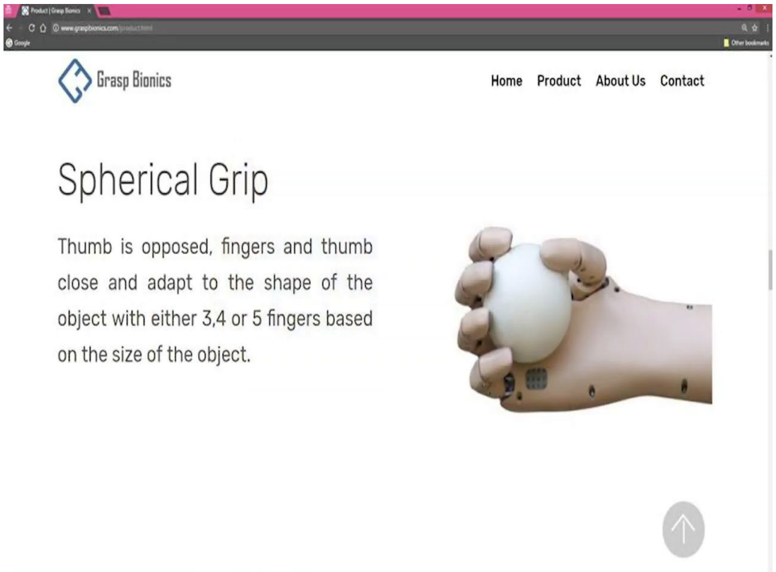

The third one is in the production. How can we create a low volume, low cost production process? See the problem is, not everything is like a PCB or a computer chip and so on, which is coming out in millions. Your market is small in size. You will sell probably 20 in one month if you are doing well. 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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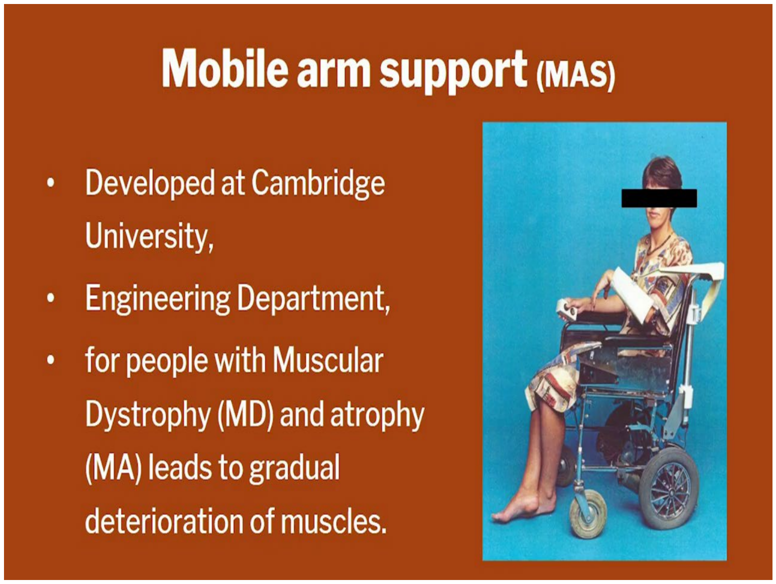

Third example is going back to that Mobile Arm Support project where I want to spend a particular amount of time on only one part of the production level, so the detail design. I want to show how complex it is and therefore how important it is to pay attention to detail.

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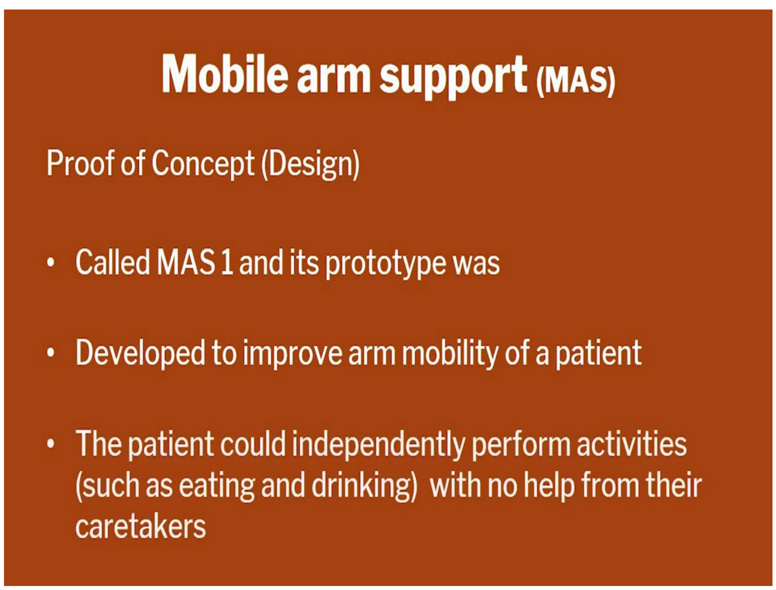

What did we do? We went through two different cycles. First we created a proof-of-concept or design or prototype. We call it MAS 1 that was focused on only a certain group of people that would be fine, who would be agreeable, to testing the device. So that they could perform activities, such as eating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

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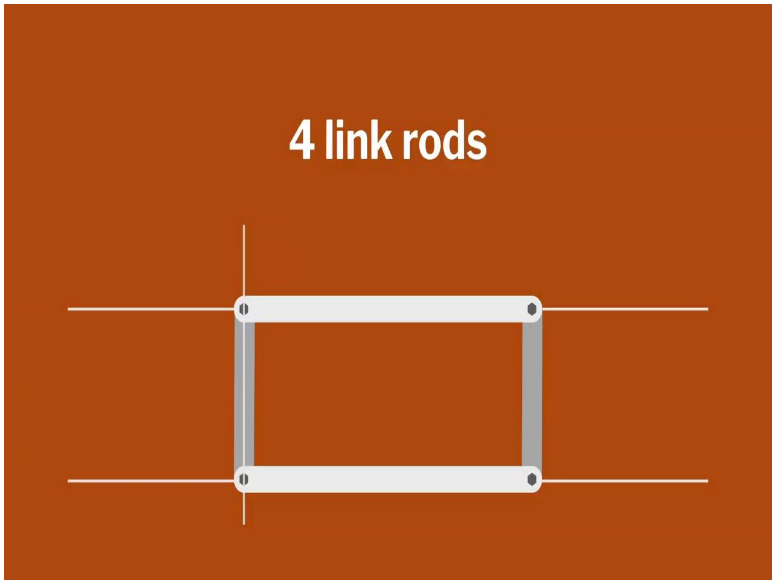

And then what did we come up with? We essentially came up with a 4 bar linkage. You know, when you have a 4 bar linkage, what happens is that the two bars remain parallel to each other. So, if I have a 4 bar linkage, imagine this is a 4 bar linkage, right? 1, 2, 3 and 4. If I take this line and if I 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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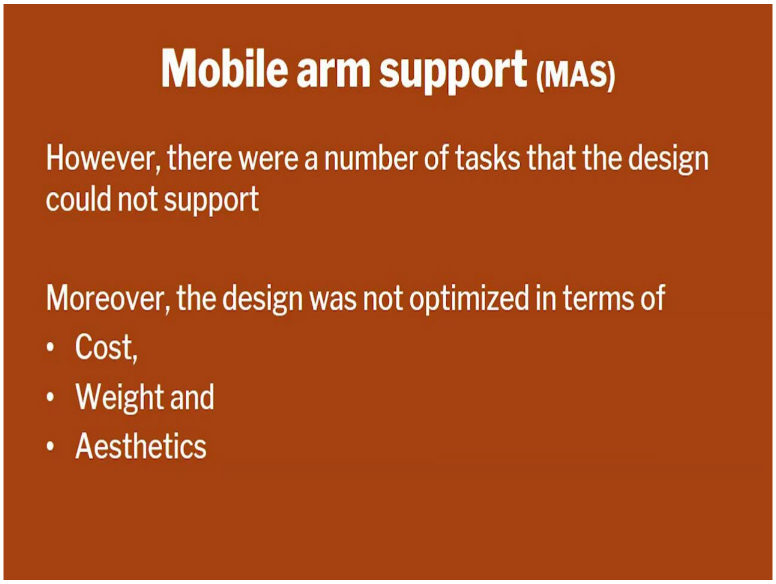

It is not optimized with respect to cost weight and aesthetic.

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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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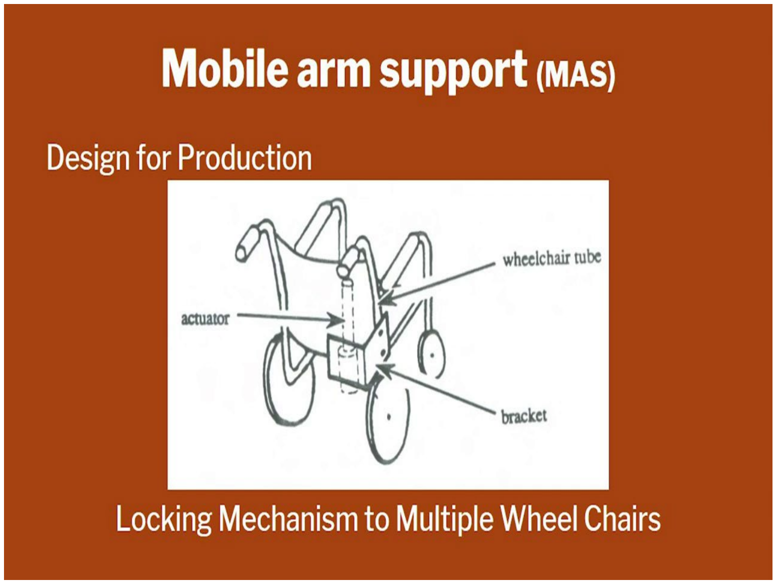

Only how to connect that to different kinds of wheelchairs, right? So, you have the wheelchair, this is just one wheelchair and it happens to have a rod there at that certain angle. And I have to fix it to that rod, let's say. But my actuator must remain vertical because if it is at an angle it is not 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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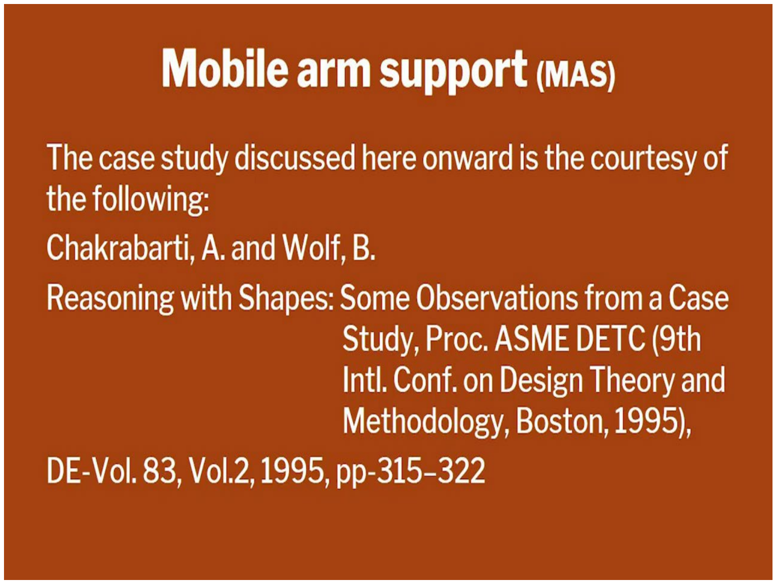

This study was published in one of the American Society of Mechanical Engineers Design Engineering Technical Conferences. A very good student of mine, Wholker who is from University of Darmstadt was the student who actually did the study. So, therefore I have a very detailed report of this and I thought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

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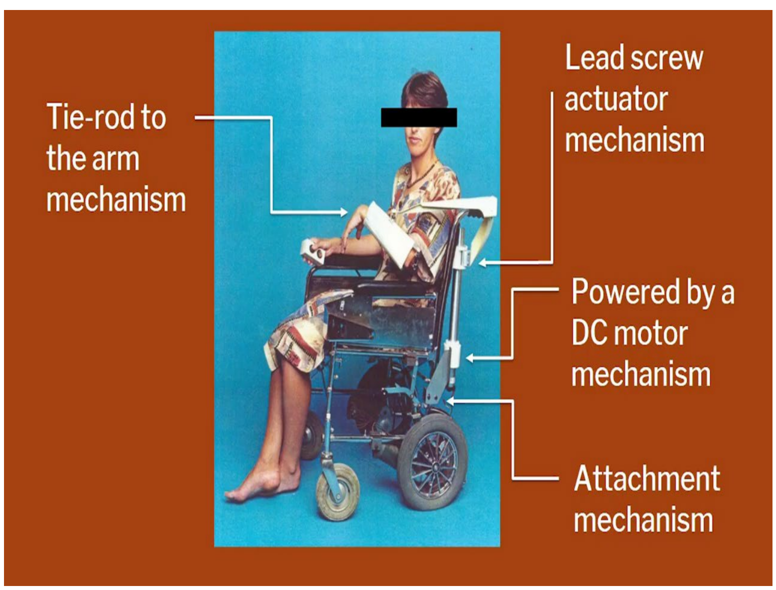

There is a leadscrew actuator, powered by a DC motor gearbox that connects and provides the power to the vertical motion. And then there is an attachment that attaches the actuator arm support assembly to the wheelchair.

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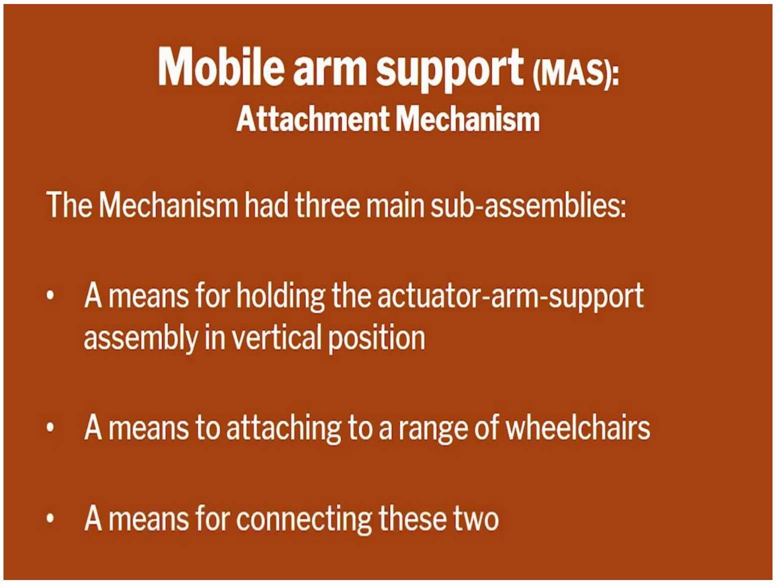

We need to have a way of holding the actuator arm support in a vertical position. It must remain vertical. Attachment to a range of wheelchairs which can have different, you know, orientation and so on and a means of connecting the two, right?

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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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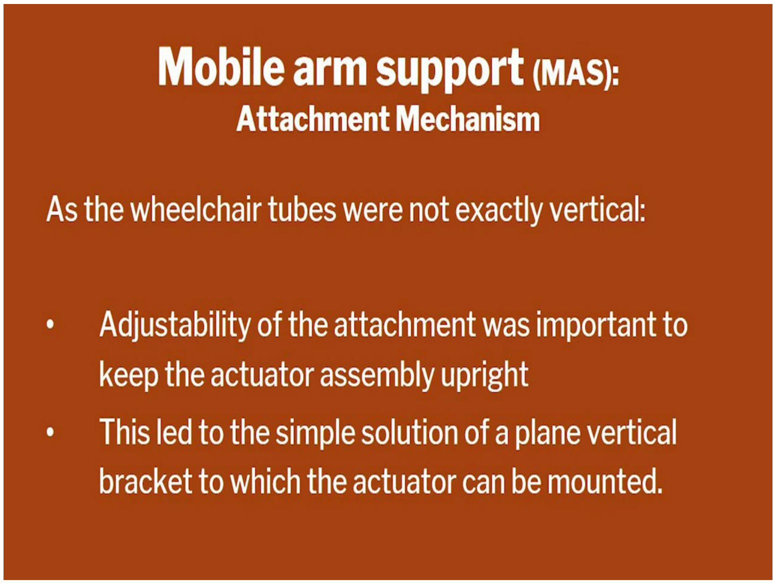

But these tubular frames have at least one vertical site that you can use. So, we decided on a vertical bracket. Therefore the problem became changed now of how to connect a vertical bracket to the actuator mechanism. Now with respect to that component we are now designing components, because we are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

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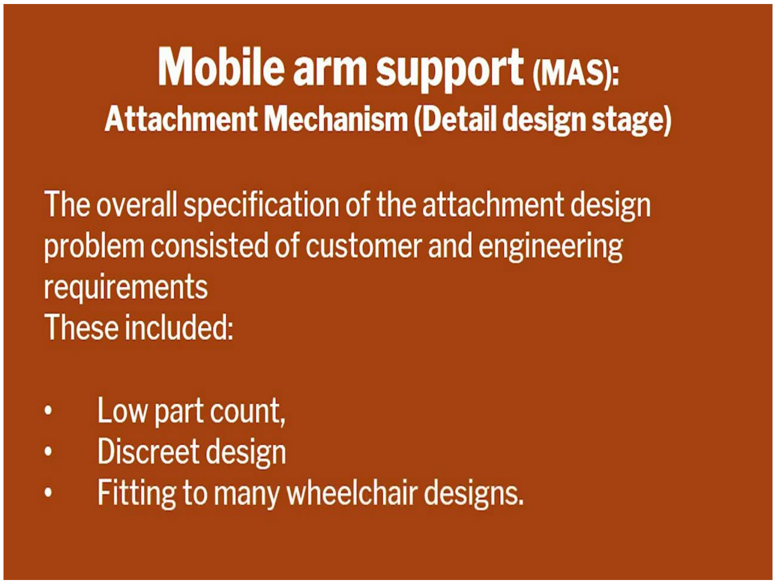

The component must cost low, it must be easy to dismantle without loss of adjustment and it's angle of actuator axis should be possible to adjust. The number of parts should be low. Why? Because it’s roughly proportional to the cost. Design should be discreet, it should merge into the rest of the design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

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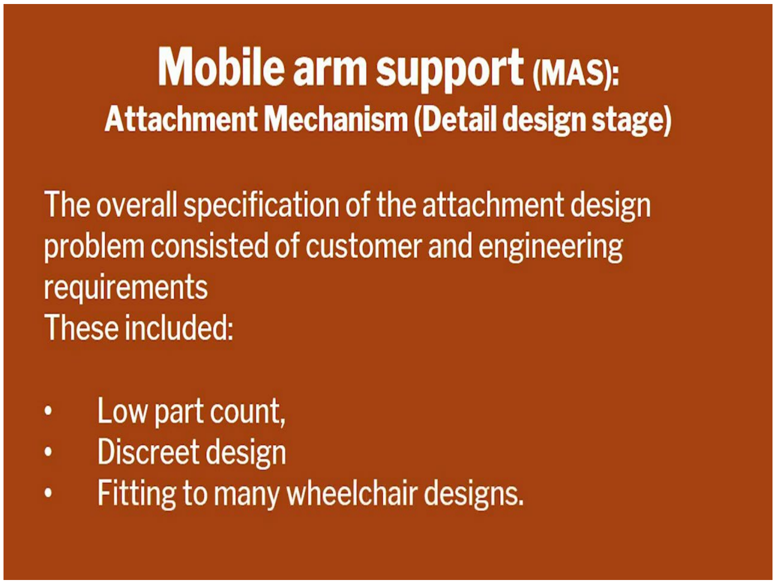

Easy to install, cheap, pleasing aesthetics and so on;

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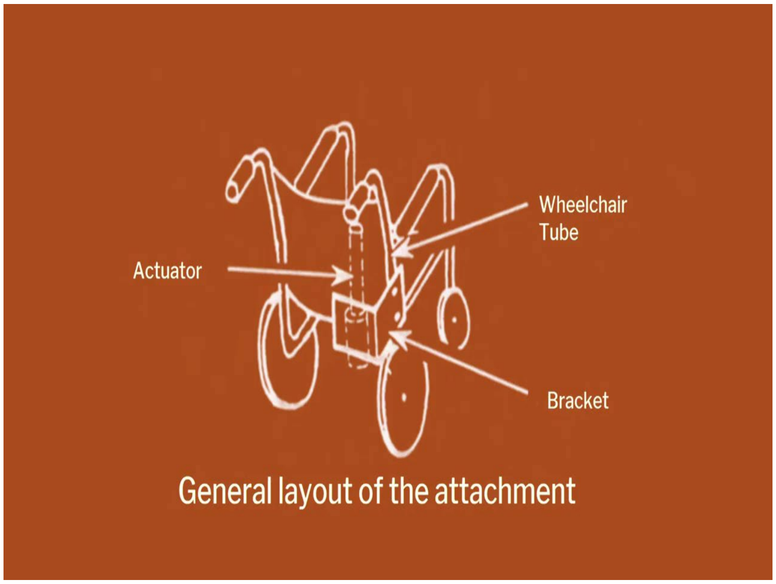

So, back to that diagram again, the bracket is already there. We are trying to connect these assemblies to that bracket.

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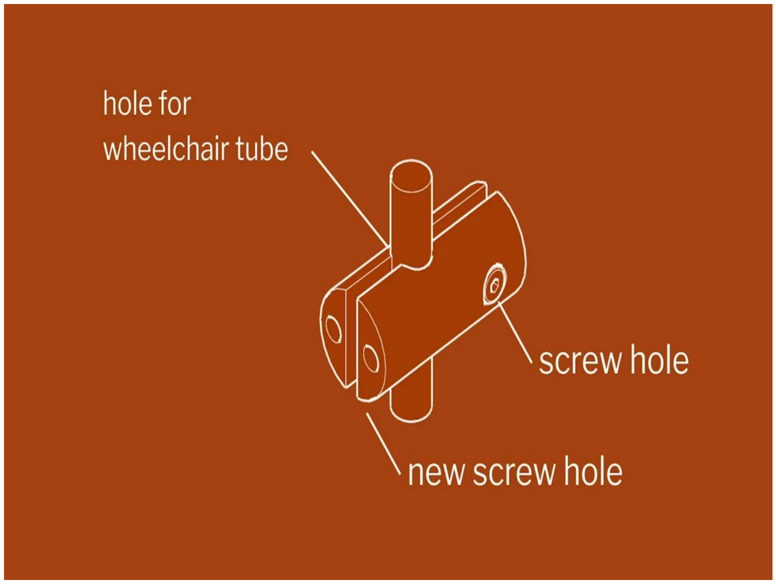

So, we are on the vertical plane and we are connecting the tube. So this is what comes from MAS 1. The hole for the wheelchair tube, where the wheelchair tube will be there, and the hole for the tube that holds the actuator assembly.

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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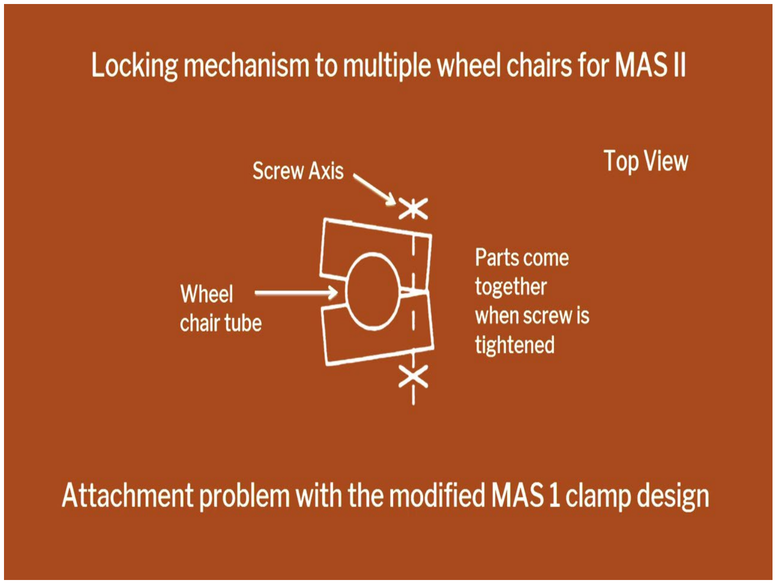

This is the top view of the Arm Support, right? This is where the bracket is. If I tighten here what happens? It forks. These two elements here, and here where there are two screws, they should form a plane. They are no longer a plane. So, it is not going to work over a period of time, the whole thing 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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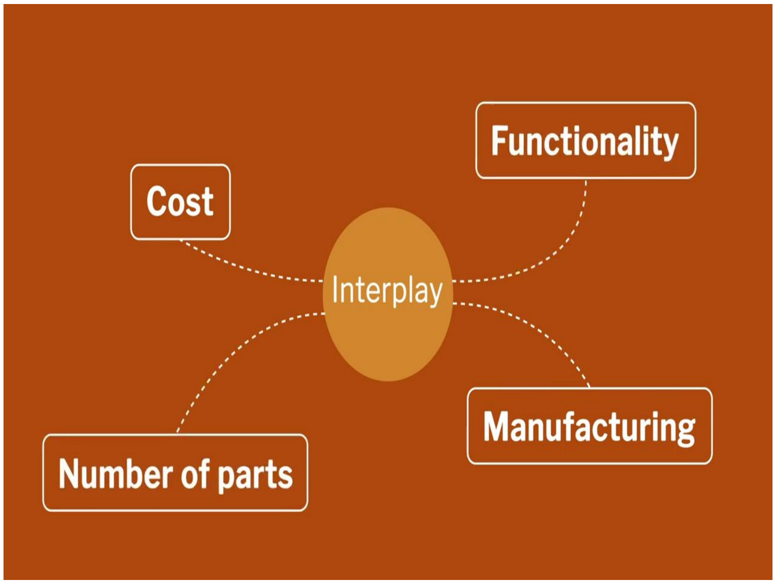

So, what I want you to appreciate is that the interplay between cost, manufacturing, number of parts, functionality. It is not one or the other. It is one and other. And that is an interesting challenge for you.

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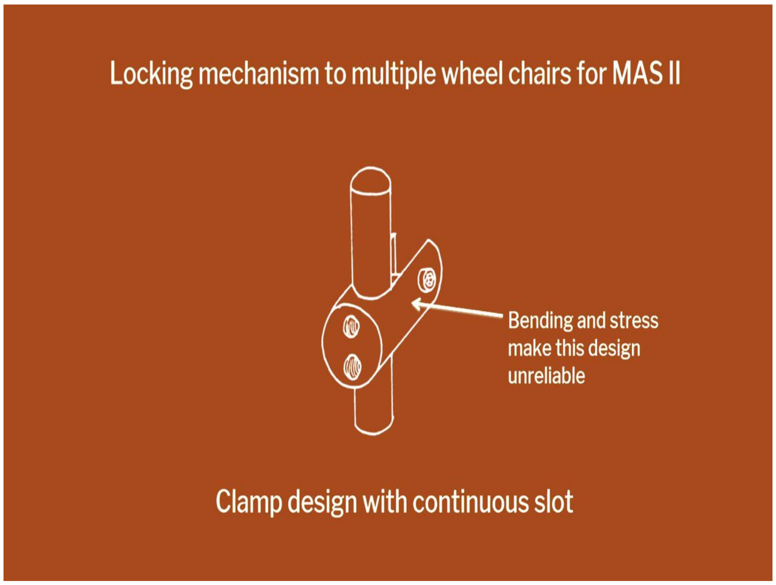

And one way to deal with this is that we are going to have this whole thing as a single part. The problem is happening because there are two parts and we have to keep these two planes on the same plane.

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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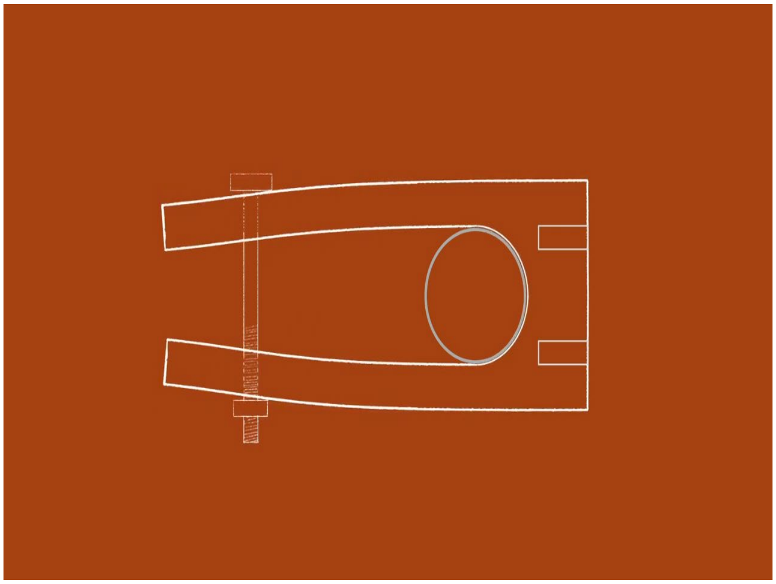

And then I can have the screw to tighten it. But the bad news here is that this part is going to have a lot of bending and that is not good.

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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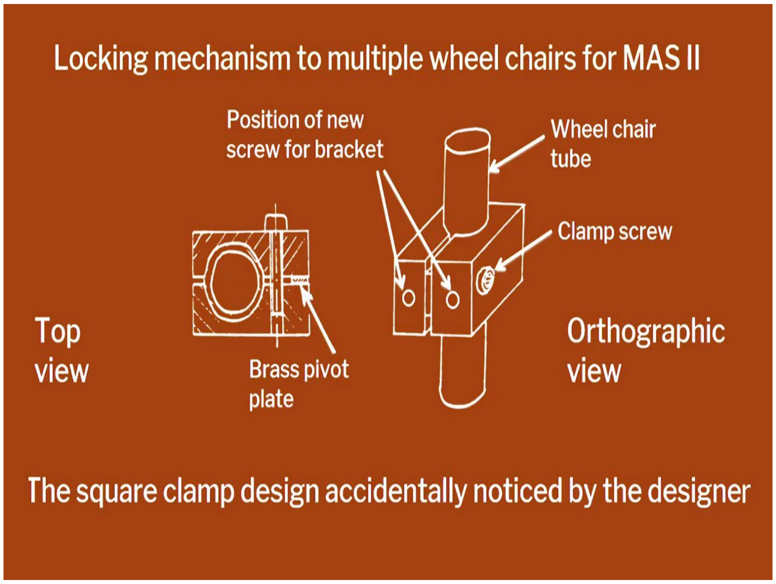

Then the team actually looked at, got inspired by another design that was a dental attachment. The dental attachment seems close enough that we could use it, so we started looking at it. Imagine this is your arm support, right? You are looking at the top view again. This is the plane on which you are 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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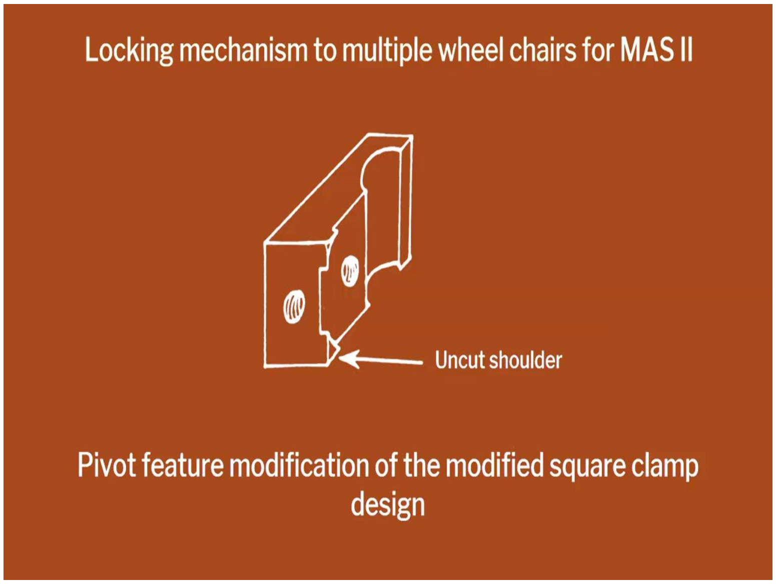

Now look at the manufacturing. How are you going to do that? Let's take a block and you cut a hole and you cut it into half. Let us say that you are using something like a CNC milling, right? So, how does CNC milling happen? Does anybody know?

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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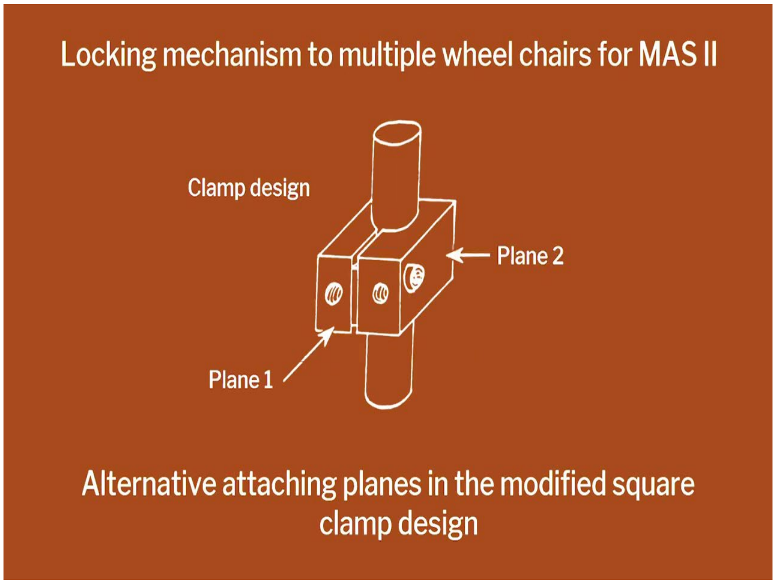

So, now I have these two attaching to this plane, attaching to the bracket, and this plane where I can put this screw and tighten it to clamp it. But then this is a rectangle. Originally, we put the two screws here because it was a circular object, and in that circular object that was the only plane 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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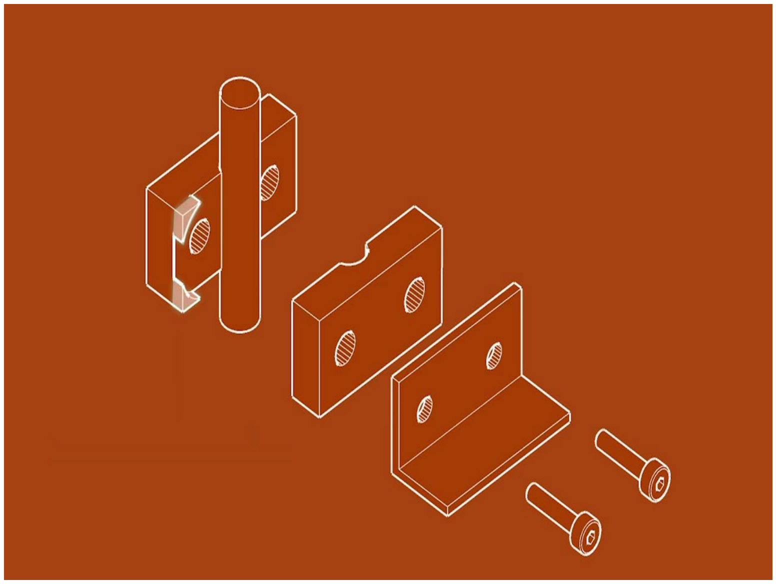

I can put the screws on this side and therefore those screws can do double function. One is they can attach to the bracket and two, they can clamp the mechanism. So in other words, my number of parts goes down. Good news. So, this becomes your design: So you have this plane where the bracket is fixed, 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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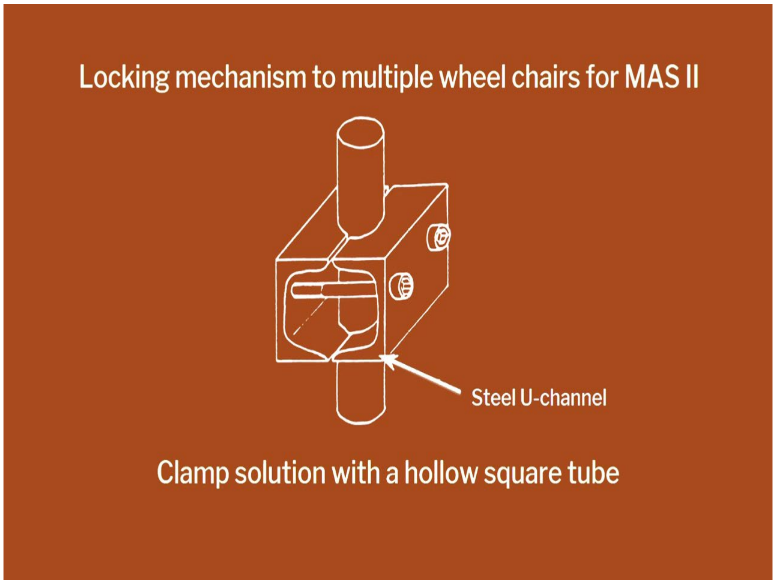

Finally that is the design. You have one channel section, one channel section. And that can come from the same material, right? So, I can take a single stock and keep cutting and then turn it around, make the cut and I am ready. And then you connect it with two screws so your number of parts has dramatically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

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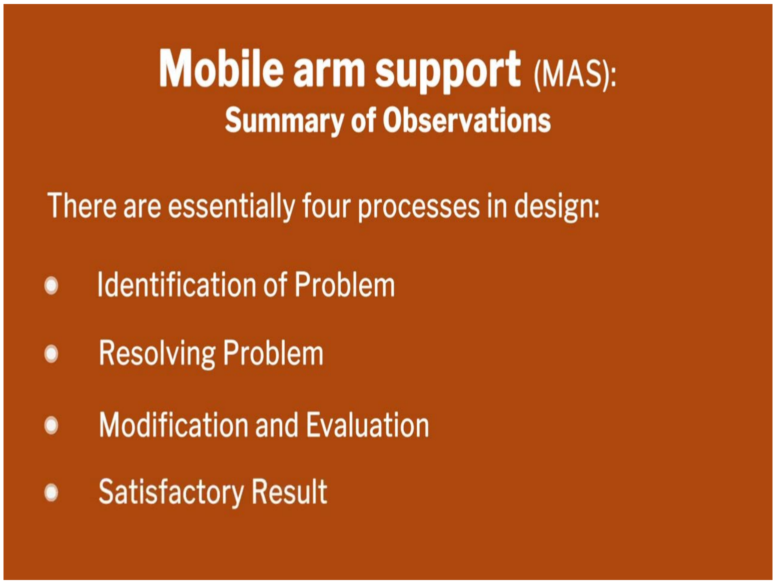

And to do that you have to go through these 4 stages. You do that almost unconsciously but I want to make it explicit. You identify problems, you come up with ways to resolve the problem, you model and evaluate the problem and this process goes on until you are satisfied or you are completely dissatisfied,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

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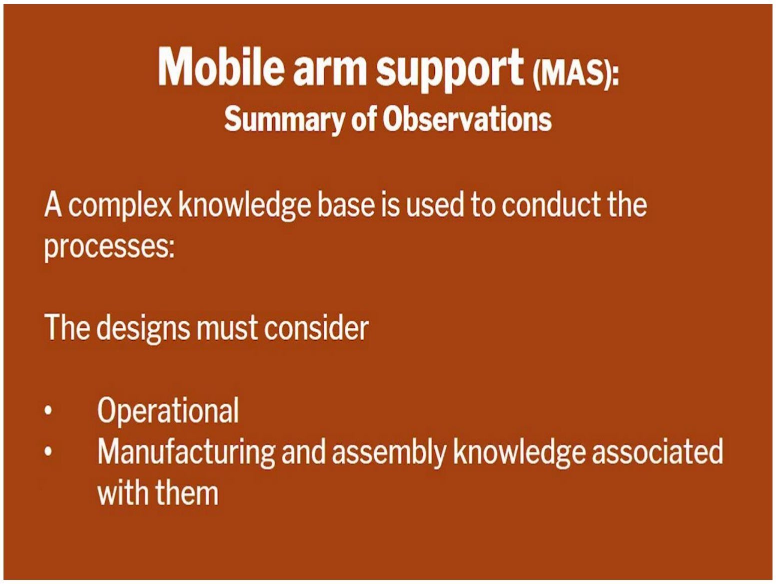

And this requires knowledge from Functional, Behavioral, Structural, Operational, Manufacturing, Assembly. It's kind of a complete package. So, I want you to therefore learn all of them in an integrated manner, that is important.

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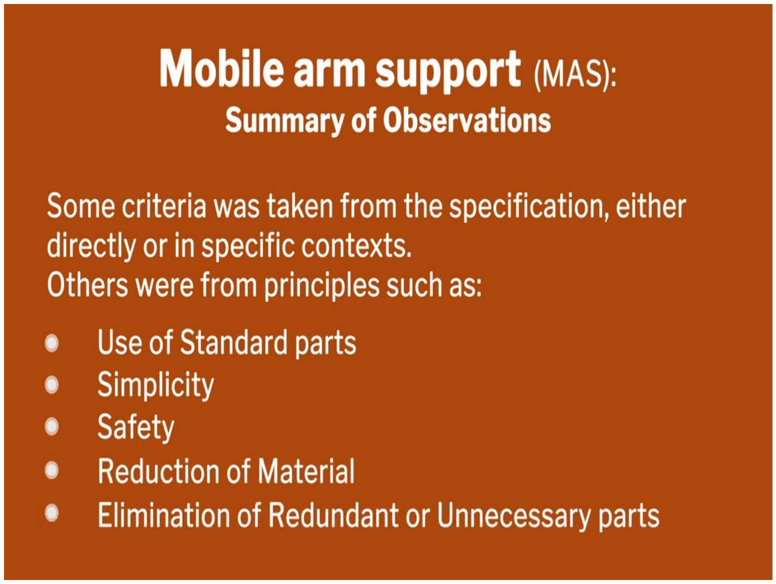

And remember the importance of standard parts, remember that there are certain things that are considered 'Common Sense'. Common sense is the most uncommon sense actually. And therefore you should look at those principles and guidelines of embodiment, ok? Simplicity, safety, reduction of material, elimination 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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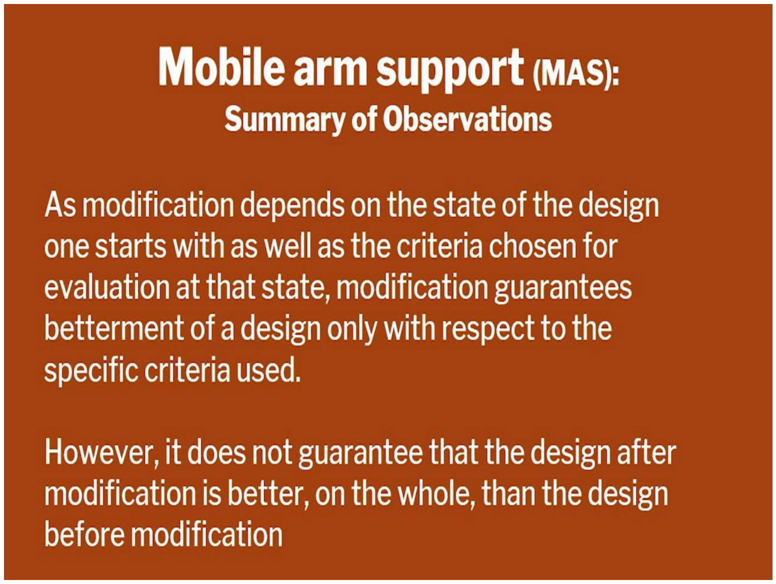

Selection, interestingly enough, when you're operating at that microscopic level, is very much dependent on your level of satisfaction. And if your level of satisfaction is low, you are going to come up with a low quality product. But it is also dependent on your knowledge and your deadlines, ok? Given 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.