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**SCOTT URMSON:** People talk about Silicon Valley engineers being risk-takers. I think it’s actually the opposite. It’s the realization that if you go and try one of these things and you’re actually good at what you do, if it fails, it fails. You’ll have a job the next day at somewhere else, right? And you’ll have this wealth of experience that people will value.

[MUSIC]

**KEVIN SCOTT:** Hi, everyone. Welcome to Behind the Tech. I'm your host, Kevin Scott, Chief Technology Officer for Microsoft.

In this podcast, we're going to get behind the tech. We'll talk with some of the people who have made our modern tech world possible and understand what motivated them to create what they did. So, join me to maybe learn a little bit about the history of computing and get a few behind-the-scenes insights into what's happening today. Stick around.

[MUSIC]

**CHRISTINA WARREN:** Hello, and welcome to our first episode of Behind the Tech in 2020. I’m Christina Warren, Senior Cloud Advocate at Microsoft.

**KEVIN SCOTT:** And I’m Kevin Scott.

**CHRISTINA WARREN:** All right, so, Kevin, it is 2020, which is both the new year and I guess a new decade, although people will get weird about the technicalities. It’s always a great chance to kind of look back at what’s happened over the last 10 years and reflect on new opportunities.

**KEVIN SCOTT:** Yeah, I mean, it is I think in our industry, and for human beings in general, really easy to get completely used to new innovations that enter our lives. But when you think back 10 years ago, the world looked like a very different place than it looks right now.

So, smart phones were just catching on. They were nowhere near as ubiquitous as they are right now. And the things that you could do on them were far, far more constrained than they are right now. I mean, for god’s sake, people were renting movies from Blockbuster in 2010.

**CHRISTINA WARREN:** Right. Right. Blockbuster was actually still a thing. And Instagram hadn’t even been invented yet. Totally different world. Like, you know? Do you -- now that we’ve hit 2020, do you have any forecasts about what the next year in tech might bring, or even the next decade?

**KEVIN SCOTT:** Well, I think one of the themes that we spent a bunch of time chatting about last year on the podcast was artificial intelligence and machine learning. And I think we are certainly going to see the trends that had started in the prior years continue to accelerate. That’s one of the reasons why I’m really interested in chatting with our guest today.

Autonomous vehicles, for instance, I believe are going to make a ton of progress over the next couple of years in particular. And I’m just sort of really looking forward to seeing some of that stuff play out.

**CHRISTINA WARREN:** Yeah, I couldn’t agree more. It’s funny. I don’t have a driver’s license, but I’ve actually been on a few self-driving car panels over the years. I think the technology behind it is so fascinating, which is why I’m really, really excited about your conversation with today’s guest, Chris Urmson. And Chris is an engineer known for his work pioneering self-driving car technology.

**KEVIN SCOTT:** Yeah and you know, one of the reasons that I’m especially interested in self-driving cars and looking forward to this conversation that we’re about to have with Chris is that there are so many ways that the world is going to change for the good once we are able to put this technology into the hands of lots of different companies.

One of the things that we’ll hear about Aurora is they are a company building the self-driving car technology as a platform for other companies to use to build autonomous applications. And so, you know, like one of the things that I’m sort of hopeful that will come into the world in the not-too-distant future is some technologies that may help my grandmother.

So I’m lucky enough to have a grandma that’s still alive. She’s 89 years old and lives in a very rural place in Virginia. And she can still drive, which is awesome, but the day is coming where she’s not going to be able to drive her car in the same way that she is right now. And then it begs the question of how she has access to all of the things that she needs in order to help her live an independent life.

So, how does she get her prescription medicines? How does she get her groceries and just sort of the staple things that she needs to exist?

And one of the things that I think could be really incredibly beneficial with these self-driving technologies is the possibility that you’ll be able to have autonomous deliveries for people like my grandmother.

**CHRISTINA WARREN:** I think you’re absolutely right. I think the potential for this stuff is really fantastic. Let’s hear more about some of the potential for this technology from Chris Urmson.

[MUSIC]

**KEVIN SCOTT:** Our guest today is Chris Urmson. Chris is the cofounder and CEO of Aurora, a company that builds self-driving vehicle technology. Before founding Aurora, he was CTO of Google’s self-driving car program. Prior to that, Chris was a faculty member of the Robotics Institute at Carnegie Mellon University, where he was the technical director of the DARPA Urban and Grand Challenge teams. I’m excited to hear what he’s up to these days. Hey, Chris, welcome to the show.

**CHRIS URMSON:** Thanks for having me.

**KEVIN SCOTT:** So, I’d love to start by learning how you got interested in technology in the first place as a kid. Were you taking engineering classes or programming classes when you were in high school? Or you just discovered that in college?

**CHRIS URMSON:** No, back when I was in high school, there wasn’t really computer science at high school. And so, I bought some kind of Tandy x86 clone or whatever back when I was in probably 9th or 10th grade from money from my paper route.

And, you know, tried to learn to program at first, where you go -- I don’t know if you recall this, but you go to the bookstore and you’d buy this paperback book that was program whatever it was, and it was just the source code listing.

**KEVIN SCOTT:** Yes, and this is before CDROMs even.

**CHRIS URMSON:** Yeah. (Laughter.)

**KEVIN SCOTT:** Which people probably don’t even remember now.

**CHRIS URMSON:** That’s right. We -- before that, actually, we bought a Commodore 64. And of course that was exciting because it didn’t have a tape drive. Right?

**KEVIN SCOTT:** Right.

**CHRIS URMSON:** Right? Or --

**KEVIN SCOTT:** It didn’t have a floppy disk drive.

**CHRIS URMSON:** Didn’t have a floppy, yeah.

**KEVIN SCOTT:** And, like it --

**CHRIS URMSON:** It had 5.25-inch disks, that’s what it had, yeah.

**KEVIN SCOTT:** Yeah.

**CHRIS URMSON:** So, anyway, so was doing that. And then there’s this language, C++, which seemed to be the hot new thing. And so started actually the first programming language I really learned was C++.

**KEVIN SCOTT:** Wow, that’s rough. (Laughter.)

**CHRIS URMSON:** Yeah, no, it was -- yeah, it was a little crazy. And I--

**KEVIN SCOTT:** I mean, and I guess on some level, like C++ was a challenging first language, but the good thing is after you’ve mastered it --

**CHRIS URMSON:** It’s all downhill. (Laughter.)

**KEVIN SCOTT:** It’s all downhill. And so did you know from all of this experience in high school that you wanted to get a computer science and engineering degree?

**CHRIS URMSON:**  You know, I was up in Canada, so applied to a variety of schools, got into a couple of them. And then in my senior year, I met a girl. Turns out, now she’s my wife.

And decided I wanted to stay at the University of Manitoba, which is right in central Canada, Manitoba. And got into the computer engineering school. Computers seemed like, you know, they had a future.

**KEVIN SCOTT:** Yeah, and how -- and so you got your undergraduate degree and you went straight to grad school, right?

**CHRIS URMSON:** That’s right, yeah.

**KEVIN SCOTT:** And you went to grad school at Carnegie Mellon?

**CHRIS URMSON:** Yeah.

**KEVIN SCOTT:** So, how did you know you wanted to go to CMU?

**CHRIS URMSON:** One day, I was in the engineering building just outside the library, and there was this poster next to the elevator that showed this robot crawling out of a volcano. And I saw that, I thought, “That’s really cool.” Right? I like robots, I like space, this seems exciting.

**KEVIN SCOTT:** Yeah.

**CHRIS URMSON:** And my girlfriend said, you know, “You should really apply if you think that’s cool.” And I figured, you know, it’s Carnegie Mellon, it’s like -- there’s no way. How might -- I’m at the University of Manitoba, how am I possibly going to get in there. And, you know, they made a mistake. (Laughter.) But --

**KEVIN SCOTT:** Well, no, I think they did not make a mistake. (Laughter.)

**CHRIS URMSON:** We’ll see. But, yeah, no, it was really -- I have been fortunate throughout my career to kind of look at, hey, this seems interesting, this seems cool and fun. And you know, gone and tried it. And it’s mostly seemed to work out so far.

**KEVIN SCOTT:** Yeah, and so what was the -- what was the experience like at Carnegie Mellon? Because I remember -- it still is to this day, like, just one of the most extraordinary places in the world, especially to do computer science and robotics. And like the Robotics Institute is just fantastic.

**CHRIS URMSON:** It’s fantastic, yeah.

**KEVIN SCOTT:** So what was that like as a grad student?

**CHRIS URMSON:** Oh, for me personally, it was eye opening, right? That you would have people come and lecture who had written the textbooks I’d used in undergraduate. So meeting these people, meeting people that worked at NASA, meeting people that worked at DARPA, meeting people from Microsoft or Intel at the time. And just -- it opened up this whole other world of possibility.

And then the faculty were great. There wasn’t really -- as a graduate student, you didn’t see politics, you saw people working together. We got to work on cool things.

One of the things I love about Carnegie Mellon is that it’s very much a systems school. You know, they’ve got incredibly deep, strong, fundamental and theoretical underpinnings, but it’s about “make it work” and see it out in the real world and learn about that part of the development and engineering process and actually touching real things.

And so it was fantastic, and I got to go up to the Arctic Circle and we had a robot up there driving around. I got to go down to the Atacama Desert with a robot and, you know, explore that. It was just -- it was an incredible experience.

**KEVIN SCOTT:** What was the first useful robot that you worked on?

**CHRIS URMSON:** Useful? I don’t know that I’ve worked on a truly useful robot, yet. (Laughter.) We’re getting closer. No, so the robots we built for going to the Arctic, this was a robot called Hyperion, and we were exploring how can you make a robot think about -- how can you make it so a robot can operate perpetually?

So one of the challenges, you send a robot to Mars and you put solar panels on it, well, it can only operate when there’s enough sunlight. And it can only operate when there’s a communication window back to earth. So we were looking at both how you plan so that if you, say, launch it to the pole of a planet, that you have constant power by rotating and driving such that the solar panel’s always pointed at the sun.

And then how do we make science discovery automated? So, instead of asking should I look at this rock, should I look at this rock, should I look at this rock? Have the robot go and look at a bunch of rocks and then try and figure out, hey, this one was unique and interesting in some way, and send that back so that you get -- maximize the use of the narrow com bandwidth that was available.

So that was cool. You know, didn’t go anywhere other than as a research experiment, but some of the technology ended up --

**KEVIN SCOTT:** And what year was that?

**CHRIS URMSON:** Oh, that would have been 2001, I think.

**KEVIN SCOTT:** So that was before that -- like the big deep neural network, computer vision revolution.

**CHRIS URMSON:** Yeah, oh, very much so. This was the -- you know, you spend five years working on your PhD and you make something 20% better by coming up with a new set of feature vectors and you earn your PhD, yeah.

**KEVIN SCOTT:** And so your PhD was -- were you -- I’m guessing when you’re working on robots, there’s such broad systems. So, like, there’s the software and the software is very complicated. It’s all the way from control loops to perception to, you know, planning and it’s just a ton of complexity there.

And then there’s also all of this complexity on the electromechanical side of things, like how do you make it light enough, how do you like give it the sort of strength and durability to do the things that you want it to do? How do you power it? How do you like make it resistant to the environment? So did you have one thing or the other that you specialized in or that you gravitated towards?

**CHRIS URMSON:** So, I was definitely more on the software side. And kind of the software and systems side of how do you think about the whole thing working together?

You know, I’m definitely not a mechanical engineer. Right? Now I kind of know enough to be dangerous and really frustrating, I’m sure, for the mechanical engineering folks that I work with. But on the software side, I kind of worked at this intersection of motion planning and perception.

**KEVIN SCOTT:** And so say a little bit more. What is motion planning?

**CHRIS URMSON:** Yeah, so motion planning is figuring out how do you make the vehicle move through the world?

And there’s a bunch of different techniques you can use for it and there’s variations where you’re thinking about just kinematically what the limits are. And then you think about kinodynamic motion planning where you’re actually counting for the fact that there are dynamics of motion and inertias.

And so the earliest robot, like this robot we took up to the Arctic, it moved at 15 centimeters a second. And so, you know, put that in context, that’s like a slow person with a walker. And --

**KEVIN SCOTT:** And it had to be that slow, why?

**CHRIS URMSON:** Well, one, we actually probably couldn’t plan much faster than that.

**KEVIN SCOTT:** Got you, so it was like the speed of the processing?

**CHRIS URMSON:** Yes, it was complicated. It was truly off-road. It was also solar powered. So we had -- you know, there’s a power budget limit, given we were driving this thing around, and so there was only so much power we could put through the gearboxes and the motors.

**KEVIN SCOTT:** Fascinating. But, so even though you were on the software side, like, if you are writing planning software and, like, the planning software -- I mean, like, we just are getting to the point where deep learning systems can learn a kinematic model from scratch. But, so, like, these kinematic models are basically -- they’re sort of a model of the physics of the system. And so you do have to understand mechanics in order to write the software.

**CHRIS URMSON:** Yeah, you really -- you have to look at the kinematics of the vehicle and figure out, you know, in our case, this vehicle -- the Hyperion robot was four-wheel-drive, and it had this cool design. Made it much more fun, where the front axle was just -- there was no active actuation on it. So if you turned one wheel faster than the other, that would turn the axle.

**KEVIN SCOTT:** Got ‘cha.

**CHRIS URMSON:** And then if you want to change the trajectory of the overall vehicle, you’re actually driving all four wheels and you’re kind of slipping the back wheels and steering -- you know, steering the front wheels. You know, it’s actually a really interesting -- as you say -- you know, you have to understand the mechanics of it. You have to understand the forces that are interacting to make it work well.

**KEVIN SCOTT:** Yeah, and then -- I mean, just sort of the perception part of navigating the real world is also complicated. Some of the -- I mean, for a long time before the -- some of the more recent advances in perception that are being driven by deep neural networks and GPUs and whatnot, perception was one of those, like, real intelligence, artificial intelligence gaps that we really weren’t sure when we were going to be able to bridge.

And so you were doing all of this work where we were still in that, you know, universe of confusion about, like, will we ever be able to get the perception to be as good as a human?

**CHRIS URMSON:** Oh, yeah, and again, it’s been fun to watch what we can actually bring into scope and start to solve. So back then, you know, this robot was designed to drive around in the Arctic. It turns out, one of the benefits of being in the Arctic is there’s nothing there that moves. Right? There’s just rocks.

And so we were using stereo vision systems to reconstruct 3D geometry and then estimating the load-bearing surface from this and, thus, figuring out which were the flat bits we could drive on.

You know, we were not particularly adventurous in the terrain we would drive over. And then, you know, the next step from that was looking at -- there’s this great program that I wasn’t part of at Carnegie Mellon called Crusher, and this was this six-wheeled, multi-ton thing that could move at -- you know, I don’t know, 30 miles per hour, but it was like a little tank.

And so there, they were figuring out the load-bearing surface, but they were also figuring out like what’s the stuff you can just drive through? Because if you’re -- you know, if you’re driving a tank, turns out, the grass doesn’t get in your way, right? The small trees don’t get in your way.

And so, you know, that was the next level of figuring out what was vegetation, what was a load-bearing surface, what’s the slope I can really drive on?

And then a lot of the stuff that I’ve been associated with over the last decade has been the actual underlying geometry of the world is pretty simple, right? You drive on a road, it’s flat. But now you have all these actors moving through it, whether it’s vehicles or bicyclists or motorcycles or pedestrians or, you know, ducks or wheelchairs. Right?

And so now you have to separate the stuff that moves from the background and be able to track that and then understand that is a car or that is a pedestrian because that -- your model of how they’re going to behave in the future is somewhat a function of what you think it is, right?

**KEVIN SCOTT:** Right.

**CHRIS URMSON:** A pedestrian is very unlikely to move at 60 miles an hour. You know, whereas a car, you know, that can happen. And so you -- the way you interact with these vehicles and actors changes.

**KEVIN SCOTT:** Interesting. And so while you were at Carnegie Mellon, like, were you a graduate student or faculty? Like, that -- the DARPA Grand Challenge, like, happens. And I remember this was just one of those shockingly cool things as a computer scientist. Like, I -- I wasn’t a roboticist or like even an AI person, and I was like paying very close attention to this program and what was happening because at the time, it was just sort of shocking the notion that you could have an autonomous vehicle that could, like, navigate a complicated environment by itself. So you were part of that.

**CHRIS URMSON:** Yeah, it was really cool. It -- so this was -- I was a graduate student and then I worked for a company and then I was a faculty member. So, we kind of went through three different phases of life I guess there. And, yeah, it was really cool. And it was a “grand challenge” because back in 2002, we were not sure you could actually do this. So --

**KEVIN SCOTT:** And so, what was the “this”?

**CHRIS URMSON:** Yeah, so there were three different events. There were two grand challenges and then the urban challenge. And the Grand Challenge was to get a robot -- we called it a robot back then -- to drive across the desert and do 150 miles, nominally from Los Angeles to Las Vegas. And it had to do it in less than 10 hours, and it had to do it on a given day.

So, you know, we showed up, launched the robots in the morning and, you know, some number of hours later, they come back, hopefully.

And when it kicked off in 2000 and -- probably late 2002, 2003, we were -- like I said, like, we had conversations where, is this even doable? You know, there had been a lot of great work in this space before, there’d been No Hands Across America, which was at Carnegie Mellon program that had actually used neural networks to drive a car down the freeway -- or at least steer a car down the freeway. It didn’t do gas and brake and there’d been some great work by Ernst Dickmanns in Europe and some interesting work in Japan.

But the idea you’d drive off-road for 150 miles was just -- like it was impossible, the state of the art was some guys had a Humvee driving at -- I want to say 10 meters per second through a field with giant hay bales. And the idea was, don’t hit the hay bales. And they mostly didn’t hit the hay bales.

**KEVIN SCOTT:** Mostly.

**CHRIS URMSON:** Mostly, right? (Laughter.) And so the idea we could go across the -- you know, across the Nevada desert for 150 miles, like, on command, you know, and again, a lot of the robotic research at the time and still today, rightfully so, is you work really hard at this thing, it’s such a brutal system that you get a video working the one time, and that’s your conference submission, right?

And that’s the right way it should be, right? In an academic setting, you’re kind of trying to prove out ideas. So the idea that we would show up one morning and a starting gun would shoot, and it had to go and it had to work that time was just -- it was exhilarating. And the problems, you know, it was a classic under-defined problem to begin with, where you know, we notionally were worried, we just have to drive across tumbleweed and cactus for 150 miles and truly be off-road.

Now, it kind of morphed into “drive down the trails,” which made it more viable and, you know, more useful, honestly. But even that, when you know -- a trail isn’t the smooth, perfect ground that we see on the road, right? There’s ridges to it and rutting across it and it was a heck of a lot of fun.

**KEVIN SCOTT:** And so, when you were doing all of this, did you think that you were going to be a computer science professor for your entire career?

**CHRIS URMSON:** When I -- yeah, that was kind of the mission. So, when I was an undergraduate student, was -- I want to go to graduate school. And then when I was a graduate student, I was pretty convinced I wanted to be a faculty member at Carnegie Mellon, because it seemed like a great place. Yeah, and ultimately, got the opportunity to be that, so -- that was exciting.

**KEVIN SCOTT:** Sort of an extraordinary thing. And so you know, in my mind, like, as someone who also thought they were going to be a computer science professor a while, like getting the faculty gig at Carnegie Mellon is, like, pretty much the top of the mountain.

**CHRIS URMSON:** It was pretty good, yeah.

**KEVIN SCOTT:** So why do something different?

**CHRIS URMSON:** Yeah, so in -- you know, we had this chance to work on these challenges for a couple of years and that was exciting. And then I spent a couple of years on the faculty and worked with Caterpillar and we were automating these dump trucks that were the size of houses. Like, 400-ton thing moving at 45 miles an hour.

**KEVIN SCOTT:** They’re shockingly big.

**CHRIS URMSON:** It’s amazing. Just incredibly cool and a great team with Caterpillar, great team at the university. And I’d been talking with Sebastian Thrun, who was at Google at the time.

And we were thinking we should do something around self-driving cars. Again, we still didn’t -- we called them “car robots” or something, I don’t know what we called them, but we hadn’t invented that term for them yet.

And you know, he’s at Google. And I got a phone call saying, you know, effectively, like, we’d actually like to do self-driving cars at Google.

And this is 2008. So, Google had quietly just very recently acquired Android. And that was, you know, that was a search engine. I was like -- why -- this doesn’t make any sense. And we talked about it and I came to realize that they -- you know, Larry and Sergey thought they had this incredible engineering resource and wanted to go solve cool, interesting problems. And they were asking me to come out and lead the team.

I thought, well, you know, and initially it was a two-year gig, the idea was we’d come out, see what we could do for two years, and you know, it’s kind of like the Dread Pirate Roberts you know, a good day today, I’ll probably kill you in the morning, right?

**KEVIN SCOTT:** Yeah.

**CHRIS URMSON:** Like, well, you’re going to be gone in two years.

**KEVIN SCOTT:** Yeah, and I want to like -- I want to draw a line under this, because I think now people probably almost take for granted that Google having Waymo and like all of the self-driving car stuff was just sort of an inevitable consequence of how things were going. But I was at Google from ’03 to ’07, so I left before you got there.

You started close enough after my last day that, like, the company -- it was a search and ads company. And like, the idea that -- I mean you had two things. You had this company that, like, it wasn’t obvious I think to anyone that they should be building self-drivingcars. And, like, I’m not saying that in a pejorative way, it’s just, you know --

**CHRIS URMSON:** It’s not what they did.

**KEVIN SCOTT:** Yeah, it’s not what they did. And the state of the technology was also nascent enough where it just wasn’t obvious that commercially, like, you could make a profit on any of this stuff -- on any sort of reasonable time horizon.

And so, them having the idea to do that and you sort of saying this would be a cool enough thing to do to take --

**CHRIS URMSON:** A sabbatical, yeah.

**KEVIN SCOTT:** -- take a sabbatical from my tenure-track job at the number-one computer science program in the -- I mean, that required a lot of courage all the way around.

**CHRIS URMSON:** Yeah, no, and it was -- yeah. And it was a big decision because, like, this was the thing that I had aspired to for the last seven years. And it wasn’t obvious that it was a good idea. But it seemed like, you know, it -- my wife and I, we just had our first son, and our second.

And we were thinking, well, I’ve got this opportunity here, but you know, we could go try California for a couple years. You know, it’s where the crazy people with the Birkenstocks are. So, you know, if we’re going to go, we may as well go give it a shot now and then we can come back and pick up here afterwards.

And it was -- so Carnegie Mellon has this tradition in the Robotics Institute where in the fall, the new faculty members come in and talk about their research and their aspirations and whatnot, and there was three of us.

And, you know, I came in and did my, you know, little thing. And at the end of it said, “And, by the way, I’m --” You know, now it’s -- because I think I was special faculty and then I was faculty-faculty.

“By the way, I’m leaving for two years, thanks for having me.” You know, and -- went over about as well as you might think. But, you know, it was -- to their credit, they let me do it. And to Google’s credit and Larry and Sergey’s, you know, they had the foresight to try this out. And it really was, can we-- went into it with no degree of confidence that it would go anywhere. Just go try it.

**KEVIN SCOTT:** What did your dad think of this or your mom?

**CHRIS URMSON:** They were very supportive. Right? It was -- it just seemed like a neat opportunity. And yeah, I think -- I think if I had left to try a startup, I think that would have been a little more -- you know, I can tell you actually, they were a little more skeptical of that. (Laughter.) But, you know the opportunity to—to go there-- they got it.

**KEVIN SCOTT:** I know my mom was really anxious for reasons I didn’t quite understand when I left Google to go do a startup. It’s like just very hard for her to reason about like how you could leave a good job like that to go try this, like, very risky thing.

**CHRIS URMSON:** Yeah, no, and it is, right? I think one of the things that people outside of Silicon Valley who haven’t been here don’t realize is that it’s not really.

That, like, you know, people talk about Silicon Valley engineers being risk-takers. I think it’s actually the opposite. It’s the realization that if you go and try one of these things and you’re actually good at what you do, if it fails, it fails. You’ll have a job the next day at somewhere else, right? And you’ll have this wealth of experience that people will value.

And I think that is something that it’s hard, you know, I’ll categorize this as you know east coast people but, you know, kind of more conventional business folks haven’t -- don’t kind of have that sense of the opportunities that are around. And maybe we’ve just been here during a particularly fortuitous time.

**KEVIN SCOTT:** Yeah, but I do think it’s a piece of advice that I give people all the time is that if you -- however you do it, like whether it’s be a software engineer in Silicon Valley where you’ve got a bunch of career opportunities, or whether it’s avoiding taking on like huge amounts of debt early on in your life. If you can give yourself the opportunity to be able to have choice in what you work on and to like always choose the thing that’s interesting and looks like it’s going to give you a bunch of learning, like, you will probably do better than you would in other circumstances.

**CHRIS URMSON:** Oh, for sure. There’s this -- what is it? If you do something that you love, you’ll never work a day in your life?

**KEVIN SCOTT:** Yeah.

**CHRIS URMSON:** Right? Like, that -- it’s not just that, right? It’s that you get the best out of yourself. You get the best out of people when they’re invested in the thing that they’re doing, when they’re passionate about it.

You know, and it’s -- I guess it’s easy for me to say, having been in a position where I’ve had the opportunity to do this and I -- you know, understand that not everybody has the same opportunities that I’ve had. But if you can find that, if you can -- if you are able to seek it out, it seems like the way that you get a chance to shine and the way that you help build something awesome.

**KEVIN SCOTT:** Yeah, so tell me about the early days of the self-driving car program at Google. So it start -- it was like you and Sebastian.

**CHRIS URMSON:** Yeah, well there was -- there was -- I want to say there was a half dozen of us who started at the beginning. There was me and Dimitri Dolgov, who’s now the CTO there. He and I started on the same day. And Dirk -- and Mike Montemerlo who was actually an office mate of mine at Carnegie Mellon and, you know, is one of the -- brilliant minds in simultaneous localization and mapping.

And who else? There was -- oh, Hendrik, so we were -- we were very much a black project. So, you know, we were kind of sworn to secrecy. We were kind of hanging out in the Google Maps building, but didn’t really -- you know, people didn’t really know what we were working on because it was kind of weird.

And it was how do we learn as quickly as possible? How do we show, you know, how do we convince ourselves that we can actually build something meaningful with this technology? And so we had two goals when we started, the first one was to drive 100,000 miles on public roads, and then the other was to drive ten, 100-mile, really interesting routes.

And the idea was kind of to get kind of statistically interesting coverage, and like focused ability to learn about particular places we could go, and so--

**KEVIN SCOTT:** And it was, like, drive safely for 100,000 miles on public roads, right?

**CHRIS URMSON:** Yeah.

**KEVIN SCOTT:** I mean, like --

**CHRIS URMSON:** Well --

**KEVIN SCOTT:** I know that it’s implicit in what you’re saying.

**CHRIS URMSON:** Yeah, of course.

**KEVIN SCOTT:** It bears saying, because one of the things that I think you all did extraordinarily well is like you were very thoughtful and even conservative in a way with the choices that you made, to make sure that safety was always the number-one thing.

**CHRIS URMSON:** Yeah, that was one of the things that I helped instill in the organization early on, and we had a great group of people who would have done it without me. But how do we think about training people to operate the vehicle? How do we transfer the knowledge from the engineering team to the operations team so they understood what was going on?

What processes do we put in place so that we have people checking one another? How do we make sure that we trust the release software going out to them? So, yeah, that was a really important part of it.

That’s one of the fundamental bits of culture that I helped instill there that I’m very proud of and one of the cores of the way we operate at Aurora as well.

**KEVIN SCOTT:** Yeah, so you had these two goals.

**CHRIS URMSON:** Yeah.

**KEVIN SCOTT:** And nascent technology. So, and this is 2008.

**CHRIS URMSON:** 2009. I started February 2009.

**KEVIN SCOTT:** Okay.

**CHRIS URMSON:** So, yeah, and so we did exactly what engineers do. We optimized to the constraints. And so for the 100,000 miles, the vast majority of that was driving on 280 between 85 and Sneath.

And so, we had a fleet of Toyota Priuses. And if you lived here in 2010, you would have seen a bunch of them going up and down on the freeway there, gathering 100,000 miles.

**KEVIN SCOTT:** Yeah, you guys were on my commute. My startup was in San Mateo and I lived in San Jose, so I was on the 280 every day.

**CHRIS URMSON:** Yeah, and, you know, they got incrementally better over time and, you know, we burned through the 100,000 miles. It was really kind of a fun time because you know people didn’t know what they were, right?

We had people think they were weather trackers. They thought we were storm chasers. They thought -- this was my -- one of my favorite at a gas station and somebody was convinced we had kind of a perpetual motion machine, which is on its face a problem, because we’re at the gas station. (Laughter.)

But, you know, like the laser that was spinning on the roof was clearly a wind turbine, and at the time, we had this encoder on the rear wheel. And so that, you know, the model was we were gathering from the wind from the car driving, and then we were recuperating energy through the encoder on the wheel.

It’s one of these things where we couldn’t tell them what we were doing, so we kind of nod along.

**KEVIN SCOTT:** I knew a lot of people who knew Google’s business who thought that they might have something to do with Street View.

**CHRIS URMSON:** Oh, yeah, I remember, we had -- we were definitely that. One time, we were driving back -- we were up in Sacramento or Tahoe testing driving back through that stretch of 80 just kind of where it’s really flat.

And it turns out, there’s a part of that where there’s like a parallel road. And we’re driving along and this motorbike passes us, cuts over to the parallel road, and then pops a wheelie. For like three quarters of a mile, is just doing a wheelie beside our car.

And I am sure that for the next two or three years, that guy was still checking for the street view footage of him doing his wheelie, yeah, so --

**KEVIN SCOTT:** That’s awesome.

**CHRIS URMSON:** Good times.

**KEVIN SCOTT:** So what had to change after you accomplished the initial goals? So the initial goals were good ones, but like that is not like how you get to a commercial business for self-driving cars.

**CHRIS URMSON:** No. And it became, okay, we’ve started -- we’ve got this initial proof point that the technology at least can work some of the time on traffic, on public roads with real people. So now how does this turn into a product? What is the application we’re going to go after? What is kind of the MVP.

The first thing we thought about was basically what looks like Auto Pilot today on Tesla, except we set a very, very high reliability goal so that you really could kind of take your eyes off the road for periods of time.

And so, we spent a couple of years working towards that. And you know, I’ve talked in the past about some of the experience we had at that, the point -- we got to a point where it was extremely good, then we started to “dog food” it, and you know, despite warning people about the fact that, A, it was beta, and B, you know, effectively, we knew where they lived, they worked for the company, we were going to monitor what they did. We saw them, you know, being overly confident in it.

And, you know, checking things in the back of the car or putting on their makeup, all kinds of things that you wouldn’t want. So, then we moved from that to how do we turn this into something that really can drive -- do the whole driving task for you? And, in particular, thinking about how do we move people.

**KEVIN SCOTT:** Right, and so at some point you decided that you were going to go start a company.

**CHRIS URMSON:** Yeah.

**KEVIN SCOTT:** Which is what you’re doing right now. So, Aurora, tell us a little bit about that.

**CHRIS URMSON:** Yeah. I had a tremendous time at Google. It was an incredible opportunity to work with great people, you know, good company and go and build something neat. And then by the time we got to about 2016, it was time for me to move on.

And so, I resigned in the middle of 2016 and then spent a few months trying to figure out what to do next. And I met with all kinds of people and you know from tech companies, to automotive companies, to startups. And, you know, it was fascinating because after you spend that much time at a company, you kind of get used to seeing the world through a particular lens. And being able to get outside of that lens and engage with people more as an individual, and kind of deconstruct lens, you learn a lot through that process.

And what became clear to me was there was a chance to help accelerate this technology. And that given the experience I had and given kind of the state of the industry at the time, it seemed like if I could find great people to found a company with, we could really do something meaningful as an independent company. And, you know, build technology that mattered and see it in a world in a way that we could do a lot of good.

You know, and ultimately build a sustainable, successful business.

**KEVIN SCOTT:** Yep. And so what does Aurora do?

**CHRIS URMSON:** So, Aurora’s mission is to deliver the benefits of self-driving technology safely, quickly, and broadly. And what that means is we want to make a driver that will make it easier for people to get around, make it less expensive for them to get around, and easier for us to ship goods and perform logistics.

**KEVIN SCOTT:** And you all think about yourself as a platform company. So, anybody who wants to build an application that needs self-driving cars, like they could use your technology to like help realize it?

**CHRIS URMSON:** That’s exactly right. We think about the thing that we can do best in the world is build the driver. And so let’s go do that. People -- you know, it’s easy, you look at, say, Uber and what you see is an app that you figure, how hard can that be?

And what you miss is just how complicated that business is behind the scenes. And you know, the operational aspects of it, the matching driver with vehicle or passenger with vehicle, if you look at -- again, if you look at a company like FedEx, right? It’s incredibly complicated, the logistics that they do.

And so, we don’t want to go build that, right? We think those people know what they’re doing, they’re really good at it. Similarly, you know, it’s really easy to dismiss an automotive company. Oh, they just bend metal. Well, no, it turns out that they build these incredibly complicated products that operate for the next 15 years and have an immense amount of technology under the hood.

And so, you know, we don’t want to do that either. We’re not going to be very good at that. So let’s concentrate on this one thing, this driver, and let’s make it a platform that everyone can use that will make it for the end user, it’ll make it safer for them to get around, it’ll make it easier, and it will make it less expensive.

And then for our partners in the automotive community and in the transportation and logistics communities, you know, they’ll have an opportunity to help build better businesses themselves.

**KEVIN SCOTT:** Right, and the idea is, like, there will be lots and lots of these businesses, like not a small number, but like you will have maybe hundreds or thousands of companies that are, like, instantiating some sort of AI driver in a vehicle of some sort. And the vehicle could be your giant 400-ton Caterpillar thing or it could be like a consumer-owned automobile that you’re using to commute to work, or it could be a completely unmanned drone vehicle of some type.

**CHRIS URMSON:** Yeah, that’s exactly right. That I think -- I don’t have enough imagination, and we probably as a team don’t to figure out how -- all the ways -- all the great ways this could be used out in the world. So, again, stick to the thing we know how to do, open it up, and let it flourish.

**KEVIN SCOTT:** So one of the things I’m really interested in is your perspective on what has changed in the technology over the history of autonomous vehicles, from the point where you entered, which was pretty early, you know, like, you know, sort of Grand Challenge, you know, DARPA problem, all the way through to 2020.

**CHRIS URMSON:** Yeah, no, it’s been incredible. You know, you could start by thinking about the hardware side of this. And maybe even the mundane hardware side. So, vehicles are now almost all electronic. And so you can communicate to the brake system or the steering wheel or you can talk to the gas pedal, right?

And that wasn’t the case. We literally had a motor with an arm on it that would press the brake pedal in those earliest vehicles.

**KEVIN SCOTT:** That would compress a hydraulic cylinder somewhere --

**CHRIS URMSON:** Yeah. And they all still have hydraulic cylinders, but the front end of them now, almost all of them there’s --

**KEVIN SCOTT:** There’s no mechanical linkage --

**CHRIS URMSON:** Oh, sorry, no, there actually is in cars. But there’s on top of that there’s also an electronic control.

**KEVIN SCOTT:** Okay.

**CHRIS URMSON:** And that’s actually one of the challenges --

**KEVIN SCOTT:** And so you had the mechanical linkage for safety?

**CHRIS URMSON:** So today, yes. And this is actually one of the areas where there’s still steps that have to be made before we’ll see broad distribution of this technology.

**KEVIN SCOTT:** So, this is fascinating. Like, this is some of the minutia I think we like sort of skate over sometimes when we’re thinking about these technologies.

But, like, one of the things that the auto industry does incredibly well is like they understand manufacturing for safety perhaps better than any other industry maybe other than aerospace in the world.

**CHRIS URMSON:** Pretty much, yeah.

**KEVIN SCOTT:** And, like, there’s -- they have thought about this problem so deeply and for so long.

**CHRIS URMSON:** Oh, yeah, and that’s why it’s so great to work with them on these kinds of problems. So, when you -- and let’s take one very specific example. So, let’s talk about the brake system on a car.

So the way that works today is when you press the brake pedal, you’re actually pressing -- you’ve got a metal arm that’s going in and compressing a cylinder that’s the master cylinder that’s then creating pressure -- hydraulic pressure in your brake system.

And that brake system is actually split into two circuits that are generally diagonally linked across the vehicle so that if one of them fails, you’ve still got two brakes and it turns out that the torques applied by the brakes and the wheels don’t spin the car when you apply the brakes. You don’t have as much authority, but you still have brake power. Now --

**KEVIN SCOTT:** And that’s a mechanically, like, brilliant design.

**CHRIS URMSON:** Awesome. And then what’s happened is with the introduction of more advanced features, like first electronic stability control and now adaptive cruise control, there needs to be a way for a computer to actuate some part of the brake system.

And with electronic stability control, you’re actually modulating whether that pressure that’s being applied by the master cylinder is effectively on or off around that. And with adaptive cruise control, you’re actually wanting to generate pressure itself.

Now, in both of these systems, the redundancy -- so if the electronic system fails, you’re still able to apply pressure through that master cylinder system and so you know, the force of actuating the brakes is coming from your legs.

If you have a robot driving, if it’s a self-driving car, then there’s nothing applying that force. And so we need to design new brake systems where there’s you know a parallel system to actuate the force.

And so this is one of the parts that will become standard on vehicles as we move to automate them. And similarly around the steering shaft, right, the steering column.

So the backup in -- if the power steering system breaks, is your arm muscles. But if you are a self-driving vehicle with nobody grabbing the steering wheel, then we have to come up with an alternative system for backup. And so it’s, you know, interesting things like dual (inaudible) motors or second motors.

**KEVIN SCOTT:** And so in addition to like reengineering the cars themselves to have new forms of mechanical redundancy, like you also have to think about how you make the software redundant. Like, this is one of the things that wasn’t obvious at all to me when I first started learning about self-driving vehicles is I think people have in their imagination that the software is this one monolithic, machine-learned thing that is doing all of the perceiving of the environment and all of the you know sort of driving and reacting to the environmental conditions and like that is not the way the systems are engineered.

**CHRIS URMSON:** Yeah, so you don’t necessarily need to make it redundant, but you need to have a certain level of resiliency in it. And redundancy is one way that you could implement that level of resiliency.

And so you could imagine having two teams working kind of in closed rooms and coming up with solutions, or you can do more thoughtful things about how you -- the more thoughtful approach is where you think about how the system can fail and mitigate those to a point where you’ve reduced the risk to the point where it’s no longer unreasonable

One of the benefits we have over aviation is that we’re on the ground. And so we just need to take the kinetic energy out of the system and bring it to a safe state.

In aviation, you know, you’ll ultimate take the kinetic energy out, but it’s going to be a very bad day. So it’s a slightly different problem, and so you probably don’t need the full kind of -- the full degree of redundancy, but you need something where you’re kind of meeting your safety targets.

**KEVIN SCOTT:** And so how do you think about sort of interpretability of these models that are -- I mean, like one of the things that I learned about over the past couple of years is in airplanes, you have this thing called MCAS or the Midair Collision Avoidance System. And so, every modern airplane has MCAS.

And like MCAS’s job is to sort of look at all of the air traffic. And if you get close -- too close to another plane, the planes communicate with one another and like one will go up and the other one will go down in order to avoid the collision from happening.

And there’s a document -- so there’s two versions of this MCAS. So there’s the old version MCAS that is described in a document that has a bunch of pseudo code and it’s like hundreds of pages long.

And there’s a new version of MCAS which is sort of almost like a dynamic programming-based thing. So it’s not full machine learning, but like all of its decision points are like codified in a table. And the argument is that like even though it’s not this human readable pseudo code, that this new system has better provability properties that it’s going to do what it’s going to do. Although, like from a human perspective, it’s probably less easily decipherable.

**CHRIS URMSON:** Understandable, yeah.

**KEVIN SCOTT:** And like if you look at the pseudo code, like the pseudo code is sort of a wreckage. Like, it’s full of inconsistencies and no one really understands 100 percent of like what the thing says that these systems should do.

And so like one step further along this level of sort of human inscrutability are these, like, machine-learned models that we’re building right now, where they are very large and like how they -- you can’t easily learn how they behave by just inspecting the weights of the parameters that are sort of in the interior of the model.

So like how do you think about this? Because, like, you’re working on one of the most important safety critical systems in software engineering.

**CHRIS URMSON:** Yeah, no, it’s a great question. And the way you talked about it actually is a really great way to frame it because as we started to bring machine learning into these systems, people began to really worry about this, like, can we trust the ML system? Well, if you knew anything about the way these perception algorithms had been implemented before, it’s like it was pretty darn opaque, right? You couldn’t -- you’ve got feature vectors that you’re creating and parameters you’re tweaking and weird case statements that happen to work.

And like, you know, so it’s the same problem. Because by the time these perception systems actually worked, even if you human coded it, it was not human readable, per se.

**KEVIN SCOTT:** Yep.

**CHRIS URMSON:** And so the way we think about this is there are some strict “don’t violate,” we call them guardrails that, you know, our vehicles shouldn’t plan to be in the same space as another vehicle.

Our vehicle should not plan to leave the road. You know, and there’s a bunch of this stuff that we can kind of codify. And they’re relatively straightforward and relatively -- you can write a requirement for it, you can trace that and use kind of classic engineering approaches.

**KEVIN SCOTT:** And you can write a piece of software where a human being can look at it and say, like, this software enforces this guardrail.

**CHRIS URMSON:** Right, and you can put testing around it and you know have confidence that you’re implementing that. And then -- and so we do that. And then we take the machine-learned approach to basically stick it in the guardrails. And so, you know, we don’t kid ourselves in believing that we could really interpret all of the weights in that system, but we put rails around it so we kind of bound the operating environment.

And we believe that that will get us to a point where we can have enough confidence in the system that it really works.

**KEVIN SCOTT:** And theoretically, I mean, one of the things that we’ve seen over and over again is you have these moments with complicated systems where you start off not being able to really understand and characterize the performance of the complex system, and so you don’t really trust them.

And in certain of these complex systems, they eventually evolve to the point where you both understand them and they have superior performance to like everything that proceeded them, and in some cases, you know, the thing that proceeded them was like a human brain and like the software system is better at that narrow thing than a human brain, like no -- like I think it bears saying that no piece of software is close to being better than a complete human brain at the complete set of things that human brains are good at. But at narrow things, yes.

**CHRIS URMSON:** Yeah.

**KEVIN SCOTT:** And so like we may get to the point and like it would be a fantastic thing for the human race to, like, have -- have an autonomous driving system that is better than a human from a safety perspective.

**CHRIS URMSON:** And that’s what our aspiration is. And the good news is that I don’t even know that we need to be strictly better than the best human driver at all times because a lot of times, when people are driving, they’re not paying that much attention. They’re distracted one way or the other. Their mind wanders. They’re inebriated. Right? There’s an awful lot of error that happens not because we’re operating at our best and couldn’t handle it, it’s because our attention is somewhere else.

You know, and one of the things that we can do for these vehicles is we can make them superhuman. And superhuman in kind of trivial ways. Like, our vehicles see all the way around the vehicle all the time. And now that I’m used to that in the technology, when I’m trying to make a lane change on the 101, it drives me nuts because, you know, to make a lane change, I’m watching traffic in front, and then I need to look and assess the state of the traffic behind me.

And, you know, what happens if -- you know, particularly when it’s kind of jerky flow of traffic, you know, if I’m taking a half-second or three-quarters of a second to look behind me and the guy in front of me has hit the brakes, I’m having a bad day. So I find that incredibly stressful.

**KEVIN SCOTT:** Yeah, well, and that’s the thing already about a modern automobile. Like, forget whether or not it has autonomous technology in it or is like on a path to autonomous technology. From a sensing perspective, like, modern automobiles are already superhuman. Like, they can see the world like -- just because they can see behind them at the same time they can see in front of them. Like, they -- you know, like, you’re -- the cars that you all, you know, pioneered at Google have LIDARs in them and so, like, they can sort of see in dimensions that human beings can’t see.

**CHRIS URMSON:** Yeah, it’s really cool. And it’s one of these things where -- this is why I believe we should be using a combination of laser radar and camera, not just one modality. Because you know, like, the people who believe that you should just use cameras, for example, they say, you know, the argument is effectively people just have two eyes, it’s like cameras, we should just use that.

And the obvious response to this is, look, people don’t have wheels for legs, but it turns out, when we made the car, a wheel is much better than trying to make legs work. (Laughter.)

So let’s go use whatever engineering hacks we can to go make this safer. And so when we can use lasers which allow direct 3D reconstruction of the geometry of the world, when we can use radars that allow us to see through certain obscurants and allow us to see velocity instantaneously, when we use cameras to see the state of traffic lights and get higher resolution data, like, we should use it all.

One of the things I’m really excited about at Aurora is we just bought this company that builds this brand new kind of LIDAR technology, it’s called frequency modulated continuous wave LIDAR.

**KEVIN SCOTT:** And what’s LIDAR, for folks who don’t know?

**CHRIS URMSON:** LIDAR is light detection and ranging. So think of it like radar, but instead of using a radio wave, you’re using a beam of light. And for this technology, so the way kind of classic LIDAR, so the LIDARs we used to use at Google and most of the LIDARs that are out there that you’ll see on cars, the way it works is you send out a pulse of light and you wait for it -- goes out in the world, bounces off something, comes back, and you measure how long it took for that little pulse to go out and come back.

Because the speed of light is constant, you can get distance from that. Now, the trick is you have to make that pulse so bright that it is brighter than everything else out there, because otherwise you don’t see it when it comes back. And so that means it’s got to be brighter than the sun.

**KEVIN SCOTT:** Which is incredibly bright.

**CHRIS URMSON:** Yes, now, the good news is you’re looking over a small period of time, so you can kind of do it and maybe you don’t -- you know, you don’t necessarily care, because not many cars come out of the sun, but it makes it -- you know, you basically have this really challenging signal to noise problem because you’re doing DC measurements.

With this FMCW technology, what’s happening is instead of sending a pulse out, you’re sending out a continuous wave. And you watch that go out, hit the world, and come back. And now you interfered the outbound wave with the inbound wave and look at the phase difference.

**KEVIN SCOTT:** Oh, interesting.

**CHRIS URMSON:** And now you measure the phase difference effectively and that tells you how far away the thing is that it’s reflecting off of. And what’s cool is that because of this new physical property of self-heterodyne you get you know 10 to 100 to one amplification, which is --

**KEVIN SCOTT:** That’s great.

**CHRIS URMSON:** You know, and because you’re no longer DC, you know, you filter out stuff that isn’t at this frequency, so you don’t like -- turns out, the sun is roughly constant. So, it doesn’t -- there’s no frequency to that.

So it makes it so you can be much more sensitive. And then the other really cool thing that comes along with this is that you actually get to measure velocity instantaneously. So, using Doppler. So when you hear a siren go by and how it changes pitch, that’s the Doppler shift in that audio signal.

So with this, is we’re measuring vehicles at distance. With each one of those measurements that come back through that pulse or through that wave, we’re actually --

**KEVIN SCOTT:** So you can tell whether you’re accelerating or decelerating relative to that other object.

**CHRIS URMSON:** And not just whether we are, exactly what the delta in speed is. And so this -- the reason why Aurora -- why we bought this company, and why we brough this technology in house is it’s magical. Right? Because if you’re trying to use a normal LIDAR to measure the world out, let’s say we want to see whether there’s something 200 meters out in front of us on the road.

And we want to know, is that a truck or is that a pedestrian or is that a bicycle? Or something else? We need to get enough points on that -- little dots back from it -- that allow us to see the shape of it. And then we need to run a classifier on it. So you need to get a whole lot of points on it because if you only have -- you know, if I have two dots back from something, you know, that’s a line.

I can’t tell whether that’s a person or a dump truck or a Bugatti or whatever. And so that’s a lot of points. It turns into a really hard problem.

In contrast, if I hit that thing with an FMCW LIDAR and can measure the speed of it, well, if it moves at 60 miles per hour --

**KEVIN SCOTT:** It’s not a human.

**CHRIS URMSON:** Right. It may not be -- I don’t know if it’s a Bugatti or a dump truck, but I know it’s a vehicle. And so I can classify it much sooner so I can respond to it much more quickly.

**KEVIN SCOTT:** Super interesting.

**CHRIS URMSON:** Yeah, it’s really cool stuff.

**KEVIN SCOTT:** Yeah, and like that -- I mean, the safety applications of that must be interesting, so like you can pay really close attention --

**CHRIS URMSON:** It’s profound.

**KEVIN SCOTT:** -- to stationary things.

**CHRIS URMSON:** Yeah, low-speed things. You know, you can -- you understand -- you have this whole additional signal that we can incorporate into the classification and, thus, make us more robust and make us react more quickly.

**KEVIN SCOTT:** Fascinating. So a couple more questions before we go. So one is like looking forward, like, what’s the thing that you’re most excited about in the autonomous vehicle space?

**CHRIS URMSON:** Aurora, obviously. (Laughter.)

**KEVIN SCOTT:** Obviously. But, like, like at Aurora, like, what’s the interesting thing that’s going to happen over the next handful of years?

**CHRIS URMSON:** Yeah, so over the next handful of years, you know, we’re going to get to the point where we have vehicles on the road that we can trust. And that they’ll be doing -- they’ll almost certainly be in fleet applications and they’ll be driving around. Big clap here. And I think that’s going to be really exciting.

Over the next year, there’s a couple things we’re really excited about. One is we talked earlier about Aurora building a driver, and it’s this platform -- well, because we now have this special LIDAR capability, we’re now confident that we can build vehicles that can drive on the freeway.

So Aurora spent a lot of time building passenger vehicles -- or passenger vehicle technology. We’re now going to be moving into logistics and trucking. And so that’ll be a big thing for us over this next year.

We’re also going to be putting an awful lot of effort into codifying our safety process. And kind of convincing ourselves, getting along the road to convincing ourselves that this vehicle really is sufficiently safe that we can trust it out in the world. And those are two, you know, really big kind of chunks for us over this next year.

And then, of course, we are going to continue on the core driving technology and moving that -- you know, moving that from, you know, the capabilities we have today to more and more confident driving.

**KEVIN SCOTT:** That’s super awesome. So, last question. I do all sorts of things that are somewhat orthogonal to software engineering and technology to -- it’s almost like meditation.

So, like, I -- like, my latest thing is, like, I have access to a machine shop, and I’m, like, doing a bunch of -- bunch of CNC machining, which is incredibly fun and like exactly what I need to get my brain detached long enough from the things that I normally think about where I can like go think even more clearly about the things I should be thinking about. So what’s the -- interesting things that you do in your copious free time.

**CHRIS URMSON:** Copious free time. (Laughter.) Yeah. I, so, you know, I have a startup that I helped found. So that’s almost all of it.

**KEVIN SCOTT:** Yeah.

**CHRIS URMSON:** I think the two things that I would -- that I like doing, so one is I like rock climbing. So, I do indoor rock climbing, because my wife is not excited about me climbing outdoors. But I find that to be just -- when I get the chance to do it, you know, it’s this blend of, you know, the physical exertion of climbing, you know, I’m not a small guy. And so, you know, there’s a lot more work for me than some people.

But then the real interesting part is when you climb at the higher grades, it’s a puzzle. And how do you load this rock so that you know, so you can actually hold it rather than just slip off it? How do you contort your body up the wall? I just I enjoy that, right? It’s a workout, and it’s thoughtful.

And then the other is I play -- we play games with our -- with my kids, right? And we’re into these fantasy flight games, which there’s this one called Imperial Assault, where you know the -- there’s a team that plays the heroes, and then I get to play the empire. (Laughter.) And so, you know, you have these Star Wars battles, which are –

**KEVIN SCOTT:** Oh, that’s -- sounds like a ton of fun. Yeah, that’s super awesome. I mean, on the rock climbing thing, like, you must follow Alex Honnold a bit, so he’s the -- he’s the climber who’s, like, famous for free-soloing the -- what was it? The Dawn Wall or El Cap?

**CHRIS URMSON:** Yeah.

**KEVIN SCOTT:** I find him absolutely fascinating just the mental preparation that goes in -- I mean, like, there’s the physical aspect, which I can’t even conceive of --

**CHRIS URMSON:** No.

**KEVIN SCOTT:** -- like, physically, how he does what he does, but the mental preparation that he goes through to be able to do what he does is, like, maybe even more fascinating than the physical side of things.

**CHRIS URMSON:** Yeah, I thought it was really incredible. Actually, one of the most impressive things to me about that movie was the aborted attempt, that I -- you know, the self-awareness and confidence – the self-confidence, you know, particularly with the big film crew there and everything, and this has been the thing you’ve been working to, to be up on -- on the face at some point and just say, “You know what? I’m not feeling it.”

And, you know, and abort, right? Like, I think that was the most impressive thing to me in that whole movie, that he was able to do that.

**KEVIN SCOTT:** Yeah, I have a keen enough sense of vertigo that I haven’t actually watched the movie, but I have -- I have watched a bunch of interviews with him. It just sounds extraordinary.

**CHRIS URMSON:** Yeah, I think people that do that kind of thing, there’s just something special about them, right, in one way or another, yeah.

**KEVIN SCOTT:** I love this incredible diversity in human beings where there are so many people who are so obsessed with being really great at their particular thing. And I just love it. I love it all, like, it makes me so happy to like see this guy -- and it’s like not just him, like there’s so many of these rock climbers who are just extraordinary at what they do. And like I’m amazed at concert pianists and I’m amazed at roboticists and I’m -- I mean, it’s just --

**CHRIS URMSON:** Yeah.

**KEVIN SCOTT:** What a great thing it is to be a human being.

**CHRIS URMSON:** It is. I don’t know if you’ve watched this, the YouTube video of people – “People are Awesome”? And it’s that. It’s like the -- all these crazy things, you know, people juggling while on a unicycle or doing -- you know? And it’s just like -- yeah, like, the diversity that is humanity and the fact that people -- there’s so many things out there, and people can pick them up and -- yeah.

I wonder about my lack of imagination, that you know I see some of these things and I think, you know, you see it after the fact, you think that’s incredible, and then I think, I could -- it would never have occurred to me to do that. (Laughter.) And, you know, it’s -- it’s a bit of a shame some days. (Laughter.)

**KEVIN SCOTT:** Well, I’m sure that there are plenty of people who look at you and have the same reaction. I think building a -- building autonomous robots and, like, trying to help self-driving cars come into the world seems like an inscrutable, almost impossible thing to some folks. But, like, thank goodness we have people who are captivated by the idea of trying to do it and have the you know determination to try to make it happen.

**CHRIS URMSON:** Yeah, thanks very much.

**KEVIN SCOTT:** So, with that, thank you for being on the show today.

**CHRIS URMSON:** Oh, my pleasure, thanks.

**KEVIN SCOTT:** Awesome.

[MUSIC]

**CHRISTINA WARREN:** All right, so that was Kevin Scott chatting with Chris Urmson. And, you know, Kevin, as we were discussing before the interview, one of the things I think that is so interesting about Aurora and about Chris’s journey is the fact that he’s not -- Aurora’s not just building, you know, self-driving hardware, which a lot of different companies and startups are doing, but they’re really looking at building that entire platform around self-driving technologies.

**KEVIN SCOTT:** Yes, and I think that’s a really -- I mean, one of the things that Chris said in the interview about this platform approach that really rings true to me is like he doesn’t believe that they have sufficient imagination inside of Aurora to conceive of all of the many things that you may want to do with a AI driver.

And, like, I totally agree with that. So I think it’s really presumptuous to think that one company or even one industry is going to have all of the best ideas about what to do with a really transformational technology like autonomous driving.

And like it makes me really happy that there’s a company like Aurora out there that is building things in a platform way where hundreds or thousands of tens of thousands of companies will be able to use their technology to realize the vision that they have for what you could do with an autonomous driving agent.

**CHRISTINA WARREN:** Yeah, no, I think you’re right. The potential there is so great. I think that as interesting as it is and as important as it is for lots of different companies to be coming up with their own solutions, there’s real value in a platform, right? If we really want this sort of technology to have transformational effects, it can’t just be focused on one auto maker or one technology company. It needs to be something that people can build off of a platform, which has historically been what has made other companies -- whether they’re technology based or otherwise really successful. So, I agree with you, I think the potential there is tremendous.

**KEVIN SCOTT:** Yeah, the other thing, too, that’s interesting that I’ve been thinking a lot about and I write a little bit about this in the book that I’ve got that’s coming out in April, is the whole thing about platform companies is that you measure your success in terms of the successes of people who are using their technology to accomplish their goals.

And so if you think about AI and its potentially negative, disruptive impacts on the world, you’re much less likely to have like weird sort of re-concentrations of economics with a platform company than you are with someone who’s trying to build a set of technologies that completely disrupt an entire industry.

Like the platform gives a whole bunch of people opportunities to build new economically viable businesses that do useful things for large numbers of people, that it allows you to have more sort of inclusive and diverse points of view and perspectives participating in the development of products.

And like I think net-net, that is a good thing for the world to like have these like really complicated platform components that are available to a huge number of people so they can go sort of express their creativity and where the economics are lined up in a way where the platform, the builders of the complicated technology only get rewarded when the people that they’re empowering are successful themselves.

**CHRISTINA WARREN:** No, totally, and I mean at a certain point, you could even think about it like disruption will come, but it will come from those people who are building on top of things. It’s not necessarily going to be directly tied to the platform itself, which I think is probably a good way of doing things and making things more available to lots of different types of people.

**KEVIN SCOTT:** Yeah. Awesome.

**CHRISTINA WARREN:** Well, that’s the end of our show for today. And as always, we would love to hear from you. You can reach out to us anytime at BehindtheTech@microsoft.com. Tell us what’s on your mind. Tell us your new year’s resolution and of course, be sure to tell all your friends, your colleagues, your self-driving cars, if that’s what you’ve got, you know, your assistants, your voice assistants, your Uber drivers, whatever. Be sure to tell them all about our show. And thank you for listening.

**KEVIN SCOTT:** All right, see you next time.

[MUSIC]