



Cool Tools Show Podcast Episode 096: David Lang

Transcript

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Our guest this week is David Lang. David is an entrepreneur, writer, and National Geographic Fellow. In 2012, along with Eric Stackpole, he co-founded OpenROV to create a low-cost robot to explore an underwater cave. Since then, OpenROV has raised over \$900,000 on Kickstarter and has become one of the largest underwater drone manufacturers. The team also created OpenExplorer as a digital field journal to empower and connect citizen scientists and explorers. David is the author of Zero to Maker. Part memoir and part guidebook for participating in the growing maker movement.

Mark: Welcome to the Cool Tools Show. I'm Mark Frauenfelder, editor in chief of Cool Tools, a website of tool recommendations written by our readers. You can find us at cool-tools.org. I'm joined by my co-host Kevin Kelly, founder of Cool Tools. Hey, Kevin.

Kevin: Hey. It's great to be here.

Mark: In each episode of the Cool Tools Show Kevin and I talk to a guest about some of his or her favorite uncommon, and uncommonly good tools they think others should know about. Our guest this week is David Lang. David is an entrepreneur, writer, and National Geographic Fellow. In 2012, along with Eric Stackpole, he co-founded OpenROV to create a low-cost robot to explore an underwater cave. Since then, OpenROV has raised over \$900,000 on Kickstarter and has become one of the largest underwater drone manufacturers. The team also created OpenExplorer as a digital field journal to empower and connect citizen scientists and explorers. David is the author of Zero to Maker. Part memoir and part guidebook for participating in the growing maker movement. Hey, David. How's it going?

David: It's going great. Thanks for having me.

Mark: Yeah. Absolutely. So we've got a great list of tools to talk about this time and the first one on the list is the Garmin inReach device. I don't even know what that is, so I'm excited to hear about it.

David: Yeah, so I gotta be honest. I don't actually own this tool. My business partner and teammate, Eric Stackpole, has one and he has convinced me that this is the coolest tool and he's let me borrow it a number of times. And I have to agree, it is the one tool that he has that makes me think, "Yeah, Eric is definitely cooler than I am." So what it is, is it's a satellite hand-held GPS navigator. So what it does is you can be anywhere in the world, totally off the grid, and it's going to bring up a map and show you exactly where you are. It communicates using the Iridium satellite network, but it also serves as a two-way communicator. So you can text anybody from anywhere in the world no matter where you're at.

It's pretty amazing and it comes in handy in surprising scenarios and my experience over the past five years as we've kind of gone on these expeditions with these underwater drones is that connection is just absolutely necessary. And I think there's been a lot of press and stories around trying to shut off your phones and get outside, but I think the reality of the world we live in is connections is absolutely vital and this device it's fairly cheap. It's a couple hundred bucks and then you have a monthly payment plan. But it keeps you connected, whether that's through emergency or you're going off the grid or whatever comes up. So that's my first device.

Kevin: So, you say a couple hundred dollars. The website says it's \$450. What kind of a monthly do you think it is? Is it \$10 a month or is it \$50 a month?

David: The cheapest plan is \$15 a month.

Kevin: 15, okay.

David: And I find that's really all you need. I mean that's what Eric has and when I borrow this to go on these different expeditions I need to send off usually one or two text messages to put out a fire or if Eric needs to get in touch with me he can use that. So the \$15 a month is plenty, but if you're out there a lot I could see how something like this would be much more useful. And you can send a pin to your friends and family and say, "Here's where I am. Everything's okay." That kind of thing.

Kevin: And the text works is that you have your own separate text number other than your usual phone. This would be a separate number that they would text to the device?

David: Yeah, exactly. It shows up as this weird number, but you're able to send your message through that and it's got a link to the map and to the message.

Kevin: And the map is like a Google Map quality, at least?

David: Yeah. I mean it's the Garmin map. So it doesn't look like Google Maps. It looks like the kind of Garmin terrain maps. But depending on where you are, often times that's actually a little bit more useful than topographical maps.

Mark: I see it has something called ... It has an SOS button and it says, "Trigger an interactive SOS to the 24/7 search and rescue monitoring center." Do you know anything about that?

David: Yeah, they have this service where if you get in trouble and you need to send a message to this service, they'll come and get you anywhere in the world. I've never had to do it, so I don't know actually how well it works, but if you read the reviews on Amazon, or wherever, that's what people talk about is, well, this thing saved my life. This thing was a huge ... this thing basically kept us alive because we were able to send this SOS message. I can't speak to exactly how it works. I don't know if a helicopter shows up and people come down the line to pick you out of wherever you're at, but I know it does have some service like that. I'm sure it's really expensive if you pull it.

Kevin: Boy.

David: Pull the trigger.

Kevin: I like the idea of having one of these to share, because I mean you probably don't spend a lot of your year in a place where this would be necessary, but you might. But if you had a group of 5 people or 10 who were kind of out a lot, you could have a co-op or you could rent it maybe, to some extent. Have you heard about that? About just kind of having-

David: I think that's a great idea. I haven't bought one myself because I've always had Eric there. So it actually works really well because if I'm going somewhere I can take it with me. If he's going somewhere I know how to get a hold of him. I totally agree. I think that's the case for a lot of these adventure tools. So we make these underwater drones, so we're always going off and looking for different things. But some of these tools are really expensive and you only need them once in a while. So it does make sense to kind of have them as an access, rather than an ownership model.

Kevin: Right. Right.

Mark: One thing that looks pretty cool about it is that you can pair it with an iPad so that you can see the maps larger.

David: Yeah and you can kind of sink up-

Mark: That's really useful.

David: Yeah or if you want a bigger screen to type a message that's absolutely true. You know if you're hiking, you're backpacking, a lot of times it doesn't make sense to kind of carry that much gear. But if you have underwater drones and you're controlling them with the iPad or the Android Tablet, you already have those devices with you.

Kevin: And also I would guess work in the oceans, unlike any cell tower that I know, right?

David: Yeah, exactly. And you know if you spend a lot of time on the water-

Kevin: Even in the ocean you should still be able to get some sense of where you are.

David: Yeah and a lot of sailors, and if you're doing circumnavigations, will have satellite phones and you can start to get into some more expensive tech through that. But for the base, like if you're just going out and doing coastal sails or going up and down the coast, I think this is the perfect tool.

Kevin: Cool.

Mark: Looks like a good one.

David: There are more expensive ways to stay in touch anywhere in the world, but this one is I think is the best bang for your buck as far as the lower cost end of the spectrum.

Mark: And I understand with a Radium network you kind of have to be outside with a clear line of site to the satellite network. Is that right? It doesn't work inside a house or car or something?

David: Yeah, correct, and it can take 10 minutes, 15 minutes, for some of these to go through. So it's not instantaneous. You're not waiting on the dot, dot, dot of a text message. But it works. It works.

Kevin: Great. Cool tool.

Mark: Very good one. How about Where the Animals Go? What's that?

David: So this is a book and it is I think a cool tool, but it's also definitely a Wink book. It's one of those things that you want to hold and look at. And I know that Wink is kind of the companion site, so I wanted to include it. But it is a collection of 50 stories and it's put together by a cartographic designer and an ex-National Geographic writer and they go around the world and tell the stories of scientists who are tracking animals using all sorts of different technologies that have kind of just become popular. And the book, aside from being beautiful, is actually pretty interesting.

I know one of my favorite books that I write about in Zero to Maker is The Toaster Project, which Kevin and I were talking about this. This guy who tried to build a toaster from scratch. And the book turns out to be this wonderful time capsule of where we are in this kind of modern complex civilization. Of how hard it is just to build a simple \$5 toaster. And this book achieves something similar. It uses all the latest technologies and each story kind of follows a different animal. It's like where a pack of baboons are going. How the mountain lions are traversing through California. How the humpbacks are going around seamounts and it starts to talk about birding and just the different things that have happened in ornithology over the past half-century. It's no longer just people with telescopes. These birders are out there wired up and they're measuring the flora and fauna on this planet in an incredible way.

So the book is one, it's delightful to hold. It's delightful to read. The stories are great. But it's also really inspiring and I think there's a lot of things, especially towards the end, that will inspire you to kind of go out and want to start kind of tracking and following individual creatures wherever you are. So that's what the book is and it kind of leads into the next cool tool, which is iNaturalist.

Kevin: So actually I have Where the Animals Go and I actually have to concur that it's this wonderful convergence of the wild and outdoors. No technology and high technology where you're putting your radio transmitters and GPS and stuff and then the whole mapping aspect. So it's this fantastic union of the digital and virtual embedded into the most physical and primitive, or primeval, and I think it's just beautiful. Just conceptually, in that sense.

David: Yeah, and like The Toaster Project, it captures a place in time, because it goes through all the current technologies that we're using, which are these radio-tags and these acoustic trackers and collecting photographs from a number of different people. And it's all of these animals that we've known about for a long time, but you start to see with these new tools that we get this granularity that we haven't had. At the same time, a lot of these species are endangered or are potential going extinct. So having this kind of increased granularity of exactly how they're living at this moment where we might lose them, is really an interesting, like I said before, time capsule.

Kevin: Right, and it is remarkable how little we knew about things like bird migrations. I mean we just had really no idea where they were going. How long they did. How they got to where they were going. And all these new tools are allowing us to kind of see that and it's a little bit like the kind of stuff that you're involved with the underwater drones, which is it's a tool for us to look into places we've never seen before and to see with eyes that we've never had before. And that's always really beautiful I think.

David: Yeah, and to me, the best part about is that we're on the edge of understanding a lot of these different species and creatures and communities. You know there's still

so much we don't know and the tools for understanding them have become more accessible than ever. This is one of the things I learned in the maker movement was all of the tools that we were playing with. The Arduinos, the 3D printing. Scientists didn't have access to that. They didn't know about those technologies either and as soon as they've gotten their hands on them, they've started to ask really interesting questions. So, this book really encapsulates all of that.

Kevin: Fantastic.

Mark: And that's great. So you said this is kind of related to your other pick, the iNaturalist.

David: Yeah, and the iNaturalist is an app and you can go to the app store and download it. It's free. Pretty simply, it's just a camera app and you go out and you can snap photos of birds or bugs or plants or whatever, and you can upload it to iNaturalist. And it's been around for probably almost a decade at this point. It's now at The Cal Academy of Sciences and there's an incredible team there. And for the past 10 years what it has been is you go out, and you make an observation. You snap a photo and you say, "This is a butterfly." Or, "This is a fiery skipper." Or, "This is a cabbage white." You could identify the actual species and if you didn't know what it was you could say, "I don't know." And the iNaturalist community would come in and there's these naturalists all over the world who kind of sit and monitor and go in and say, "Oh, actually that is a nodding trillium." Or, "That's just a common land snail."

So there are these people who will go in and kind of either correct you or help you with your identification. And for the past few years that's what this tool has been, but just in the past six months what's been really amazing is this tool has evolved. So they have so much data. They have so many photos and identifying metadata information about these animals that they started applying some of these machine learning techniques to these photos. So what iNaturalist is now, is you can go outside and you can snap a photo of some creature that's in your backyard, or some plant, and the iNaturalist app will actually generate a suggestion based on all of this A.I. And it's remarkably good.

It still has a ways to go, but it's surprisingly good and it's really fun because this is kind of the ... You know I'm kind of a wannabe scientist and I'm not great with identifications or bird calls or any of that stuff. But this tool actually makes me feel like I know what I'm doing because I'm able to snap a photo and get an identification right away. If you haven't tried it yet, it really does feel like magic. It's almost like Shazam where your phone is able to identify the song. It feels that magical. So if you haven't tried it, iNaturalist, highly recommend it.

Kevin: And I think the A.I. is off on The Cloud so that you need to be connected for it do that ID.

David: Yeah, correct. It's not doing it on your phone. It takes a few seconds, but it's pretty fast.

Kevin: Yeah. This was the dream that we wanted to have when we were doing All Species was to have this little device that could do these IDs. Because what that allows you to do is that if you are doing it and what you've picked up is known, when you come to something that isn't known, that's really big news. So that enables the amateurs to actually participate in trying to discover new species instead of just rediscovering them again and again. The app can actually do away with that rediscovery just by saying we know what this is, it's a land snail.

David: Exactly. But the other thing about that is the community aspects are pretty powerful and I'll give you two examples. So one are they have these bioblitzes that are happening all over the world all the time. So you can kind of go on the events page and see when the next bioblitz is happening in your area and go out and actually go out with a group and see how many different species you can identify in a given time. And I think that kind of bonding of getting people together and identifying together, was a really important part of getting over the hump of how do you get people excited about this tool. So they did a really good job with that and it's actually a really fun experience.

And if you look across all of these different sciences that have big, amateur populations that are contributing, whether that's astronomy or ornithology, they all have these community aspects. Like you can go out with the Audubon and go bird watching and it's a fantastic community. Or you can go to a star party and see what kind of telescopes people are building. So I think that's a really underrated component.

The other thing that it does is scientists are able to go on there and say, "Hey, we haven't seen this species in this area for a long time. Keep your eye out for this." They can kind of hint people at what would be an interesting find and where that species would be interesting to be found. So it kind of sends people on these missions to find the different things in their area.

Kevin: That's cool.

Mark: Very cool. So is it a combination of A.I. and then crowdsourced identifiers?

David: Yeah. So right now the A.I., I mean it's kind of the hip new thing and it actually makes the app fun in a way that it wasn't as immediate before. You used to have to wait like day or two for the naturalists to kind of come on and actually go through and look through your spotting to see what it was. But now you get this kind of instantaneous feedback. There are still naturalists who are going through and kind of double checking. Like I said, it's not perfect yet, but it's really good and it's gonna be getting better all the time. So, Kevin thinking about ... When were you guys doing the All Species project?

Kevin: In the early 2000s.

David: I don't know if at the time, I mean from what I read about it and my understanding is it kind of came to the point of this is just a lot of work. Like you would just need thousands of people working all the time to try and actually do this. I mean is that true? I don't know exactly how it kind of evolved or ended?

Kevin: Well, yeah the idea of the initiative was to actually try to raise some money to develop new tools to make it happen. At the same time to try to raise some money to fund barefoot taxonomists in the countries that they were living who might actually know more than other people. To kind of employ them as amateur taxonomists. But neither one happened. We weren't able to raise the money and it was just a little early. There was no A.I. available. So it was just too early in trying to make that tool. So it was premature.

Mark: Yeah. So, David you wrote a book a few years ago, maybe five years ago or something, was Zero to Maker. When did that first come out?

David: It came out in 2013. So I did a Kickstarter project for the book Zero to Maker and it came out in 2013.

Mark: Okay. It basically chronicles kind of your journey, like the title suggests, from somebody who never really considered themselves to be a maker of things to someone who wanted to learn how to use these kind of new suite of tools and technologies and stuff to become kind of a generalist in making stuff. You've got a new addition that's coming out this month. Tell me about what's new in this one.

David: Yeah, so the book is largely the same. It tells the story of how we begin our OpenRV project. So the actual history was I met this guy named Eric Stackpole who told me this story of this underwater cave in the Trinity Alps in Northern California and said, "Hey, there's rumors of gold in this underwater cave and I want to build an underwater robot to explore." And I just thought this was the most fun story I had ever heard. The big problem was that we didn't have a robot that worked. So we started sharing our designs online and showing up at Maker Faires and asking people to help us design and build this underwater robot.

So through that whole process, we met all these amazing people in the maker movement. So we'd show up at makerspaces, like TechShop and Noisebridge, and we shared our project online on Kickstarter and raised the first \$100,000 to start building these DIY robot kits. And the Zero to Maker story is the story of how kind of the company got started. So how do you go from not being technical, not having an engineering background, to having an idea for a product and bringing it to life and bringing it to life in a way that involves a lot of other people? That creates a company and that kind of stirs a movement around whatever it is you're interested in. In our case, it was underwater robots.

That was four years ago and the maker movement has kind of come a long way. I would say it has matured in that time span where I went back and looked at all the different tools that I had written about in the book and they almost all needed to be updated because there had been newcomers or things had changed. So I just went through the book with a new eye and figured out which tools I thought were still the best in class. The best to recommend for somebody who was just getting involved.

And I also added an entirely new chapter on citizen science, because as I was saying earlier, I noticed all of these scientists who were starting to see these tools and to start asking interesting questions and all of these makers who were kind of looking for the next thing and thought, "Well, you know what, I'd actually like to contribute to this branch of science." Whether that's building DIY biotechnology or building forest listening devices. People were asking interesting questions and so I added a chapter about that.

Kevin: So you've actually gone on to make this underwater robot, this drone. Can you tell us a little bit about that because I think that's your fourth tool? What can you say about that right now?

David: Yeah, so the fourth tool I included is the OpenROV Trident and this is the newest kind of product from our company, OpenROV. And it's not quite out yet. We're starting to ship the first beta units right now and we'll have those shipped hopefully, by the end of January. We gotta get through the entire backlog. But we've spent the past two years, two and a half years, working on not just a DIY kit of an underwater robot, but an actual product. And the reason I brought it up is because it is actually a really cool and fun tool and I can't wait for the world to try it out and to start to send back videos and stories. But also for me personally, it's been an incredible learning experience. To go from the Zero to Maker thing not knowing anything and now to building and shipping products, actual hardware products, all over the world. So it's been an incredible learning experience.

Kevin: So if we describe this thing for our listeners, I don't know, it seems to be about the size of a bathroom scale or something. I don't know how you would ... Approximate size maybe half a meter by a third of a meter or something. It's an appliance.

David: It's like a thick laptop.

Kevin: Thick laptop and it's connected with a chord. It has a long cord, a 100-foot cord or something. But it's self-propelled and it has its own lights. So you steer it underwater and it's going through wherever you're steering it to and then it has a camera. So it's gonna stream back through the chord a movie, pictures, of what you see. So it's way of diving without having to dive in places that may be dangerous or just difficult to get to or too deep or something. Is there anything else you wanted to add to that description?

David: Yeah, so that's basically it. It's a swimming camera that you can control from the surface, and you have to use your phone to see what it sees and you can drive it around and control it from there. It can dive to pretty deep depths, a 100 meters, so 328 feet. And most divers aren't going more than 60 feet, 100 feet, so you're actually getting into territory that most divers don't go to. Some can, of course, but most aren't going to.

So everyone always asks about the tether. They say, "Why does it have the cord or the tether?" And the answer is that radio waves don't travel well through water. So if you want that live video, if you wanna get that feeling of presence with this underwater robot, you need the tether. So that comes up to the surface to this little Wi-Fi hotspot and you can basically login from your phone from there.

Kevin: And the resolution of the camera, is it kind of like what we would call 4K?

David: Our camera is not 4K. That's a good question because the reason we didn't go with the 4K camera is we decided we wanted a camera that had really special kind of low-light capability. So when you get into these darker areas that it can pick up more light. So we couldn't find a 4K camera that had the low-light capabilities that we wanted. I've seen a lot of Chinese kind of knock off competitors now that are saying, "Hey, we've got a 4K camera." But they're just not gonna have the kind of low-light performance that we are. So it was an interesting discussion because it is kind of a nice marketing thing to go and say, "Hey, we have a 4K camera." But ultimately we wanted the best image and that's what I think we're doing.

Kevin: When it does go on sale, just give me the price range of what you're expecting it to cost?

David: So, it's \$1,500. So it's about the price of a laptop as well. And that comes with a 25-meter tether and you can use whatever device you have to control it.

Kevin: You say it's a 25-meter tether, but you can go down a 100-meters. How does that work?

David: Yeah, so we sell the additional, if you want to get a 100-meter tether-

Kevin: Oh, I see.

David: ... with a reel we have that as an addition as well.

Kevin: As an option, okay.

David: Yeah.

Kevin: Well, really cool. I definitely want one.

Mark: Yeah, they're really great.

Kevin: The swimming camera. I like that.

David: Yeah. So to give you an example, I live in Sausalito and one of the things that is happening in and around the San Francisco Bay right now is all of these leopard sharks are starting to die off. And there've been, I think, over a thousand deaths of these leopard sharks in the Bay in just the past few months and they think this brain parasite, but they don't really know. They also don't know how many sharks have died because they're negatively buoyant. So when they die, they sink to the bottom.

So what I've started doing is going out on my little kayak and sending the robot down and trying to get video of the seafloor, trying to collect data. I'm gonna submit that to iNaturalist. It's kind of the full circle of all these different tools.

Kevin: I like the idea of having a kayak where you have your swimming camera trail you or parallel you. That would be great.

David: I think that's the big thing with our robot. I mean underwater drones, or ROVs, remotely operated vehicles, have actually been around for 20 years. They've been around for a long time. But they've just been big and expensive. They've been used by oil and gas industry and the military and all sorts of big industrial uses. And we've just taken all the latest technology that's in our cellphones, the sensors, cameras, and put it in a much smaller package. So it fits in a backpack. You can take it out on a kayak. You can bring it in carry-on luggage. There's all sorts of opportunities and potential.

Mark: Tell me about some prototyping tools you have in your shop that you really like that have made it easier to build prototypes for the ROV?

David: Yeah. So the original OpenROV kit was a laser cut shell and then a small acrylic tube just filled with different electronics. So when we started the Raspberry Pi hadn't come out yet. So there weren't the miniature Lynx computers. So we were waiting for something like that to come along and when it did, we jumped right on it. So basically it was just a laser cut box that housed all these different electronics and then these brushless motors that we figured out could work okay under water. But the laser cutter was a godsend. We started off using the laser cutter at TechShop and then eventually got our own and we're still manufacturing and building those kits right there in our lab in Berkeley. And we're still using that laser cutter all the time and we're still always prototyping new ideas. We have 3D printers, of course, but the laser cutter is really the workhorse.

Kevin: Do you have a recommendation if someone wanted to buy one themselves? Maybe they were intending to do a project like this, prototype, would you have a recommendation for a laser cutter that you recommend?

David: So if I was just getting started, I would go to a makerspace and use the laser cutter there. I mean it's just like the satellite communicator before. If you're not using it all the time, it's probably better to borrow, or rent, the time on one of those. But if you are looking to buy one I think we're starting to see the consumer laser cutter. I haven't played with them personally, but I know the Glowforge laser cutter is starting to ship and people are saying a lot of good things about it. I think Dremel just came out with a desktop laser cutter.

Mark: They did.

David: Have you played with it?

Mark: No I haven't and I've just seen the Glowforge at Maker Faire and I had Dan Shapiro come to Institute for the Future with one. And I'm just so impressed with the ease of use of that thing.

David: Yeah, it's amazing. You know experience makers will tell you that the laser cutter is probably their favorite tool. It's easy. It's fast. The trick with making it an actual desktop product has always been kind of the safety and kind of the off guessing and making sure you don't run into any problems there. So it sounds like they've solved those problems. I met Dan and he takes that so seriously. So I can only imagine that they've got it figured out.

Mark: Yeah, I think so. They have a version that has a filter, the HEPA filter, that's integral to it or attachable and then the other kind is just a hose that vents outside. But it's cool. What kind of 3D printer are you using?

David: We have a LulzBot that we really like.

Mark: Yeah, okay.

David: And we have an Ultimaker. You know what, I would say the Ultimaker gets the most use right now.

Mark: I have a Prusa that I'm happy with. Have been using that quite a bit.

David: Do you ever use Shapeways or any of those kind of services?

Mark: I've not used Shapeways, but I've used Ponoko for laser cut things. I mean that's another thing if you want one level higher than going to a TechShop to borrow their laser cutters, is to use Ponoko and you just send them your file and they'll laser cut it on any material you want and then send it back to you.

David: Yeah, interesting. So when we were prototyping the Trident, all of a sudden the tolerances got much more serious and then kind of the desktop 3D printing wasn't

quite enough for us. So we started using the Stratasys service. But what we actually found is that we could go to China, we have contacts now in Shenzhen, and they have these CNC farms. And they'll just CNC the plastic parts that we need out of basically just blocks of plastic and it's so much faster. The turnaround was amazing. That's what we ended up using actually as a service, were these big CNC houses in Shenzhen. So I don't know if that's an actual service yet, but I can imagine that something like that is coming.

Kevin: So wait, you were using it, but it wasn't a service? I'm really confused. I mean-

David: Well, we found kind of a shop. It's not like you can go online and-

Kevin: I see.

David: ... you know submit your part. I know people are working on that. Like Plethora is doing a lot of really interesting CNC machining here in San Francisco, where you'll be in your CAD program and you just hit print and your part will ship in the next day or two. So I know that kind of automation and service is happening. Plethora is a great example for metal parts. But for us in plastic, we found this group in Shenzhen that could do it just so much faster. So I would venture to guess that that kind of service is coming. It might already be here. I just haven't seen it.

Kevin: And Plethora is a place that is available for a service right now, but for metal?

David: Yeah, exactly. Plethora right now.

Kevin: Okay and you could go online?

David: We don't have many metal parts, so we don't use them. But I know that a lot of people are.

Kevin: Okay. So presumably you could find that online then.

David: Well, you know it's just so interesting because I wrote that book in 2013 and so much was changing and so much was happening. But the tools right now really have matured and all of these services are available now. And I really I think it can't be overstated that is the best time ever to be a creative person, to be an inventor, and to have an idea and to bring that to life. Everyone always says, "Hardware's really hard." But it really is a miracle that you can just have an idea, like Eric and I wanted to build these robots and explore with people all over the world, and here we are five years later and we've kind of done that. And that's a pretty cool thing to know and to be able to tell other people.

Mark: I agree. The world of prototyping tools and low-end, or small part-run manufacturing, and also things like the Raspberry Pi and Arduino, have made it so that you don't even really need an engineering degree, or something, to create

something interested anymore. You just have to be passionate about it and you'll get it done.

Kevin: I think in the next 20 years, maybe 30 years, the next step will be full-scale simulations of your product with physics. So that you can actually do basically a CAD model of it, whatever you think it is, and then test it to some extent before you even build anything or test versions of it as you go along. I think that'll be the next layer.

David: Kevin have you seen-

Mark: Definitely.

David: Autodesk has done some really interesting stuff with A.I. and kind of generative design, where they're just putting in the parameters. Like we need a chair that will support this much weight and it actually lets this software design the product. And it's coming out with all of these bizarre shapes that actually make a lot of sense, but it's nothing that a human ever would've designed. Especially now that we have 3D printing and you're not constrained by ... So I think it's gonna be weirder than that. Where it's not like they test the physics, but you just say what you want something to do and it'll design something completely surprising.

Kevin: Yeah. Actually, I wrote about that in Out of Control. So I hadn't seen the stuff at Autodesk, but I've been waiting for it for 30 years.

David: There's a great TED Talk about it by Maurice Conti that kind of goes through all the stuff they've been learning and these guys are really on the cutting edge. So it's pretty cool.

Kevin: Yeah. Yeah. Well, thanks David.

Mark: That's so cool.

Kevin: This is very, very, inspiring.

Mark: Well, David this has been so great talking to you.

David: We'll have to go out exploring with the underwater robot sometime.

Kevin: Absolutely.

Mark: That'd be so cool. David, thanks so much. Your new book, well the second addition to Zero to Maker, should be out by this time this podcast runs. So you can check it out in the usual places and where can people go to find out more about Open ROV?

David: So, openrov.com is the best place to go to find out about the bot. But if you wanna see what people are doing, and exploring, go to openexplorer.com and that's got all of these wonderful citizen science stories that you can actually follow along with, but also get involved with. So that's another good site.

Mark: Sounds great. Thanks so much.

Kevin: David, it's been great. Thanks.

David: Thanks Mark. Thanks Kevin.