



Stanford eCorner

Products With a Purpose [Entire Talk]

Scott Summit, *Bespoke Innovations*

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As the Co-Founder and CTO of Bespoke Innovations, Scott Summit leads a continuing effort to create products that radically change lives. In this lecture, Summit shares insights from creating customized prosthetic devices using new technologies in nascent markets. He also discusses some of challenges his company faced in discovering a working business model and developing customers.



Transcript

He is doing things to really change lives in a remarkable way using extremely cutting edge technology. So, without further ado Scott Summit. Thanks, Tina. It's really exciting to be here and it's great to see everybody, this is the kind of crowd that I relate to most the wild-eyed, blue sky thinkers in the area. Like Tina was saying I used to be an industrial designer, I guess I still am, but that was doing - mass produced, lots of stuff for high tech companies in the area. Those days are kind of done because there's some new exciting technology that allows us to think in very different ways and I just got really excited about what can be done with these? How to put these technologies to use to create something really meaningful? And so that's what I will be speaking about today. I have always been interested in prosthetics and the amputees and the challenges they face and I suspect really strongly that this stems from the same place that a lot of people who are in this field where they get their inspiration, which is growing up in the 70s and watching the \$6 million man every Sunday night at 6 o'clock. This was an inspiration for us; it seeded an entire generation with ideas because you know, the main takeaway from the show was that a massive DARPA grant and a triple amputee and you can do some really cool stuff. And so now the generation you know, here 30 years later we are all doing stuff and we are seeing this huge growth of what can be done with prosthetics and amputees. So, when I was a kid I used to look at amputees and I was curious about two things about how far they are coming along.

Well the things I discovered is that it isn't \$6 million man time yet, it has got a long way to go that that was a reality that came crashing down on me as a kid. And the other thing is \$6 million is a really poor attempt at a seed grant, you really can't do much with \$6 million anymore. So much for that thought it was this vast sum of money that allowed you to do everything. But I would always look at the amputees that I would see and I would stare and just be fascinated. There are so many questions I wanted to ask them about their life and the challenges they dealt with and the thing that I was always reminded is that you can't stare, you're not allowed to stare because that will make them uncomfortable. You know, somebody would always remind you, don't stare at them. And that is the worst possible response you can have. Because how you make somebody more uncomfortable than saying don't stare because it will make them uncomfortable and that struck me as strange too as a little kid because I'm thinking wait. So, because of this one challenge we have a wall of separation, we have to disassociate from them, we have to disconnect from this one group of people because we can't engage them, we can't connect with them, so how strange is that? Because in a sense it's just another challenge that needs another corrective device and this one in particular, however, has a stigma associated with it, has something about it that separates us in ways that others don't. But you look at other corrective devices, there are tons of them around, you know, nobody says the same about corrective eyewear.

In fact, there's actually as many people wearing corrective eyewear without the corrective part, so purely for the fashion part as there are people wearing it for the corrective part. And there is something weird about that because that means we've come full circle, that because the designers are involved with glasses it means that there are people emulating less than

perfect vision so that they can get the prosthetic device that accentuates who they are, it gives them the more personality, it gives a connotation. Well that's really strange, that's come full circle and that's really owing itself to design. And you don't look at somebody wearing eyewear and think, you certainly don't pity them, you are not uncomfortable around them, you don't, they don't try to disguise it certainly. This is something that we accept, it's something fairly normal. So, why does that only apply to eyewear why can't that extend broadly? So, there are all kinds of things, there are all kinds of prosthetic devices of sort that accentuate or augment what we already have, but it really comes down to the design that separates one from the next. For example, can you imagine if Ducati had to go designing the walker with the tennis balls, it wouldn't be so bad to walk around with that anymore. It has a sense of changing the stigma and changing the message that's associated with it. So, why the problem? Well I think one of the problems is that we have this mentality, this form follows function mentality and it's kind of a bastardization of what was one said a hundred years ago by Louis Sullivan and it has come to mean that form follows mechanical function. And so, we have now come to accept that this is a mantra handed down by Louis Sullivan, which gives us free rein of creating something that's clunky and mechanical and utilitarian instead of something that really has form and beauty to it, sometimes when it's needed.

So, when you are talking about form follows function in the amputee world, it usually stops at about this point, form follows mechanical function, get somebody walking, but that also overlooks the complexity of humans that we are a little more nuance than that, that the body is not simply something that keeps the head from falling on the ground. It's something that we adorn, we wrap, we cover with jewelry, we tattoo, it's so much more nuance than simply mechanical solution can allow. And so, when you are thinking about a prosthetic in that aspect the idea of function, what does the function offer is much, much broader. Well the challenge though with the prosthetic limbs is really has a lot to do with the mechanical nature of them because in this case you are talking about something that has to be mass produced and a lot of the artifacts from mass production are always going to get in the way because this is what you have to associate with mass production, it's one size fits all, it's inherently impersonal. It's inherently mechanical, there is nothing individualized about it, that's just the nature of mass production, that's the way it works. So, that's one of the reasons - such an odd juxtaposition against the human body which is inherently mass customized, it's unique, it's emotive, it's expressive. So, what I set out to do a number of years ago was actually to look at how one might change this? How you might evolve a prosthetic leg? If you threw out some of the basic tenets that guided it's evolution to this point? And so what I came up with is okay well if you are going to do that you have to create something that is really created by the person and for the person and of them and something that's as unique as their fingerprint and it has to be as fluid lined as possible, it has to be essential and sculptural and has to represent the personality as well as the physicality, if you are really going to do something that is a part of that person. So, then I got a little bit more elaborate and said okay what I wanted to be able to do is drop down into Jordan or Cambodia or Laos or you name it with nothing more than a camera and a laptop and access to the internet and scan somebody, capture their data, come up with the solution and have that solution ready to go and let it go viral so that legs can propagate all over the world, solve problems, you know, that's the kind of Utopian vision that you set out for one of these things for. Decided also if it was beautifully sculpted and crafted it would associate some of the - it would change some of the stigma associated with prosthetic limbs, it would change the way the person actually perceives their own body and hopefully would actually change then the way society sees prosthetic limbs and amputees in general. It's a lot worse in the U.S., it's a lot worse in the rest of the world and there are many places where an amputee is a real social stigma.

It stops somebody from getting a job, from getting married, all kinds of things. So, it's a fairly meaningful thing to start altering the perception that we have. The idea is that if you can change something from utilitarian to sculptural and beautiful maybe you change the dialogue that goes on, maybe change the perception. It had to give somebody their symmetry back, but not in a way that's mimicking or emulating human because that takes us into this area we call the uncanny valley, something that is uncomfortably human but not human, so the idea is to create something that's beautiful, that suggests the person, that is unique, but doesn't try to be something it's not, it is as honest as it can possibly be. So, that goes down into this Pandora's box of all the different technologies that have to coalesce if you are going to actually create a solution in this area. And so dove into it, head long to solve things, the first thing that had to be done was to get the body into the computer because from that point, no matter what you do it's a unique artifact that is of the person and so I realized that the 3D scanning done with the camera, it's just not there yet. Autodesk is working on it, give it a few years we'll get there, but right now this is a stop gap. So, I invented a 3D scanner that is two cameras, projector, it's a whole structured light type scanning. 3D printed the product itself, so that's a 3D printed 3D scanner, the world's first of its kind and it can scan a person in a few seconds and get a very decent scan for \$5,000 and can capture both legs, a smoothing algorithm smoothes it to make it fluid, but still very honest and very faithful to the person's original morphology. And then how do you get that into something physical that you can actually use, that's another challenge altogether.

But a quiet revolution happened in the maker world about 5 years ago that 3D printing used to be a way to make a disposal product, something that was fragile, that wasn't going to last very long, that was simply a facsimile of something you'd later injection mold. Well, what changed is that 3D printing now can print a physical, solid strong survival artifact. Now that changes everything because now you can print something that will survive, that will solve your problem in that one artifact. And we have seen what happens when 3D printing is in the hands of an artist, you can create beautiful complex structures. You can create

things that you can really only imagine any other way. But what also is amazing about this technology is that it lends itself very well to printing one thing per person. It doesn't care if you are printing a million of it or one of it, cost is pretty much the same, unlike injection molding and unlike other traditional means and complexity, which is kind of the bane of the mass production world, complexity is free. More often than not actually complexity is cheaper than simplicity if you make a brick and you 3D print it, it's going to be very expensive. If you make the same volume and it's a bunch of gears, parts and this and that it's going to be cheaper because it's just less material used. 3D printing follows a very different type of math than traditional manufacturing.

So when you take something like prosthetics, which have inherently complex parts and components to them and you apply this thinking, well, now you are allowed to create a leg that is inherently customized for one person and can have great mechanical complexity built into it and it all comes at no extra cost. So, it kind of changes the game. The leg that I have here is shown on the display there on cross section. It shows some of the internal workings that actually nobody has even ever seen because it was printed, it was printed in its entirety. The feature set that you get from 3D printing a leg entirely is, well, you get a ball and socket foot which is, it would be a very expensive component in any other way. In this case, your plantar flexion, your dorsiflexion, your rotation of the foot can make it emulate human motion very accurately, just because your 3D printing it again to the specific needs of that specific person. You can create in this case, it is a seven-bar linkage knee, this would be a \$20,000 knee on the open market. It all comes for free because it's just printing it and that emulates human motion very accurately there. You can create tension into it. In this case, it's a very springy, very resilient material and by 3D printing it, you have the contour in the back and the gastrocnemius, which behaves exactly like a human, in the sense that it gives spring force to correct and to redirect the force of the foot.

And finally, your load bearing structure, it's hollow, it's trabeculated just like a bird wing. It's very, very light, so your strength to weight ratio increases because when you are 3D printing a part, you are simply printing the molecules you need and not those that you don't. So, you are allowed to get away with things you can never get away with traditional manufacture. So create a number of these, put this one on John and he walked around. The other goal with this is that if he wants to hide this, he puts on pants and he pulls on socks and no one knows it's there because it's an exact mirror image of his existing morphology. So, he can be as discrete as he wants, but also if he wants to show it to the world, it's not so off putting, it's not so alien because it completes his form. This is of him and by him and uniquely his. It has a couple of other kind of interesting weird attributes that aren't obvious. One is that it's made in the U.S., it would not make sense to make it anywhere else because you would only incur shipping charges, that the laser doesn't care where it gets made, so just makes sense to make it in the U.S. It's also the greenest possible way to make a physical thing that it's, this was created simply by 130 volt laser running for about 30 hours, so use your garage door opener once or twice and you've used far more electricity.

You know it's about a dishwasher being run a couple of times that's the amount of electricity it takes to create entire leg in this case. And at the end of the day it's curbside recyclable. And then here is the other one is that it is dishwasher safe, which sounds weird enough except that it's important to be able to wash your leg as well as the rest of you and your clothing and anything else, why not? And there is nothing quite like seeing the look on your girlfriend's face and she opens the dishwasher and sees a leg staring back at her and feel like Jeff Dahmer in a strange, modern way. So we made a number of these. This was another one with a monocentric knee, meant to have a little bit less friction, little more survivable. And the amazing thing is this actually worked. This guy's shorts, he didn't have shorts, he didn't own a pair of shorts before the photo shoot, so we had to cut these off. He just didn't like wearing shorts because he didn't like the attention, he didn't like the stares that he got. So now all of a sudden he is wearing this leg, he hiked all over Tahoe with this leg. So, the idea worked great.

We printed a leg \$4,000 and it had the feature set of a leg probably in the sixty to a hundred thousand dollars set range. And my hope of getting this virally spread throughout the world fell apart because the rest of the world doesn't have \$4,000 to spend on it. I talked to the International Red Cross and the said yeah, \$400 tops, try to get it down to the 200 range. So, I was an order of magnitude off, you know. So all of a sudden, the idea that I had of creating this very disruptive change in the prosthetic leg world didn't really happen, kind of fell apart. So, I thought about it, redesigned everything and thought okay, if I am going to create a leg that's now for the U.S. market, let's shift markets and gears. How do you make something that is just flat out beautiful? That's the thing that I want to see when I wake up in the morning, that's the sports car that I get to wear and get to show off to the world. So, I set about to that and this is what was created. This is a guy named John Siciliano, hit by a drunk driver at 18.

And so again, a 3D scan of his leg mirrored over. In this case thinking of a higher dime, higher budget, so did leather, chrome, polished metal and the idea is just to make it look good. Now he gets a couple of other details. He gets to switch out the leather in the front because if you are going to treat it little bit like fashion why not? The leather is going to wear out, swap it out from one time to the next. And this was looking great. His girlfriend saw him wearing this, I guess, wearing is a term when there isn't even a term that's terribly good for this. His girlfriend saw him with this and she said 'Wow, I like that leg better than your other leg'. And here he is scratching his head and he turns and he says 'Nobody has ever said that, nobody says that to an amputee, that's the weirdest thing I ever heard'. And I was like yeah, that means score, that was a victory. So, the problem there is that I started realizing that the amount of time it takes to create this and the complexity, the pure geometric complexity

to create this leg was pretty prohibitive.

I'd narrowed my market down to probably about five and so the business model, for all the business people here, they'd do the math and realize, yeah that is... So, I started thinking okay, really how do I strip this down to the core with the essence of it, giving it, giving something that is otherwise clumsy machinery, giving it a beauty and a grace and a form and a sensuality and a uniqueness that wouldn't inheritably have. And so I was riding around on the motorcycle - this isn't mine, I wish - but riding around on my motorcycle, thinking okay well motorcycles do this all the time. You know, why don't we just strip it down to its basics, it's essence here. And so I tried making something that was the lowest cost way to get the job done here and had a test pilot. Chad here tried it out. Now Chad is a competitive soccer player and his challenge was that you can't play competitive soccer when your legs have been replaced by a thirty millimeter titanium pipe because somebody is going to kick you at full speed and bust their toes and all their metacarpals. So, he was not allowed to play, and on top of that he couldn't feel the ball because you can't anticipate the trajectory of how the ball is going to ricochet off your leg when it's a 30 millimeter titanium pipe. So, scanned his sound-side limb, mirrored it over and 3D printed this leg and we put it on him and watched him play soccer. And what was interesting is after a few weeks - this is not entirely expected - he said all of a sudden, his brain started to recognize and remap this new leg to his body again.

He lost his leg, eight years before he lost his leg to cancer. All of a sudden he is playing soccer, competitively again, because his brain is thinking that his body is in some form back. So, it's a type of, it's a way of really regaining your sense of self, your sense of physicality. We tested it for durability, it survived. I put it in my check bags a few times and traveled around the country and yeah it worked, it survived. So, that was this pattern. It was a very utilitarian pattern, it was meant to just be sports, structural, meant to survive. So, tried some variations on them, said 'Okay, well, how about looking into some old Arabic patterns from old architecture books?'. Or there is this woman I did another leg for, and she was just positive and happy and cheerful. So, I wanted to kind of represent that in her's.

Or lace, you know, what could be done here? So, I started doing variations on this. This is a guy I am working on right now in Germany, business guy, he wears tweed herringbone. And so he is going to have a chrome herringbone back leg and a debossed front. Another guy, a motorcycle guy. It's all motorcycles in this industry, sadly, which is good that I have got my legs scanned in advance. He had this, that was crass, I guess. He had tribal tats head to toe, he was a case study in tribal tattoos. So, captured one of them recreated it in illustrator and laser tattooed it on to the leather and so we are making it this week, this will go out pretty soon. So, a part of it is that we can do it, we're showing off and there is some artistry that we'd like to build into this. But part of it is, if that's the way we can connect somebody to their body, then that has meaning and that has value.

We want this not to be a utility, not to be an artifact that they have to wear if they are going to walk, but something that they connect to, they relate to, that represents something expressive of themselves. Mike here, we took his old bomber jacket that he had for ten years and took an exacto knife and sliced it up and laminated that to his tibial part there. And so he now has something that was very familiar and comfortable to him as a part of his body, in a sense. And recreated the tattoo that he had on his calf and, so again, just to recreate that body part for him. And they can't see it, but down at the very bottom there is little recycling symbol because his wife thought that was really cool and hey, it is curbside recyclable and there is something cool about that. But, to be able to give somebody the shape back, your first reaction when you see him is okay it is different, but it's not bad, it's not freakish, it's not off-putting. And that's the goal. And all of a sudden now Mike is showing off to everyone who sees. He is wearing shorts wherever he goes. James Keeman - another motorcycle - he had this tattoo on his forearm and I was asking if he had other tats and he said yeah he had one on his left ankle and it was the same chain that you see.

So recreated that, debossed that into his left shin. And his bike was a black and chrome Harley and so used black and chrome materials. And the cool thing what resulted is that it became this kind of liaison between him and his bike: it kind of suggested some of both, that it was this, this go between that connected both James and his Harley. And so all of a sudden he loved it. And the interesting thing is yeah it's kind of hard to tell where James stops and where the Harley starts, and kind of unexpected. We created another leg for Chad for him just walking around town and I wanted to use this suede because it just looked good against his skin. But the fear of that is that that starts getting into one of the rules that I have, which is that we don't want to look like a human, we don't want to look like we are pretending to be something or not. So we put the medallion debossed into his back, that's our logo, and he was okay with that. But, we have three rules that we live by. It's that we are not trying to look human, we can never emulate human because that's wrong, it's not allowed.

We can never violate the person's physicality. When we do a 3D scan of them, we use that literal scan, we don't grow anything, we don't alter it, we don't make it any more slender, we don't change them in anyway. That's Photoshop magazine covers and that's just wrong, we don't have the right to do that. I mean the third is that we don't do any gimmicks. We have been asked to do bottle openers, LED, lighting, pistol holsters, knife holsters, you know, all kinds of things and that's not really what the leg is about, this is about the body, this is not about adding gimmickry to it. So, we tried to talk to people and engage them - what they like, what they connect to - so that we can better represent them in the design and the artistry of the leg that we create for them. And this is what one woman sent to us, Deborah sent this. And she said that for some reason, she doesn't

know why, she just relates to it. There's something sexy, there's something sensual, but at the same time it is still cyborg, and could we capture that? And so we worked with an artist who came up with a pattern. And this being kind of a lace pattern that would still work in a very digital environment like we have.

And here is the result. This is the leg that I have here - we made copies and she was okay with that. That we want to capture feminine, but we also want to make sure that we weren't pretending that she wasn't part cyborg in her perception. That it was still mechanical, it was still manmade. It was beautiful, it was fluid, sensual, but not her original equipment. And so this was the first text that she sent that was really cool for us to get. And what struck me about this was that people started engaging her. And instead of looking at her and looking away uncomfortably they would look at her and stare, and be okay to stare because they knew that she was fine with it. And so all of a sudden people are coming up to her for the first time in her life, or in the 8 years since she lost it. They are coming up to her and asking about it and talking to her, and okay and comfortable with asking, they are staring but it is just for the right reasons.

So, then just for fun we decided that we would match her Chanel handbag. And this is just kind of going for style points to this point because we can, why not? And Chanel hasn't yet complained. And here is another text she sent a while back. That people are okay talking to her and they are not looking away uncomfortably and that changes everything. The skirt that she wore for the shoot, we had to buy this skirt for her because she didn't even own a skirt. So, then we tried another experiment here, we worked with an artist and took her art work and laser etched it into the leather, so that she can have a tattoo on demand and how cool would that be to have a tattoo for an hour and then take it off when you don't feel like to have tattoo anymore. Well, she can do that she has got all kinds of different parts and we let her swap out her hardware whenever she feels like it. And then we pushed that one little further, took this guy, some tribal tatts and interesting thing is to recreate that, but to take the person away and just leave the tattoos. So, we have three-dimensional physical tattoos in the shape of his original body, where some tattoos had originally been. As far as I know that's the first time that a tattoo has created the body instead of just simply adorned it.

Did another variation here for a mountain biker, just wanted to capture a pattern that just represented him, speed and agility. And a bike messenger: gave him a little bling, something that looks cool on the sun when he is riding through the cars. And so in this case our whole goal is to really embody that person to capture them and to change their perception of how they feel about being an amputee, about their condition, about the way they treat every day. And if we can get them psyched just to wake up and wear shorts and walk around and put that on and change the way people perceive them, then that's really the victory that we have set out to achieve, that means we nailed it. The coolest thing was when this guy reaches down, he reached down and put on his leg and he just started feeling the shape and running his hands up and down it. And then after a long pause, he said: 'that's the first time I have felt my leg in 8 years. That was pretty cool, that means we nailed it. So, that's really our goal. Thanks a lot. Okay so let's take some questions from the audience.

Who wants to go first? Okay right here. Can you do anything if the person is a double amputee? So, the question is I believe can we do anything for double amputee? Yes we are working with a number of double amputees now. It's a strange one because you actually have to, by kind of the rules that we set out, we have to transfer somebody's body to somebody else. So, we have had a number of people approach us willingly being scanned as surrogates, as stand-ins for somebody else. We actually had our lawyers draft up a body morphology release document, which they were all confused to write, but they actually wrote it. Now we have people sign it because you can't have somebody come back to you 10 years later and say, that's my leg. So, we have the body morphology release document and we are doing scans. We are working with a woman named Aimee Mullins in New York, she is a double amputee. She is especially difficult because she wants like 3 extra inches on her legs so she is super tall so we are looking for a really tall person for her legs. And, yeah, we have had I think six or eight, we're working with a lot of veterans now and when they step on a landmine, it usually takes out both and so we've got a whole string of doubles that we are working with.

It's really challenging. Yeah. I've two questions. One, if a person has a lower limb amputation like under the knee can you use a similar technology? And two how exactly are you able to control all of the motion of the foot like, if you have a double amputee you don't have another foot that can derive the force, how does that work with how a person can walk without being noticed that they are walking with a prosthetic. Yeah, the question is how do we work with the below the knee amputees and how do the feet work because it is a purely passive foot, it is not strong foot, it's not an active foot. As far as below the knees, BKAs or transtibials, we work probably about half and half with BKAs and AKAs. So, that's, we've kind of figured that out. It's a tricky one mainly in the kneecap because the kneecap always puts the difference and we can't, we have to either mount to the lower leg or the upper leg and really hard to do a kneecap. But as far as the foot goes, the foot's tricky no matter what until you get into active electronics and motors. And so the I-walk out of Boston is the best thing there is replicating real human motion, so short of that you try to store kinetic energy and release it in a swing phase and we can do that with this leg and there is a pivot and you press here, it distorts the spring and the spring simply stores the energy and releases it as you've gone through your stride.

With the legs that you see here, in this case we are not reinventing that we are using existing components. So, in this case it's simply a shroud that attaches around the existing hardware so we are not trying to reinvent that one right now. Can you talk a little bit about the team that's working on this? So, I imagine that you are only one part of the team and so like, do you engage any medical doctors to help you with this or who's involved? So the question is about the composition of the team. We are a really odd mix, because for one thing about 10% of what we do is what I'm showing here. So, we've got a really broad plan that we're working on and we just can't talk about it until the patents have issued, but we are a combination of a guy named Ken Trauner who is an orthopedic surgeon from Stanford and he's my business partner. We have a CEO, marketing guy. We have another industrial designer from ArtCenter, so he and I are kind of the industrial design component and a couple of programmers from Rice and handful of other just random people. As we add people, we'll probably add somebody in the fashion design world or jewelry design world and probably a biomedical engineer too. So, we're really -- we're a strange mix. When it works, it's a great synergy because nobody really overlaps anyone else enough to second guess anyone.

Everybody has kind of a domain. But we are a strange combination. I don't know how to define us, if we're jewelry, if we're fashion, if we're industrial design, products line, engineering, you know, that's kind of up for interpretation and can change throughout the day. Yes, so naturally the composition of our business is pretty varied as well. So, can I ask a question? Since I'm up here I get to ask a question. Funding of this. I mean, you told me that you're just about to close your B round. If you have people who were investing in venture scale, can you tell us a little bit about the business model and, you know, how you pitch this to VCs? The question is our business model and our funding. About a year ago we spoke with an angel and we landed 3.4, I think, million and that was our A round and we are now in our -- in the midst of our B round. The A round is really based less on the stuff we were doing with prosthetics and more with the stuff that unfortunately we can't talk about.

So, that's a very elusive response. So, yes. The prosthetic work is kind of sustaining itself, but it's really not the stuff that interests the VCs. The stuff that goes way beyond this is where they are interested, but this is a platform for us to explore, a lot of the different technologies that we are using for other areas. What sparked off your passion in this area? Question is what sparked off the passion in this area? I actually really think it was watching the \$6 million man as a kid. That wasn't just like to get them laughing joke. That was real. I think the \$6 million man was this promise that with funding and some creativity you can do anything and you can augment a person in ways that you hadn't imagined. And what I think is exciting is that we are seeing that happen now maybe not the Steve Austin and the leisure suit thing, but we are seeing Oscar Pistorius running at Olympic speeds, we're seeing Aimee Mullins as a supermodel, we're seeing any number of people who are doing these unbelievable things, climbing Everest and doing extreme sports of all kinds. And that's exciting.

That changes the way we perceive it altogether because it's hard to say what are they if they just ran past you in the Olympics. So, there's a lot of changing of our frame of reference that's happening right now. And I think it's kind of exciting to be a part of that. We are not doing the biomechatronics that's getting people running at high speeds, but we are doing the other component and what happens when they are walking around town and getting into some of the psychology of it a little bit. So, my passion is partly driven by being an industrial designer and looking for the ways where industrial design can really create meaning in somebody's life. It's not about selling product, it's about creating a lasting meaning. And I think at the end of the day that's far more significant and important and more satisfying to work with, yeah. Can you elaborate on the first rule that you mentioned about not trying to mimic the human body, because if that's - if some of your customers require that from you, isn't that an impediment to further growth perhaps? Yeah, the question is, the rule that we are - the self-imposed rule - that we will not mimic the human body. There are plenty of companies that will do that and there are people who simply want that. They want painted toenails and whatnot and tissue colored materials and things like that.

And that's fine. There are companies that do that and that's up to them. Our goal is really to rephrase the question because to some degree that's saying that this is something that you should try to hide. That if you are an amputee, you should hide it, disguise it and perhaps be ashamed of it to some extent. We are kind of saying they don't be ashamed of it. Just make it the coolest thing anyone has ever seen and it really rephrases the question in the first place. So, we are not about disguising it or pretending it's something it's not. To us really beauty comes from honesty and the honesty is to say this is really what it is, it's a manmade thing, but it's a really, really beautiful manmade thing. I imagine you do a lot, obviously, innovating in the 3D printing area, can you speak to where you see 3D printing and additive manufacturing? What's your vision where that goes? The question is what's the trajectory for 3D printing and additive manufacturing. That is a huge topic and it's a really exciting topic.

This is Columbus hitting that first rock and saying there's something out there and I don't know how big it is, but it's big. 3D printing is going some big places. I can spend the rest of the day talking about it but I think the two interesting things, three interesting things. 3D printing in space, that's going to be huge. That will happen. It's taking shape. 3D printing houses, for much cheaper and much better quality of everything you look for a house for, that is taking shape down at USC. And 3D printing in biologics is the other one that's happening in Berkeley, at UPitt, at a number of these places. We'll soon be able to three dimensionally print tissue and the promise there being that this will all be irrelevant when you can three dimensionally print out of cultured cells, living tissue and bolt it on, connect the blood flow and you can walk off. Okay, that's the simplification, but that is all in the works.

So, yeah, 3D printing is just in a very, very nascent stage right now and the trajectory is looking pretty exciting. It's huge. Yeah. Thank you. So, can you talk a little bit more about this because I think you're sort of racing the technology, right? Your vision and the technology go hand in hand and obviously the ideas that you had were initially ahead of the technology. Can you tell us a little bit about that race? The question is how the race between the technology growing and our ambition is growing either work off each other or against each other. We set out with the ambitions that were just beyond what the technology is capable of doing, originally, and when we started showing these to the companies that make the 3D printers, they said, my God, I didn't know that was possible. And that was pretty exciting for us to actually blow away the companies who make the technology and they've caught up and they are doing some more elaborate things, but that just spawns our imaginations to go that much further. So, we're always actually dismayed by how the technology hasn't yet caught up with the ambitions that we have. Our goals are much, much beyond what the technology allows.

The biggest problem with the technology with 3D printing in general is that it's too costly right now and it's too slow. That we always want faster and cheaper and it has got a ways to go and the trajectory is not getting there as fast as we'd like for the kind of products that we'd like to do. So, we're waiting for that technology to -- for the technology to catch up to the point where, yeah, it can 3D print stuff very rapidly, strong, durable and very cheap. It will come. There are a bunch of revolutions that are right on the horizon and the rumors and we all know that it's on the way, but we have to just watch and so our business model is actually anticipating this and hoping that once those floodgates are open, we can just ride the wave that follows. You focus on the leg, is there - I notice there's no arm, is there a different technology or is it harder or is it just the market you focus on? The question is we're focusing on the legs and why not the arms? And the main thing is that I set out to work when the whole project started, I was working for - to come up with solutions for developing countries and in the graying economy a leg is so much more vital than an arm. So, that was the original goal. I'm on the phone quite a bit with the DOD and the VA and they're wondering about arms because they have lot of soldiers missing arms. It's a different technology but in theory it's not all that much different from where we are. The challenge is that where the leg is basically two pivots, a ball pivot at the bottom and a polycentric pivot at the knee, the arm has freedoms of motion that are much, much harder to replicate.

So, we started with lower hanging fruit that was perhaps more valuable, but my hope is to get there because the emotional value of a hand and an arm is still very, very great to the user. How long does this process take from the initial scan to the endpoint? The question is how long the process takes from the scan to the finish. We actually, like it to take a while because we want the person to let everything sink in and let it gestate. So, we try to tell people 2 to 4 weeks. We can actually - if we have an emergency - we can create something in about a week. Takes about two days to do all the data and the design and engineering and all that stuff, but we actually prefer to just give it time, let the person think about. It's kind of like getting a tattoo. It's something you don't want to be too spontaneous about it. You know, you really want to let that one sink in and do some debate before you - a little bit of soul searching once, it will go a long way. In the beginning you were talking about making the actual prosthetic...

The question is how possible and how realistic is it to create the actual prosthetic as opposed to the fairing that shrouds it? It's completely possible. We walked all over Tahoe which is a pretty challenging place to walk, we had two legs that were entirely 3D printed. The only difference is some ceramic bearings were thrown into the bearing races to cut down the friction and heat. So it is entirely possible. It's really just that it is very different, it's something that processes are not comfortable working with. There are a couple of little technical challenges, but it is completely possible. I suspect it will happen very soon, Germans are working on it, Frulander, or something, a group out in Germany is making some great strides with this as well. I was just at the VA in Texas and the DOD there and they're working on doing the sockets, 3D printed all the way through. So, this is the way it will all go, it's just a question of who cracks some of the finer details. The question is would we use the prosthetics that are 3D printed.

Our goal would be to integrate the two so that it's all one and that's kind of the - like with this one. There isn't a separation between the mechanics, the hardware and the structure and the fluidity of the form, it's all one and that's I think ultimately the goal because that's the most biomedic in a sense that's really how our bodies are constructed. With all the different methods of 3D printing how do you choose the ones you print, the bearings and why might that to be the best method to do so? The question is with all the different ways you can 3D print something now, why did we choose the one we did? That was actually a very simple choice for us because there are lots of things, you can print metal and you can print glass and sterling silver and everything you can imagine now. We use a material called polyamide which is Nylon which is very, very strong and light and dishwasher safe and everything that we like. It also comes in a very large print bed, 20 x 20 x 30 inches. So, that lets us print a very large thing. But, the main thing for us is it's durable. A lot of these materials are not durable, they are meant to be prototypes, so they're meant to show you what the shoe you design will look like in production, but there are only a few machines that will actually create a fully durable ready to use part. The 787 Dreamliner has lots of parts that are 3D printed on it. A lot of the new stealth fighter, it has 3D printed parts.

If you get a new car, you are getting a lot of 3D printed parts. So, the parts are now durable and kind of ready to be used as production parts right out of the gate now which is, why we use it, but it's one of the big shakeups that happened in the 3D

printing world. What role do you let the user play in the design process, you know, you talk a lot about the person can be for them, about them and by them. Where do you sort of draw the line as to how much role the user can play? That's a really good question. How do we come up with the role of the user in this process because we want to make it user participatory with design process. The challenge is, not everybody wants to be a designer, you know from a designer's perspective, of course, everyone wants to be a designer, but that's actually not the case, you know, people are content looking at an iPhone and saying you own a black one or a white one, some people and we've had the range. We recently had a woman say I want mermaids going up the back and I want an octopus wrapping around it. Sorry, we can't, you know, we're limited. So we are trying to answer that ourselves. No matter what we're using the person's body, so no matter what it's that level of customized.

We have all kind of different materials and leather and ballistic nylon and things like that that we can use. If somebody sends us a tattoo black and white, we can laser tattoo that into the leather. If they have specific patterns, we just had a guy he wanted the San Diego Chargers logo. So, we debossed that all throughout. Okay that was fun and cool. So, we have all kinds of latitude. It's really up to the person if they want to be fully involved in the design process or a lot of times they will simply say hey that one on your website we want one just like that. So we just leave that up to them. When you realized your goal of kind of producing these prosthetics for like second and third world countries wasn't able to be accomplished how would you kind of refocus and deal with that? The question was when it was obvious that the original intent of working for the developing countries, when that fell through how was the refocus - how the refocus would take place. That was a really challenging one because everything was looking good.

I had people up and walking. All the technical riddles were met but then the economic business model which is not my forte that fell apart. That was a painful one and that was a difficult one to kind of come down and realize wow, I should have done the numbers before I started. On the flipside I like where it ended up. So, it wasn't a total loss. But it was a lot of saying well okay let's put that on the shelf until the day when this is ready when it's fully baked and move on to this other variation, see what can happen down that trajectory. So, there's a lot of being able to kind of bite your lip and wince a few times and then move on. How did you go about acquiring customers? I mean, do most of your customers find you online, do you advertise. So, like my brother-in-law just came back from Afghanistan, he's fine but, so somebody comes through like Walter Reeds, they put them in touch with you guys or how does that happen? The question is how we connect to the people that we are working with? The amputee world like a lot of communities is very, very closely knit. So, when there is any new innovation everybody is telling everybody who's telling everybody; it's the most viral group you could imagine connecting to because everybody wants to be aware of the new thing.

If there is something new and advantageous and exciting, that words going to get out fast. So, there are probably very few amputees who don't know what we do at least in a vague sense. I spent a lot of time out at Walter Reed, I was just last week down at center for the intrepid in San Antonio and down at Balboa, and I am going around all of them again. So, we are getting very connected there because the military is excited about it. In a strange way they're the perfect demographic because they're guys in their early twenties, they are very, they are still very body conscious. They are aware that they came back, that they are wrecked in at least this one physical area, and they are trying to figure out what are the new ways that they can kind of rethink things to get back, get back in the motion. And so they really connect with it. So I don't know how many amputees from Afghanistan, Iraq we are doing, but quite a few. And it's fascinating and really heart wrenching to hear all these stories too. These guys are in their early twenties and it's...

they all have something pretty wrenching to relay to us so yeah, that is something we are not used to. You know, in industrial design school they don't tell you that that's what you have to deal with. My question, why don't you go worldwide. I assume that from a 2D photo you can reconstruct the whole leg and you can just send it by normal post. You can just acquire the photo and you can just ship your leg everywhere, I mean, your equipment. So the question is what's stopping us from growing worldwide? Actually, nothing. We are working on that right now with Germany and so we are spending quite a bit of time out there. I suppose you don't need to use your 3D camera, I mean with a normal 2D camera, you can do the photo. You can do sort of do it with the 2D camera. It's not quite baked yet, there is something that Autodesk is working on called Photofly which is almost there, but we are giving a little bit of time.

It's not a fully baked software just yet. When that is ready then your typical camera becomes a 3D scanner if you know how to use it and it's a pretty simple thing. The biggest disruptive technology in the 3D scanning world, of course, is the Kinect, the Xbox game controller. That is a very sophisticated 3D scanner, so a little bit of hacking on that turns out into a very cheap upfront 3D scanner. And one of the things, we are working on is coming up with ways of reducing the cost of 3D scanning so that we can propagate it because that right now, you are right, that is the bottleneck. Like, once we have the data, we can work worldwide without a problem. The question is about 3D cameras. We are watching 3D cameras develop. They are not quite there yet. But we are watching them very carefully because the day that a 3D camera comes out, that is capable of doing the kind of scanning that we need and creating the kind of data we need, yeah, we are all over that.

So, we have guys who watch that morning and night. So I am curious, you said this is only 10% of your business and you

have got 90% other things going on. I am going to guess that you have lots of opportunities coming in the door; how do you evaluate these new things? I mean, now that you have gone through this process and you have made some mistakes along the way in terms of understanding the market and the financial models, when new deals and new ideas come to you, how do you evaluate them? The question is what happens when new ideas and new concepts come our way? How do we weigh them? What are the metrics we use? Well, one of the dividends that came from watching my own original ambitions crash and burn was that I don't trust my own intuition nearly as much anymore, that we actually have a full time marketing guy now. And his job is to look at the numbers in the Venn diagrams and insurance reimbursement codes and all these different things and he does this very complex formula that I don't begin to understand and he tell us, is this a viable thing to pursue or not? So, it is actually, we are now marketing driven which is kind of the last thing I ever thought I would hear myself say, but he decides if it is going to be viable or not and then we collectively decide is it viable and does it work with our technology? Does it work with our ethos? Does it work, does it address the kind of things that we believe we can address well? And if we answer yes to all those, then we dive headlong into it. We've actually saved a couple of lives so far which is, in the medical world is trivial, but in the design world that's big because that never happens. So, we're kind of excited about that, that we've managed to come up with some technologies to really save people and so that really reinvigorates us and it validates that yeah, this little tangent we went down, that saved somebody's life. That worked, that's cool. Okay, check, we can move on and assume that's now our checkbox, so we can move on from. Since you brought it up, in our class we have been studying about you and your company, your business model, and we'll talk about this more when we get you over there, but you talked about insurance and insurance reimbursement. I think we know that your fairings are not covered, or have been partially.

The question is do you - it seems that there is reconstructive surgery that is for less functional things that gets covered, are you doing anything in terms of lobbying with the insurance industry or doing any case studies about the emotional impact of the fairings so that you can move the dial on insurance reimbursement? That's a really good question because that is something we talk about every day. The question is how do we relate to the insurance companies because this is new and they don't like new -- well, they don't know how to deal with new stuff. It takes a long evaluation for them to understand just what to make of it. In our case, we can't lobby because that's a two to four year process. We just don't the time to start lobbying insurance companies. We do a lot of prove it, show it and get some responses back from it and that has a certain value in itself. The challenge that we face is that they have their set of priorities which doesn't necessarily gibe with ours. So, we can tell them for example, that people come to us and they have duct tape and bubble wrap approximating their body form. That's fairly common. To us that means everything.

That means there's an unmet need here and it's a profoundly unmet need that's going to drive somebody using duct tape and bubble wrap to approximate symmetry in their body. To an insurance company that's less relevant because they're interested in getting them up and walking again, but the psychological value that returning symmetry and body form has is just harder to quantify. It's not a yes/no answer. So, it's a harder story to tell. So, along similar lines, sort of with regards to a soccer player, instead of giving a new leg that sort of has more of a familiar feel to it, do you think that actually enhanced functionality at all? Like in terms of like mapping to, you know, how you are going to control this compared to other things that are simply for functionality? The question is, do we add any additional functionality with - while returning the body symmetry to somebody; is that correct or -- Do you think that the psychology behind it, sort of like feeling better about the leg actually made functionality a little better compared to just a straight up, like, titanium rod? Sure. And then the question is, how the psychology might improve the quality of medicine or the quality of care that we are actually giving somebody. Those are questions that we look for answers ourselves. I like to think that there might be some phantom limb issues that we can address. We are hoping to start a study to see if returning very accurate body symmetry to somebody addresses phantom limb at all. It's anyone's guess: phantom limb is a very elusive one to look into.

The other question, well, somebody can return to a much more active life because there are lot of sports that you just can't do with a pipe. So, for example, we have people who are back to snowboarding and skiing and rollerblading and hiking because you can't really strap, you know, a sports performance boot down unless you have a degree of body symmetry because that's just the way your brain maps it. So, there is some of that functionality. I think that it's a very difficult one to quantify. Just the one thing we do know is that people will tell us, yeah, they're more active, they're more out there. You know, they can't wait to kind of walk around and get responses. And I like to think that that translates into just a more active life in general and that that has some medicinal value in its own weird way. But yeah, we don't know and it's just hard for us to quantify. So the new stuff you can't talk about. Could you talk a little bit about the process of how as an entrepreneur you balance between the stuff you're making money on today and the stuff you're doing for the future, how you manage your team, how you manage your budget.

How do you manage your business balancing between those things? Your question is, how we manage the business balancing between the stuff we're doing today and the R&D that we are doing for future development. That's a challenge and that's one of those things again that I'm very ill-equipped to make those decisions, being an industrial designer with a background more in the arts than in the business. So, my heart lies in certain things, you know, in being able to connect these people. When somebody feels their leg and they can feel the shape for the first time again. You know, reconnecting that sense

of self to somebody. To me that's really valuable. To the pure nuts and bolts of the business of it, it's not terribly profitable. Nobody's going to retire off of doing the work that we are doing here. It just, it doesn't scale, there aren't enough amputees, the market isn't there. So, we're not telling ourselves that that's a huge growth area, but it is something that we do as a test bed and we do it really because we love doing it.

You know, I don't mind throwing away a Saturday if I'm creating something for somebody that's going to change every day for the rest of their life. That to me is a tradeoff that I am very willing to make, but as far as being able to come up with a very logical, sound business model: luckily we have a business guy who just does that. And he thinks about that stuff night and day. And he can give you those answers and he really does more of the evaluation as far what makes sense from a business perspective. So, I'm a very visual person and I know you are as well. Could you draw us a picture, paint us a picture of what the space looks like that you work in because I'm going to guess that the space has some reflection of what you do and what you do is influenced by the space you work in? The question is, what the space we work in looks like, and that's a really cool question I've never heard before. We sweated over that. I told a realtor 'if it looks like a lawyer would like this building we don't like it already and don't even show us in the first place'. It has to look interesting and funky and different because nobody can think conventionally in our office because that will be the death play to us. So, we actually have Charles Schulz's old building.

Charles Schulz who created Snoopy. So, we are the new Snoopy, we like to think. It's an old building in a historic part of San Francisco between the Globe and Bix restaurants and it has open beam ceilings and a lot of light and glass that's getting wavy from the century of melting. And we have drawings and sketches and inspirational images, things that we like all over the wall and those might be Calatrava or Zaha Hadid architecture, they might be fashion shots, they might be motorcycles or cars, anything that has some kind of connotation that we like that we're going to connect with. And the interesting thing is also how we all live up to our individual stereotypes because our programmers have cans of Dr. Pepper and Jolt and Red Bull, by their computers; the designers have all this like cool stuff and Curb magazine and all these things. And then the medical people will all have these really thick you know, doorstop, medical tomes next to their computers. So, we all are painfully victims to our own stereotypes and you see that immediately when you walk in. We have showcases of all our parts all over the wall. So, it does feel like you've stepped into the 23rd century when you walk in.

I'm sure you will agree this was totally fascinating. Join me in thanking Scott Summit.