Sue Nelson
Hello, I'm Sue Nelson and welcome to the Create the Future podcast, brought to you by the Queen Elizabeth Prize for Engineering. Celebrating engineering visionaries and inspiring creative minds.
[Music]
Imagine a ground-based public transportation but one that would enable you to travel close to the speed of sound and journey from England's South Coast to the northern tip of Scotland in just one hour. It's called the Hyperloop and a number of companies are trying to realise this high-speed system, including the California-based Hyperloop TT, and my guest is the company's propulsion levitation Technical Lead Dr Siavash Sadeghi. An Iranian American, he has a science degree from Isfahan University of Technology and a master's from Amirkabir University of Technology based on hybrid electric vehicle motors, as well as a PhD from Georgia Institute of Technology in the US, and I began our conversation by asking him to explain the concept of a Hyperloop in more detail.

Siavash Sadeghi
Hyperloop is a fast electric train, but we are shooting a capsule inside a low-pressure tube. So, reducing the resistant forces especially from aerodynamic drag, we can shoot the capsule with higher speed because the only resistance in higher speed is the aerodynamic drag from air so if we reduce the air inside our low pressure tube, we can accelerate the capsule up to 1200 kilometres per hour.

Sue Nelson
And how does it differ from say a monorail? Which is the first thing I think of that involves levitation, which is you know part of your amazing job title.

Siavash Sadeghi
Yes, we have different levitation system, we have Shinkansen and also we have Transrapid, they are all based on maglev systems, but they are not inside a low pressure tube. So, they always face the resistance of the air, they cannot go to higher speeds. So, the maximum speed that they can achieve is up to 400-500 kilometres per hour. Above that, it's almost impossible not using the low-pressure tube. In this case, you need a lot of power to push the capsule forward. But in our case, we reduce that air pressure so, it can give us this ability to go to 1200 kilometres per hour.

Sue Nelson
And that's purely from having this low pressure then that's the key difference?

Siavash Sadeghi
Yes, we are using the same almost similar levitation system. So we levitate it, but from the speed and from the propulsion system, we use a low pressure environment to increase the speed.

Sue Nelson
And how do you lower the pressure in this tube?

Siavash Sadeghi
We have strong vacuum pumps that we connect to our tube and we place them along the tube and along the guideway and we suck the air from the tubes to create a low pressure environment.

Sue Nelson
Your company is using something called Inductrack, what is that?

Siavash Sadeghi
Inductrack basically is a passive levitation system instead of an active system, so there is no power need to that. We are just pushing a bunch of permanent magnets over a conductive plate. And when we push arrays of magnets over a conductive plate it's going to levitate. This is called Inductrack. This is a passive levitation system. Instead of energising, putting active power into the cords and create the levitation and forces, we just use permanent magnets pushing over the conductive plate.

Sue Nelson
And where does your technology get involved in this process?

Siavash Sadeghi
The baseline Inductrack is using an array of permanent magnets moving over a ladder or conductive plate. So when the array of magnets are hitting those empty spaces on the ladder or track, it creates some oscillations. In my patent to that I filed for HyperloopTT we arranged a magnet on the moved somehow that we are going to damp those oscillations and we get a smooth force which impacts on the passengers comfort and also the smoothness of the drive.

Sue Nelson
You've also got this smart material called Vibranium, which obviously, any fan of Black Panther will know is a sort of mythical element. Where does this Vibranium come in?

Siavash Sadeghi
Vibranium is a special material that we use for our capsule body, it has a specific features that make it lighter, make it more strong and make it possible to move at 1200 kilometres per hour, our capsule material is a dual layer composite material using Vibranium.

Sue Nelson
What a publicity stunt to say that you've got capsules made a vibranium. And what stage is your whole concept at the moment? Is it still on paper, or are you working towards a working model that can be demonstrated?

Siavash Sadeghi
That's a very good question. So at this stage, we have built a 320 metre tube in a Toulouse, France and we already tested the vacuum and we vacuum the air inside that 320 metre tube to almost 10 pascals. So we tested down on the proportion and levitation, we have done quite a job and we developed our concept or linear motor system or levitation system. And we started some prototyping already, we have prototype, one metre of our motor already and we are testing that one in Toulouse, France. It's a huge concept, if we look at this technology, our motor is going to provide about 10 to 12 megawatt power. So it's not only one metre machine, right, it's going to be a series of motors connected to each other to create that much power. If you look at the capsule itself, to lift the capsule, we need about 600 kilogrammes of magnets on there to just lift the capsule. So it's a huge project, but we are doing some prototyping, we are working on a stability analysis and designing our damping system and suspension system. We are working with experts in different countries to develop our suspension and damping system to not going through the paths that previous companies have gone you know, we are getting feedback from Lois Livermore National Lab, we are getting feedback from General Atomics Inductrack too**,** we are using those feedbacks. And based on those feedbacks, we try to go to the analysis that can lead us to a stability because stability is the most important part in Inductrack concept.

Sue Nelson

It's no coincidence that the company you work for was founded the same year that Elon Musk set out this big challenge to everybody to rally around this technology and get this Hyperloop built. Is Elon Musk a personal inspiration for you as an engineer or is there someone else that really fired your love of what you do?

Siavash Sadeghi
I got interested in engineering and especially on the motors and controls and electronics from high school, I chose to be an electrical engineer at that time, going to the schools in my country and coming here for the PhD to continue on this subject. I'm always looking for new technologies. If you look at my background, I'm always challenging myself by moving from one company to another company to just test different technologies, you know, from automotive, to medical, medical to energy generation, and aerospace and then transportation and Hyperloop. I always looking for technology. But for Hyperloop. Yes. So it was Elon Musk when he was talking about a bullet train and going to 1200 kilometre per hour, it was insane. And when I reached out by a recruiter at Hyperloop TT, I said, "Oh, that's the one I was looking for, joining a company to develop the technology that it's way beyond the market right now".

Sue Nelson
Yes, even though levitation and this form of technology this is based on, I know that the low pressure is new, that's been around for quite a while but there is something futuristic about it, isn't it is that would appeal to you that you're taking the technology further?

Siavash Sadeghi
Yes, actually, there was some cartoons if you look back in 1940s, some sketches from different people that they were talking about this concept is, so it's not new. But if we look at the speed, you know, we are talking about a speed of sound right on the ground like an aeroplane on the ground ball much quieter, smooth, low noise and very clean, actually, it's a clean energy that we can use. It's kind of futuristic. And that's why only one person or two person cannot design the Hyperloop, in my opinion. It's a work that many partners from different industries should be involved with to do part of that, and just putting all these pieces together to make it happen.

Sue Nelson
And what is it about motors that's kept you so interested for 25 years now?

Siavash Sadeghi
Yes. First of all, it's a clean technology, So look at the electric vehicles, right, so you are removing the pollution from your electric vehicle when you start it in your garage. This is beauty of the electric motors, right. The electric motor, you know, when I was in bachelor degree, you know, I was working with those machines, when I'm looking at the performance when I'm looking at their technology that they have that you can create different designs, you can create different performances, you can have linear type, you can have rotary type, these are interesting for me. And when I'm looking at these technologies, it's interesting. That's why I always be with the motors and controllers and inverters.

Sue Nelson
Absolutely. And I noticed among your qualifications, that you have such a certificate in inventive problem solving, which rather like your job title, is another fantastic title for something. Now, what does that certificate actually involve, can you teach somebody to be inventive?

Siavash Sadeghi
We had a training session with a company called TRIZ. And TRIZ, actually, they were teaching us how we can solve the problem with the simple method. So, we formulate basically the problem. And based on what we have,

what methods we have, what is now in our hand, how we can solve that problem. It's a very interesting method. It's called TRIZ. And when we were facing a problem, we just formulate down there are some equations, you answer to some questions. And based on that, at the end, you will find the answer easily.

Sue Nelson
Now, you mentioned that, you know, you'd moved, the reason you'd made so many moves was to sort of stretch yourself and you've worked at General Motors, Honeywell. Which was the sort of job that you did that you think, "gosh, I learned a lot from that one and that pushed me to where I am today".

Siavash Sadeghi
Honestly, each company I learned a lot. And always when I go to interview they ask about that. I'm saying that in each position, I learned a lot. I was always working on new things. And when that new things ended, I'm just leaving that company and going into another company. So in General Motors, what was fantastic working with expert over there on the motors and controllers and then moving to Honeywell working on the aerospace, an aeroplane, and the power electronics and motors that they are gonna use in aerospace. It was amazing, you know, they have different requirements, they have different capabilities, they need a special design, then moving to Hyperloop right. So, Hyperloop was a different area that I was looking for, because I was moving from rotary electric motors to linear electric motors that was new and also very challenging for me, it opens another door for me.

Sue Nelson
You may be aware that the Queen Elizabeth Prize for Engineering 2022 was awarded to Dr Masato Sagawa for his pioneering work in permanent magnets, how crucial a role do they play in Hyperloop technology?

Siavash Sadeghi
Yeah, so the heart of the Hyperloop is the propulsion and levitation system, and basically the system and mechanism that we are using for the levitation pushing the vehicle, both are using permanent magnets. Permanent magnets are very important for Hyperloop and Hyperloop technology. The reason behind that is that you cannot get the power density required that you can get from permanent magnets from other technologies. For sure, we are also doing some research on non-magnetic propulsion system to see if we can replace those permanent magnet machine with non-permanent magnet machine as we as I did for other companies to basically save the magnets somehow on the propulsion system. But at this moment, we haven't had a design that we can use a non-magnet mechanism.

Sue Nelson
Now you are from Iran. What sort of an attitude does Iran have towards engineering? Is it a profession? That's considered with the respect it deserves?

Siavash Sadeghi
That's a very good question. You know, most of motor designers in California, at least I know, like 80% of them are Iranian. When we go to high school, there is a pressure from the families that either you should be an engineer or a doctor. And when you want to go to the engineering world, they are saying that the only engineering that can benefit you is electrical engineering, mechanical engineering and civil engineering and computer engineering. This is just mentality over there that if you want to be successful, and you want to get a job, and you know, make money in the future, it's best to go to these four basically major in engineering. So most engineers and most students in Iran, when they want to choose their major in schools, they usually go for these four types of engineering.

Sue Nelson
So it sounds as though it is in the same way as countries like India, where people really do regard engineering as a good profession for a young generation to study.

Siavash Sadeghi
Yes, that's true.

Sue Nelson
Is there a different approach do you find, now that you're living in the United States?

Siavash Sadeghi
Yes, the United States is different, right? So, in the United States, you can be successful almost in any majors, right. You don't have that pressure that you have in Iran anymore. You know, I always talking to my daughter, and she's saying that, you know, “I don't like math. I don't want to be an engineer”. So okay, that's fine. Here is not Iran that we can push our kids to go to engineering or being a doctor, right. But we just provide the environment that they can choose, basically, this is engineering. I took my daughter to Hyperloop, showed her around, look at the Hyperloop, this is Hyperloop technology. And she got interested to that technology, you know, how cool is that technology? And after they she said, “Oh, I want to be an engineer”. So I didn't push her. She said “I want to be an engineer, I'm gonna work on Hyperloop”. So looking at those environments and getting kids familiar with the technologies always good. At Hyperloop TT, one of the work that we did in the past was bringing kids and teenagers to the Hyperloop, giving them a tour that they see the technology, how cool is that, sitting in the capsule concept. And it was very good. It was very motivating for them.

Sue Nelson
Well, it just sort of capture the imagination, doesn't it? What's your next big stage, obviously, you've been doing this work in Toulouse and testing the tunnel part of it and getting the pressure right, what will be your next big project?

Siavash Sadeghi
Yeah, the next part that we are working on that we are finalising our propulsion design, our linear motor design, and we are testing or levitation concept with a research centre in Italy. Once we get those finalised, then we go ahead with the prototyping. So that 320-metre test rack that we have in Toulouse next step is building the propulsion inside and building a capsule to test the propulsion and levitation inside the 320 metre. But in parallel, we are also working on some feasibility study on the five kilometre and 125 kilometre track. Also in US we did a study on the Cleveland Chicago for 550 kilometre, that feasibility study has been done. And as I said, next stage, we are going to prototype our propulsion and levitation system to test it in Toulouse, France.

Sue Nelson
That's quite exciting, isn't it? And I know this is an impossible question to ask because it's like saying, “how long is a piece of string” but when would you hope in an ideal world that you'll see a working system up and running somewhere around the world.

Siavash Sadeghi
The timeline that we would expect to see a Hyperloop working, I could say 2028. In five to six years.

Sue Nelson
That soon?

Siavash Sadeghi
Yes. Also, we are working hard on the technology with the data that we have, with the design that currently we have, we are hoping that we can have this technology by 2028.

Sue Nelson
And do you feel as though there's a sort of a bit of a race going on because you're not the only company obviously, with your eye on making this happen?

Siavash Sadeghi
Yes, definitely. Right now, this is a competitive market. We have different Hyperloops, but I could say we are not competitors, we are friends also. We just want to have this technology in the market so people can use it. We want to have an impact on the climate change, right. We want to reduce the CO2 from the aeroplanes, and we want to have a clean energy that we can transport people with the fastest speed around the world. And there are different companies working on this concept and this is a good thing.

Sue Nelson
So it sounds as though you want to be a part of this, in terms of engineers, making a difference then?

Siavash Sadeghi
Yes, for sure.

Sue Nelson
Dr Siavash Sadeghi, thank you so much for joining me on the Create the Future podcast.

Siavash Sadeghi
It was my pleasure. Thank you very much.

Sue Nelson
You can find out more about the Queen Elizabeth Prize for Engineering by following @qeprize on Twitter and Instagram, or visit qeprize.org. Thanks for listening and join me again next time.