MATT RATTO: My name is Matt Ratto. I'm the Chief Scientist of Nia Technologies, which is a nonprofit that I'll be telling you about here today. It's funded by Autodesk Foundation among others. And I want to thank Autodesk Foundation, actually, for supporting my trip here today and Autodesk University for allowing me to speak with you. I'm going to be talking about technology for a higher purpose, 3D printing.

I'm going to talk a little bit about Fusion 360 and a little bit about Meshmixer. But I'm primarily going to give you some technical details about the work that we're doing but then really try to focus in on how our work is driven by a set of social values. So it's a combination of a talk that's both a little bit about tech and quite a bit more about values, actually. So what does Nia do? We basically try to add capacity to existing orthopedic clinic settings.

So we don't actually print legs. Like, I don't actually make prosthetics. What I make our tools that allow prosthetists in these clinics to actually increase their capacity. Our starting point for our work is really this idea of impact design. And I throw up here on the screen Autodesk Foundation description of what they mean by impact design. And what they say here is that they bring together social, environmental, humanitarian, sustainable, human-centric, all these different types of design activity in order to create positive change and lasting impact.

And it's that lasting impact part that I'm really interested in. So if I can go off script for just a second, 3D printing prosthetics has become such a kind of almost a buzz word around a lot of different concepts, particularly in the developing world. My goal is to change that from being proof of concepts, can we do it, into something that actually has sustainable impact in the developing world context. And we do that really by taking a value-driven approach. We start not just from the technology, but from a set of values that we use to actually change the way we design, change the kind of choices that we make in order to create real impact.

And the values that we start from include innovation, appropriate technologies, we're practitioner-centric, we believe in partnerships, supporting local talent, R&D, and sustainability. And I'm going to basically give you some background into Nia

Technologies. Here at the beginning, I'm going to talk about the need that our work tries to approach and the solution that we've developed. And then I'm going to really focus on this value-centered activity, trying to give you specific examples from our actual work.

So I'm trying to move beyond just discourse around values to give you specific choices that we've made as an organization and as a set of technology producers that have been shaped by these values. So Nia started as a project called 3D PrintAbility in 2013. The origins were a bit odd.

I was actually approached in my laboratory at U of T, at University of Toronto by a nonprofit and a clinic in Uganda who had heard about 3D printing and were interested in exploring what it might offer them. We did a pilot at that clinic. I'll tell you more about that later. And then launched a non-profit, Nia Technologies, to scale out the work of 3D PrintAbility further. We started that about last year, a little over a year and a half ago.

We're located in Toronto, but we have partners all over the world. And our focus currently is on prosthetics and orthotics and, specifically, on orthopedic clinics and walking, as I'll talk about a little bit here in a minute. Our team, I'm the Chief Science Officer. We have a CEO named Jerry Evans, who was actually here at Autodesk University last year. We have Kathleen Gotts handles our communications and marketing.

We have a number of research consultants that work in hospitals and other clinical settings in Canada, primarily. And we have a product specialist who does customer support and training, David Singh. Our partners include Vorum Technologies in British Columbia, University of Toronto, Autodesk Research, with whom I've been working for many, many years and since 2013 on this project. So they're a big part of it. And then we have hospital partners, CoRSU Hospital in Uganda, the Excede Hospital Network in Southeast Asia, and CCBRT, which is a rehabilitation hospital in Tanzania.

And our funders include Grand Challenges Canada, CBM, which is a nonprofit, Google Foundation, Autodesk Foundation, and Stronger Together Philanthropy and Jericho Foundation, which are both charity organizations. So we've assembled a mix and match of funding in order to carry out the work that we've been doing for the last couple of years. All right. So let me turn to the need.

And again, maybe you've heard these statistics before but I'll highlight them again now.

So the need that we're trying to address is basically the fact that there's over 30 million people in the developing world that need access to prosthesis and other forms of mobility aids. So they need these devices in order to allow them to be mobile in the environments that they live. In particular, they need them in order to walk.

The problem, of course, isn't just a financial issue. It isn't just that there isn't enough resources or money. Even with resources and money, there's a shortage of the trained clinicians that can actually produce good devices, not just devices but good devices, which we believe is necessary for really solving this problem. And the reason that that lack is exacerbated is because the process of producing these devices is long, is arduous, is manual, is difficult, and is resource intensive and slow.

So you have a shortage of prosthetists and other clinicians. And you have a process that takes a long time. And basically, that results in that less than 15% of people across the developing world receive devices that can help them walk. That's a pretty staggering statistic, particularly when it's applied to children. And so our focus is actually on helping children walk.

And the reason that we're so interested in that is because of the longer knock-on effects of children not being able to walk. Those effects include individual, community, and social problems. At the individual level, it means that those children don't have access to education, that they often have difficulty finding friends and socializing and building community networks. At the family or even the village level, it means that people who would otherwise be employed or making money in various ways or farming have to reduce that time in order to take care of these children.

And the result of that is that there are these direct, indirect, and long-term economic costs. Now, I wanted to actually find the number, I wanted to bring in some nice, tight number and say, those costs are exactly. Well, it's a bit of black magic when you see people calculating these things. They have done that around childhood disability in the developed world and come up with a variety of statistics associated with that.

But in the developing world, the stats don't really exist. There's too much diversity across these contexts. So it's pretty hard to really come up with exact numbers, though we're working on doing that with some statisticians to SickKids Hospital in Toronto. Now, I could tell you about the tech that we're doing. But instead of doing that, I thought I'd show you this video.

That's a picture of Roseline, the first patient we fitted a couple of years ago. I'm going to show you this video because I think it shows, number one, what the manual process looks like for producing prosthetics. It shows kind of our intervention. And it highlights the kind of effects that we're trying to get.

But I will say that the video is a bit old now, so I'm going to follow up after the video telling you a little bit more about how our technologies have changed over the last couple of years. So I'm going to kick it off here. And hopefully, the audio will be loud enough and not too loud. Runs about five minutes, OK, and then I'll come back and continue to talk with you. Too loud?

[VIDEO PLAYBACK]

[MUSIC PLAYING]

- She was born and her leg was missing the right foot. It was missing. It was very difficult for her to walk, to play also with the other children. She can be lonely. But when she was given a leg, she was able to run with others, play with others.

- When we give a child a prosthetic limb, we're allowing them to walk, we're allowing them to go to school, and we're allowing them to participate in their family and community lives.

- [INAUDIBLE]

- In a place like Uganda, there's a huge lack of [INAUDIBLE].

- For over the past decade, we have [INAUDIBLE]. It would take another 50 years just to train [INAUDIBLE].

- [INAUDIBLE].

- [INAUDIBLE].

- Given the fact that the manual processing period takes up to a week, that means [INAUDIBLE]. In the entire country. And we wanted to see if it was possible to speed that process up using 3D scanning and printing technologies.

We basically created our process, which mimics the cases, the manual process, just in a digital environment instead of a manual environment. Instead of [INAUDIBLE] it means that we can it to capture the external shape [INAUDIBLE]. Instead of rectifying that shape by adding or subtracting plaster, we used 3D modeling software to basically add or subtract those materials.

And instead of wrapping it in polypropylene in kind of physical world, we did something very similar in the digital context, wrapping that shape to create a socket model, which we then printed on our 3D printer.

[MUSIC PLAYING]

So we've tried to kind of parallel or conserve aspects of that manual process into the digital process to also facilitate the transfer of knowledge and the growing expertise of [? processes ?] that are already skilled.

- It's a tough learning curve, actually, because you're learning a lot of new skills about how to operate in digital space.

- They are teaching you to make your work easier. Like you take short time doing your work now. Like you are developing from what you already know, another stage.

- With this method, we could easily [? Skype ?] 80% of the time and produce a new device. That would mean that although there's a shortage of technicians in Uganda, at least for the technicians [? without, ?] we can use the more [? efficient. ?]

- Imagine that a patient needs a socket. Rather than spending a whole week here, you may only have to spend one day here.

- I know I can help my sister when she has grown.

[MUSIC PLAYING]

- This one is faster and more comfortable, fitting the body. When you're moving, you're just move freely. Without any problem.

- CoRSU Hospital, the University of Toronto, Autodesk Research, and CBM Canada have all brought unique skills and expertise to be able to produce a prosthetic limb for a child.

- By bringing those different groups together, it increases our capacity to truly intervene in these what we might call real wicked problems in society.

[MUSIC PLAYING]

[END PLAYBACK]

MATT RATTO: OK. So hopefully that gives you a sense of both what the manual process looks like and what the digital process looks like. I want to talk a little bit about where we've come since those initial days. And I'll just start by talking a little bit about our current impact. So we're currently engaged in the largest clinical evaluation of 3D printed lower limb prosthesis that there's ever been. And in fact, it's one of the largest prosthetic trials in recent years, 4 sites in 3 low income countries with about 200 children and youth.

There's a digital monitoring system providing clinical data. And basically, the results of this is a process innovation, where the development of devices is about 80% faster. It's from about 5 days to really about 1. In fact, we could really do it in about 10 hours, which has these effects of shorter hospital stays and about a 300% gain in practitioner productivity.

But we got there not just by focusing on technology, but focusing on innovation. And I think probably most of the people here in this room would agree that technological innovation can create positive change. That's one of our values. That's one of our initial starting points.

So for us, that really means figuring out ways to move these orthopedic technicians, technologists, and processes from the plaster room, which you see here at CoRSU Hospital in January of 2014, to the design and printing studio. You see an image here of a studio like that at CCBRT Hospital in Tanzania just from October, from our last trial. But technology by itself isn't enough.

And so we have a value about really tapping into local talent. So our focus here really is of allowing local knowledge and local expertise to shape how this work gets done. What that means for us, that's not just a value that we kind of like throw up in the air, we actually have been developing our technologies around those values. So for example, we have developed our scanning technologies initially using the 3D Sense Scanner from 3D Systems now to a structure scanner on an iPad and some custom software in order to allow for and facilitate local people, both practitioners and others, to basically do the scanning process for themselves. That's pretty obvious that we would do that.

But that also means that we really want to make sure that the prosthetists and the orthotist are doing the modeling themselves as well, that the clinicians are basically reshaping these objects around clinical requirements and clinical needs. That's meant that we've ended up partnering with Vorum, which is a company that digital CAD/CAM company dates back to the 1980s that builds a custom suite for prosthetics and orthotics design. While we use Fusion 360 for the modeling of external components, we are not really able to deploy that as a software solution into the developing world context, both because there's some cloud issues and network issues associated with putting Fusion in the developing world, but also because Fusion is a general CAD/CAM tool.

And we don't want our prosthetists having to spend time learning how to use a tool that really isn't suited to their own local expertise. So because of that, we've developed Orthogen, which is a software program that uses the Meshmixer API, automates certain types of functionalities that would otherwise take a lot of time and complexity to actually produce. And I'll show you one of those here in a second and dig a little bit more into Orthogen. And then we also very much believe in local printing, so we deploy dual commodity 3D printers into the orthopedic clinics.

And the idea here is that in those local contexts, they're doing the scanning, they're doing the design and modeling, and they're doing the printing. And that's one of our commitments. Now, as part of that, though, we're not just interested in any local person doing this kind of work, we also really want to focus and support and build capacity for the practitioners who are there.

We believe, we've been told this and we take it as a value, that expertise and practice in orthopedics is actually real, that in fact, not just anybody off the street can produce good prosthetic devices. And so our goal has really been to figure out ways to build on the skills and expertise of the clinicians that are in those contexts, as opposed to deploying a bunch of people who are going to kind of do the modeling without that necessary knowledge. And as part of that, our goal has really been to maximize the time they're able to spend on clinically relevant modeling activities and minimize the time that they have to spend on modeling activities that are not clinically relevant. So I'll give you a brief example of that here with the way that Orthogen works.

So if you see here, what you see here is a prosthetic socket. So that's a modeled prosthetic socket. And one of the things we have to do, this is all custom, right? But that custom object needs to integrate with a bunch of standardized components. So we need to figure out a way to move from the custom thing that's on the body to the standard objects that are in the world. And so we build a connector. We built that in Fusion 360 is where we build all that stuff.

And this needs to integrate with this. Now, the position of that connector actually is relevant. The alignment of the device on the patient turns out to be remarkably important for how well that device works for a patient, how well they can walk in it. So we give the practitioner the capacity to move that connector around and position it properly in relationship to the socket.

That's a clinically relevant design choice that they need to make. But then once that's positioned, they can just push this Join Connector button and it automatically integrates that connector with the model. That activity of actually it's not just a Boolean, might look like it, but integrating that with this thing is a complex modeling activity that would actually take quite a bit of time, particularly when you have to do that without disturbing the internal structure of the socket, because that is clinically relevant.

So they can move it to set the alignment clinically relevant. But then they push the button because that's really an automated task. So that's part of the way that we focus on supporting practitioners by developing design tools that really fit, maximizes their clinical knowledge, minimizes the other types of knowledge they might have to deploy. Another part of that process is that we integrate our systems with the systems they are already using.

So in these clinical settings, they use these Red Cross components. You can see some pictures of them here. And a Red Cross developed process. So we've built our system to sit with the knowledge they already have. So we didn't just ignore what they already know and try to replace it all, we've really built a system that tries to integrate well with it.

Now, other values that drive our work are partnerships and R&D. And those are really actually connected in a lot of ways in our own minds. As part of that or as a demonstration of that as a value for us is the way we've selected and developed our clinical study sites. So as I said before, we have a number of trials running. Those trials are located in Uganda, Cambodia, and Tanzania at a series of local hospitals.

And those trials basically are done, those hospitals are not just kind of clients of ours, they're not just customers of ours, they're really our partners. We iterate our software, we develop our software through the feedback that we're getting from these partners. The clinical trials that we're running, we had a first trial at CoRSU Hospital in Uganda, where we fit 35 prosthetic legs.

[CELL PHONE BEEPING]

We had a second-- I'm actually getting messages from my wife to pick up milk. She knows I'm in Vegas, I think. Anyway. Our second trial, which we started in June of this year, again at CoRSU Hospital, we printed 30 legs and 30 ankle foot orthosis, which is a kind of a brace that's very important for walking. Our third clinical trial we kicked off in August of this year at Cambodian School for Prosthetics and Orthotics in Cambodia.

Again, 30 legs and 30 AFO braces on 60 children. And our fourth trial we just kicked off last month in Tanzania at CCBRT, again, 60 devices. And the idea with all of that is to really get the clinical knowledge and information to move the 3D printing of prosthetics from a proof of concept, which, hey, we can do it, we don't need any more proofs of concepts, to something that can actually be deployed in a sustainable kind of a way in a legitimate way.

Because the other part of this is we've got to convince the ministries of health and all these other organizations that this is ready to be deployed. So again, just some pictures of these trials here. You see here, Jenan, who's prosthetist, and Moses fitting Ruth with a transtibial at CoRSU. This is Samson getting his AFO at CoRSU. Here's some folks, some prosthetists in Cambodia creating liners for their devices. And this is just a picture that came in, well, really last week of two patients being fitted with transtibial prosthetic legs, walking, and testing in Tanzania.

Now, to create that, though, and to get the data that we need, we really had to develop a system that allowed us to do that. And so we used a system called Open Data Kit. Is anybody familiar? Has anybody done anything with that? So it's actually an open source tablet based technology. And what we did is we used open data.

We developed some tablet-based questionnaires. And those tablet-based questionnaires are used to gather data from the patients and the practitioners. And it comes back to us and allows us to figure out statistically how well our devices are working. What you see on this chart here is that with the ability to walk, fit of the device, and patient's happiness, that were slightly above what you get with the manual polypropylene technologies that are currently in use.

Some people might think, oh, why isn't the 3D printed one so much better? Don't computers make everything more accurate and better? I think you all know that these things are only as good as the practitioner. So the fact that practitioners who have been using the manual processes for 10 or 20 years can begin to use the digital processes and produce devices that in fact are better than the manual ones, ever so slightly, is I think a testament to the power of the technology and how well it's working.

And then at the bottom is a graph having to do with the pain associated with using the 3D printed AFOs that we're doing. OK. So that actually is I think the kind of brunt of the technical details and some of the values that I wanted to talk about. I'm turning now to the really the two that I think are absolutely the most important. And that is really the idea of developing technologies for use in the developing world that are appropriate for those contexts and sustainable.

And I want to turn now to a little issue that typically I think engineers and people don't often think about, which is power relations between the global north and the global south. And I want to tell you a little story about how those relations have shaped the work that we're going to do. So when I first kind of started working on this project, it was actually assumed that what we were going to do was send a scanner and a printer to Africa. And the people there were going to scan the patients, send the scans back to us in Toronto.

We were going to have CAD designers and prosthetists and other people in Canada convert the scans into prosthetics, send the models back to Africa, where they would print them. Absolutely great solution. We didn't have to develop any software. We didn't have to really deploy any complex systems.

It would dramatically improve the capacity of those orthopedic clinics. And everybody would be happy, right? Except, all got to do is change the wording of what I just described a little bit and nobody would want to deploy a system like that. And the way that wording would change is the system I just described basically means that the black people do the manual labor and the white people do the intellectual labor.

So not only does that create this kind of power relation that is deeply problematic, as I think you'd all recognize, it also literally drains capacity that is already existing in those contexts out of those contexts. So it does solve the instrumental needs of these patients, but it does so at the cost of losing a generation of practitioners who could be providing services. So our goal here was to say, OK, we're going to reject that model and come up with a model that adds capacity to this context, even if technically it's more difficult to do and we have a slower progression towards the treatment of many patients.

So but that's the ways in which this appropriate technology idea and value really influences the technical choices that we're making as an organization. Now as one other kind of example of that, I just want to point to a kind of a way that we've gone about designing our system that I think people often know about in a kind of a developed world context but may not think about in the developing world context and that is developing software and hardware processes that are designed to work with how labor is done in the context you're working towards. So we call that user experience design or all these other terms.

And nobody would think of deploying a CAD tool to an architectural company that didn't understand how architectural companies relate labor through the organization. Similarly, we wanted to do that. We wanted to really develop a system that worked with the context in these clinical settings in the developing world. And so we did that, first and foremost, by thinking about how the labor associated with making prosthetics is distributed across a range of employees in those contexts. And so there are technicians there. There are technologists there.

There are prosthetists there. And so we designed our system to allow for the kind of pass off of data that they are already used to thinking about. So we have the prosthetists doing the scanning and the modeling. We have the technologists doing this Orthogen phase, where they're converting the shapes into 3D printable models, integrating components. And we have the technicians basically doing the printing.

And the idea here was to really look at the context, look at the social context in these places we were trying to improve and use that as feedback for our design process. By the way, it's interestingly or perhaps not surprising that the division of labor of prosthetics in the developed world is very different. So in fact, if what we had done was look at how prosthetists do their work in Canada or in the United States, we would have designed a completely inappropriate system. We would have broken the way way they train and the way they devolve labor in those contexts.

And actually, I added one more example here at the end simply because of this idea of appropriate technology and sustainable technologies, simply because of the kind of comments and conversations we've been having around machine learning here at this event. I mean, I think Carl Bass in the keynote spoke about generative design and in 3D machine learning as really something that's coming our way. And as part of our project, we've been looking at using machine learning to predict these modeling changes and do so in a way that it creates a recommendation system for clinicians. Now, one reason that we did that is because we had been hearing about other organizations, there's one in Bulgaria, who have claimed that they can create a machine learning prosthetist, a computational blackbox that basically replaces the work of the clinician.

So when we heard that, we said, OK, we've got to build something that starts from a different value proposition but engages with the same technology. And so we built a system. We started doing some research on it. The first thing we found was it was actually remarkably easy to build a system that predicted the rectification steps, the subtraction and addition of material to the scan that is necessary to produce a good socket. And you see here some of our initial research.

So this was we were running a Scikit Learn Python-based program if anybody knows of that, running extra tree regression. And what you see is the original scan. The white areas here are the buildups created by a prosthetist using our toolchain. And that's the prediction. OK. That's probably about 80% accurate.

And that was like our first try. We use some other types of algorithms. We tried linear regression. We got even higher levels of accuracy. I mean, you can see here that not only did they capture this buildup of this region on the tibial crest here, but they even captured like other smaller regions. And there's obviously this kind of chunkiness is something that has to be dealt with. But like this actually scared me.

I was not happy to see this in some ways. I was scared by it because I realized that we were facing, really, the possibility of a system that could be assumed to replace clinicians. I will show you one more just to show it. So this was using TensorFlow Convolutional Learning Network. It needs a little bit more. It's a little harder.

So what did we want to do? So we wanted to take our value system, appropriate technology, practitioner centric, all of these things and build something that supported and came from those values. So we decided we wanted to do was build a system that de-authorized the results of the computer. Made sure that the people using it didn't see those results as better than the work that they could do themselves. Didn't see those results as somehow objectively better than what they did as manual practitioners.

And we decided to do that by incorporating the provenance of the data into our system. We did this in a very simple way. But what was interesting was when we did that and tested that with some of our practitioners, what we found is they stopped seeing the machine learning results as objective and started seeing them as subjective recommendations. They started to see them as just somebody giving them an idea about how to do it rather than a computationally produced accurate thing that was supposed to replace them.

And we did it in a very simple way. And I highlight it to you here just because I'm hoping that maybe other people doing work on this stuff will do it similarly. All we did was we added checkboxes where they could change where the data came from, the training data came from, that was producing these kinds of rectifications. So instead of just getting a blackbox, pushing a button, and getting a result, they now had to choose, was the data, the training data that the computational system was using was just data from them?

Was it just from their local region, say, Africa? Was it just for people from certain levels of training? And what we saw was people started clicking all the boxes. They click one and run it and see what they got. And click another one and run it and see what they got.

And of course, actually, or maybe not of course, but what we found was they created different results. And the prosthetist could read those differences. All of the results were somewhat similar. There'd be a little additional buildup on the patella or there were these little changes.

And what happened was, they stopped seeing them as better. They started seeing them as subjective recommendations, more like Spotify than something you might think of as TensorFlow. So I highlighted those values and talked about those in order to tell you a little bit of a story. Hopefully, there are some takeaways that you guys can use in your own work or in your own processes around innovation technology and additive manufacturing or whatever you're interested in.

But I want to end by kind of highlighting the fact that this is a story of innovation. I mean, we've created some kind of innovative stuff, maybe not entirely deliberately but we have. But a lot of our innovations are not technical. They're not primarily technical. They're not only technical.

They're actually sociotechnical. They come from a place where it's about understanding the fit between society and technology, not from just instrumentally trying to produce a technology that just solves some simple problem. And my sense is that given the complexity of the issues and actually the ways in which simple technological solutionism has really pretty much failed the developing world, a more value-driven approach I think is really necessary to create the kind of solutions and outcomes and capacity building processes that are necessary to solve these problems. So I'll end there. And I'm happy to take any questions. Thank you very much.

[APPLAUSE]

Yes.

AUDIENCE: How do you identify potential partner clinics and, even more so, how do you--

MATT RATTO: Make contact?

AUDIENCE: How do you identify the clinics that you don't want to [? work with? ?] If that's happening.

MATT RATTO: Yeah, so it does. It happens a lot. So I get about 10 requests or so a week from potential clinical partners. We have a kind of a rubric for evaluating those that includes things like, are they an orthopedic clinic? Do they currently treat patients? Do they have the capacity to use our technology?

Have they been trained? Because there are a lot of clinics that have no training in various countries, India, for example. And so we really at this stage, we're focusing on building upon the mechanisms that are already in place. But it's relatively easy because there are these organizations, like the International Society for Prosthetics and Orthotics that kind of operates as a broad network of clinics.

And so we just have to ask a few questions and we can figure out whether or not they're kind of opted into those kinds of systems. And then we have for our clinical trials very much reduced where we've gone. We've looked for places that have relatively reliable, you know, they have power that's up for at least 10 or 12 hours a day. They have surgical capability. They're actually doing orthopedic surgery. I mean, there's a range of those things.

And then we start to build a relationship. And in fact, interestingly enough, all those objective criteria only get us part of the way. A lot of the decisions that we've made in the last year and a half are also based on how well we feel we're communicating with this those places. And that can be a real problem, particularly given the ways in which often the staff in those contexts change.

So for example, CoRSU Hospital that we've been working with for the last 3 years or so, the CEO just quit. And the CEO of that hospital was one of our major ways in which we interacted. But we're OK because we've actually developed this trust relationship with the orthopedic workshop itself. But there's all this financing stuff. So it's often about building trust as much as it is about these objective criteria. Does that help?

AUDIENCE: Yeah. I guess one follow-up questions. Do you expect that in the future when this is no [INAUDIBLE], will you still hold back from, I guess, [INAUDIBLE]?

MATT RATTO: So I'll answer that question by working around it a little bit. One of the things that we've really come to realize is that build it and they will come is not a successful strategy here. A lot of these clinics really struggle with financing. In fact, they all struggle with financing. They often very much struggle with financing because of the financing model of these hospitals, which tends to be they put in a funding request once a year, they get their check once a year, and they live off that money until it ends.

And then they put in another request. And then they're going-- I mean, probably philanthropic organizations in this room are familiar with that kind of model, right? We have to figure out a way to help them pay for devices. And so probably our scaling out activity is not simply going to be one of a kind of a company selling a solution, but of developing a more complex relationship to these clinics.

So we're a nonprofit. We're not a for-profit. We do hope to generate some revenue in order to kind of for ourselves reduce that cycle I just talked about. But the relationship is going to be a longer term one. And so I think we will still be pretty restrictive in terms of who we deploy to and how we do it. Now, one thing that makes that possible is many of the partners that I just described, the ones we're already in these relations have with operate networks of hospitals. So CSPO is part of the seed network, they operate 8 hospitals in Southeast Asia.

So if I expect 30 additional sites, which I do in the next couple of years, I can get those sites actually simply by scaling out from our current context and basically doing a kind of a hub and spoke model. But I think, how do I say this? It's like what I thought, which was you build the tech, you make it open source, that was our initial idea, and then everybody kind of adopts it. And that works. That's a failed model.

That's not going to work. We actually have to develop longer relationships with those clinics. We have to help them with financing. We have to help them with procurement. We have to help them with support. And that's the only way that we will actually scale out, for at least the foreseeable future. Yes.

AUDIENCE: [INAUDIBLE].

MATT RATTO: Thank you.

AUDIENCE: I have more of a sort of a clinical design question. Seeing that, and rightfully so, you're designing for children. But they are growing quickly. So it seems like they need these prosthesis frequently.

MATT RATTO: That's right.

AUDIENCE: So I'm wondering if, A, if there are [INAUDIBLE] choices between the lab or some growth, or B, if the design could be shaped so that there's flexibility for [? strapping ?] or something so that [INAUDIBLE]. If you're doing 60 units over a 5-month clinical trial, it seems like the standard children in 6 months or a year, can possibly [INAUDIBLE].

MATT RATTO: They do. Yeah, about a year, about a year between, depending on the age of the patient. So there's an issue with like the material. So you're right. There's material choices one might make that allows for more flexibility and expansion, for example. The problem is the complexity-- so you think the socket is just a bucket for the leg, that's what I thought initially. It's a really complex interface between the ground and the child.

And as part of that interface, it has to be kind of flexible in some areas and have some give and be extremely static and rigid in other areas. Without that rigidity, you don't get the transfer of power from the muscles of the child. And so if you start screwing around with like more flexibility, which we've done, more flexibility, you end up costing-- there are energy costs to the child. It costs them more energy to move otherwise.

So the kind of rigidity of the device really restricts our ability to use strapping or use these other models to devolve forces. What we do do and what some clinics do is they really-- and it depends on the child-- is they figure out from the child and from the family when they're going to be able to come back to the clinic. If they say, well, two years, they built the socket bigger, they provide them multiple soft linings, and they say, OK, in a year stop using this liner, they use EVA foam liners, and start using this liner. And so it's really a patient-by-patient process about how the prosthetist makes decisions about the devices they're going to produce, which actually goes back to why simply replacing the processes with a blackbox that creates the right shape is an insufficient way to actually develop these things.

But we're really interested in using single materials, but playing with things like variable density. So that's one of the major research things that we've been, in fact, we've finished it, it's working. We build a system, if I can say it in this room, that basically allows you to control regionally the rigidity of the material and the device. We do that by controlling shelling and infill and all those other kind of things. And that's actually now part of that Orthogen software.

And that does give them a little bit more capacity to adjust for sizing issues as children grow. But it's a big problem. But the other issue is, if I can not dig into too much detail here, is children's bodies actually also change not just in terms of growth. And oftentimes children, prosthetic-wearing children, develop things like bone spurs that require what they call refashioning of the residual limb. And so there are a lot of reasons why the child needs to return to the orthopedic clinic, not just that they've grown out of the socket, but they actually may need extended medical treatment, particularly if the amputation is due to trauma, which it often is. Joe.

AUDIENCE: My question is two parts. And it's related to your slide around sociotechnical solutions. That's a very [INAUDIBLE] to summarize. It's kind of matching, or not matching, but appropriately aligning the technological solution to [? the context, ?] which is a very forward thinking way to approach it. And usually, organizations learn that after the fact.

They come in with a solution and then they figure out--

[INTERPOSING VOICES]

MATT RATTO: Oh, wait. Yeah, that's right. Right.

AUDIENCE: So the question is, one, what was the impetus behind you starting from that position? And two is, are there organizations that you think do that well?

MATT RATTO: OK. So I can do the first part easily. The second part might be harder. The first part is so that idea of matching technology to the social context, it's not a new one, really. People have been thinking about that for a long time. And there are even design disciplines and practices that have formed around that, like experience design or service design is another one that gets used quite a bit.

For me, oftentimes, the problem is the scale of what they include in the context is too small. So a lot of design processes, particularly around computational systems, ends in a micro-transactional account of the device and the single practitioner. Like, we know that's inadequate. Most people now know that that's inadequate.

They now move to the small group or the collaborative small group, but that's inadequate too. What I actually am really interested in is, how do we get that social context scaled out to include society? And for me, the example of that global north, global south, like building a system that maintains power hierarchy requires thinking about social context at a global scale. Why did we start from there?

Well, I'm not an engineer, actually. Although, I was an engineer before I went back to school, I'm not a designer. I'm a social scientist. I did my PhD in a thing called Science and Technology Studies, where we are supposed to study and then write articles about how badly engineers are screwing up the world. Like, I mean, that's literally-- and scientists, scientists are also screwing up the world. We're supposed to be critiquing it. So I spent years doing that. It's like, large-scale genetic databases, boo, they're doing all these bad things.

And all of a sudden, I realize, well, maybe I need to actuate that. And so my starting point was, how do I create a design process that solves a real-world problem but does so at scale, incorporates that broader social Context So that was our starting point.

Organizations that do it well, I don't know.

I think design that matters, Tim, who I have known about for that organization, if people know of those guys, they had the Firefly, which is this blue light thing for jaundice, treating jaundice. I think they think it's scale. I met, I talked with Tim, the founder, I guess he is, for the first time. And I was very taken by the fact that he had come to these same conclusions that I got to through my social research that he got it through experience, like you just said. But we really shared like, oh, yeah, you got to think at scale.

And how difficult that is to do so, particularly when you're dealing with market forces. And in fact, that issue is one of the reasons why we're a nonprofit not a social enterprise. Because we weren't convinced or sure that we could maintain that idea of designing at scale, designing it with this broader sense of social scale if we were constrained by the ways in which market might treat us. But then it creates all these funding issues, right?

So now, like, OK, how do we do? We can't raise VC. We can't do all these other things. So the problem of incorporating broader social context into design problems is itself a problem that requires thinking about broader social context, if that's not too recursive. Does that?

AUDIENCE: Yeah, yeah.

MATT RATTO: OK. Can I answer any other? By the way, I was going to tell you, anybody who is interested, I'm happy to demonstrate the technologies that we produced. I even have our little scanner with me. And I have all the software running on this computer. So if people are interested in that, I'm happy to do so.

Probably not in this room. We'd have to find some place out there, but I could show you how Orthogen works and some of the other technologies that we've been developing as well. You have another question, Joe?

AUDIENCE: No, I was going to say, did you [? do that? ?]

MATT RATTO: I did. Yes. Yes, I did. But I feel like there's like 7 minutes left. And I have to fill those 7 minutes because if I don't, then Autodesk gets mad at me. OK. People, feel free to leave during the question period. I don't mean to hold you here, but I'm happy to address any more questions. Yeah.

AUDIENCE: You talked a little bit about the difficulty of [INAUDIBLE] funding. And you also said that [INAUDIBLE]. So how does that work for them?

[INTERPOSING VOICES]

MATT RATTO: Capital costs aren't the problem. Capital costs are not the problem. It's the ongoing costs of producing the devices that are the problem.

AUDIENCE: OK. So what's the per unit cost?

MATT RATTO: Minimal. The per unit cost for the materials, $3, $4 a device. Part of that is because of great support from organizations like Taulman that produces 3D printing filament. And we have a special deal and relationship with them. The labor costs are a huge increase in productivity, so those go down from the standard device. But really, each device costs about $300 to make, all in, including these ICRC components.

And so they really have to figure out ways to fund that ongoing $300 cost on a per patient process. So that's really the issue. It's relatively easy to raise, get money and hey, hey, we want to put 3D printers in these clinics in order to print devices for children, will you give us $10,000? Like that's not so bad. It's the ongoing sustainable operations that really require some kind of novel thinking around models.

One model that we've come up with is a voucher program that would help clinics find the money to fund on a per device basis. But I'm open to any suggestions, right? In the end, it is about children and it is about getting them the devices they need, so we'll probably raise through a number of philanthropic activities. But I do want to figure out a way where that can become a sustainable operation. They're doing some of that work themselves.

Many of these clinics are now creating for-pay services. They've always been free services and now they're creating for-pay services as a way of subsidizing their free services. I'm not quite sure how I feel about that. But it does point to what Christian was talking about, I think during his keynote or during some of the different activities I've seen him in, Christian from Africa Design Center, if people know him, talking about the growth of the middle class in Africa.

We certainly see that. And the clinics that we work with are also responding to that. So maybe that will help. Anyway. Thank you all very much. I'm happy to talk with you in person if you want.