Marcela:

Hello. This is Marcela with Next Stop Transit Tech, and I am thrilled to welcome our guests from CARTA and Chattanooga, Philip Pugliese.

Marcela:

And Abhishek Dubey from Vanderbilt University in Nashville, Tennessee. It's great. We're really representing the Southern States right now with Tennessee and me in North Carolina. So welcome. Please introduce yourselves.

Philip:

I'm Philip Pugliese. I am the General Manager of Planning and Grants at the Chattanooga area, Regional Transportation Authority in Chattanooga, Tennessee.

Abhishek:

This is Abhishek Dubey. I'm a Professor of Computer Science and Computer Engineering at Vanderbilt University. I do research in smart cities and cyber-physical systems through my lab called SCOPE lab, and it's glad to be here, Marcela. Thank you for inviting me.

Marcela:

Yes, of course. We're so excited to have you all. The work that's being done between Vanderbilt and CARTA, so interesting. And I know that the folks at the Community Transportation Association of America are really excited to hear this episode when it's all said and done, so very thrilled. So we can go ahead and kick off with questions. The first is CARTA is working with researchers at Vanderbilt University on smart transit. So I know there's other folks on the team who can't be on this call with us. So could you shout out the folks who can't be here and tell us a little about the team.

Abhishek:

We have been actually very fortunate to be given this opportunity by National Science Foundation and Department of Energy to study and develop solutions for transit agencies. Our team includes people from several universities. One of the persons that actually works with us and is leading the social science team to really try to understand the community needs so that when we are working to develop the solutions, we are doing it in a way that's effective for the communities. Professor Paul Speer from Vanderbilt University, he's been aided by Professor Chandra Ward from University of Tennessee at Chattanooga. She is an urban sociology expert and an assistant professor of sociology. Then we have people from Cornell, Professor Samitha Samaranayake. He's a route planning and dispatch expert for transit and transportation. And as this is one of the big problems that we are dealing with, we need his expertise.

Abhishek:

We also have Professor Aron Laszka from University of Houston. Aron and I, we have worked for several years with Philip in some of the other transit projects. And Aron is really a privacy and security expert. So one of the things which is going to be very different in the way we approach this problem is we are really looking at the problem of security and privacy from the get go, and Aron is helping us with that. Rounding up the team is Professor Lillian Ratliff from University of Washington. She's an expert in a field of artificial intelligence called active learning. And the idea is that most of the time, what people know

about actual intelligence is things that are learned offline. She is an expert in trying to update the models online. So this is a field called active learning, and she's an Assistant Professor of Electrical Engineering. Finally, we have Professor Mina Sartipi. She is the Director of the Center for Urban Informatics and Progress at the University of Tennessee Chattanooga, and she is leading the team dealing with simulation systems. And we'll talk about that later. So this is the whole team.

Marcela:

Very cool. I like that it's a very interdisciplinary team. I know that when I was working in academia at Georgia Tech, that was something that was really great about cross communicating with different departments and different specialties because I know that transit isn't just a transportation issue, it definitely touches on so many different aspects, urban sociology, like you were saying, security, energy. Yeah, I think that's one of the really interesting things about transit is that it touches so many different parts of our lives, whether we recognize it or not.

Abhishek:

Yeah. And I would like to just add one thing, Marcela, to that, that this has really been made possible. We have to acknowledge the support of our federal agencies like National Science Foundation. They have a very specific program called Smart and Connected Community that is actually funding us. And the greatness of this program is that it focuses on precisely the kind of interdisciplinary research agendas, as you mentioned. And this is really the reason we have been able to come together and create this team to solve this important challenge. The other agency that we really want to thank is Department of Energy because one of the reasons to actually really think about public transit and invest in public transit is, among everything else, about accessibility for people is that this is an energy mode of transportation. So department of energy also has given us an opportunity to try to optimize it further and make it more efficient, and that's another source of funding that we receive.

Marcela:

Definitely. That's awesome. And glad that those federal agencies are taking the lead in bringing these groups together to solve some of these issues that we've been experiencing for quite a while. So bringing together all these different perspectives to come up with innovative solutions is really great. And I know that Chattanooga is no stranger to innovation. When I was in Chattanooga, back in January, I rode on the electric shuttle. And I believe that started like in 1992, which is way before, I think, the conversation of electric vehicles and transit is mainstream as it is now.

Philip:

Indeed. CARTA was a very early innovator in electric vehicle transportation. And our electric shuttle program was one of the largest electric bus fleets in the US for quite some time. And it was really that experience with the electric shuttle and early research in battery technology and energy efficiency that established CARTA as ~~I guess~~ a partner with academic researchers and led to this relationship with Vanderbilt and others in these current projects.

Marcela:

Awesome. Very cool. Getting back to the smart transit project, Philip, was there anyone from the CARTA team that you wanted to shout out to as involved with this initiative?

Philip:

I mean, really our Executive Director, Lisa Maragnano, and our Director of Grants, Research, and Technology, Annie Powell, have been instrumental in giving me the flexibility to work with these partners and reach out to our federal funding sources to establish CARTA in these research efforts.

Marcela:

That's awesome. It definitely takes a village to get these types of things off the ground and rolling. So that's really exciting. So we can go ahead and dive in. Could you give us an overview of the various projects that your team is involved with? I know that the Artificial Intelligence for Better Dispatching and Access is one of the projects, but I believe there are several others that we're not quite focusing on today, but those are definitely also very interesting. I wish we could have an entire series on what y'all are doing.

Philip:

Sure. Our partnership with Vanderbilt started with a department of energy funded project to create a high dimensional energy map of our entire public transport system. So CARTA has been involved in a variety of projects to create an ecosystem of public transportation. So in addition to our fixed route buses, we operate our paratransit service, caravan. We own and operate the incline railway, which travels from Chattanooga to Lookout Mountain. We operate in neighborhood shuttles, our electric shuttle program, and in 2012, launched a public bike-share system, and in 2016, launched an electric vehicle car-share system that was integrated with our transit network. So this DOE project was looking at capturing the energy resources of the system and looking at ways that we could optimize that. And that led to continued opportunities, which I'll let Abhishek explain those.

Abhishek:

Yeah, thanks Philip. So that was actually one of the first opportunities to work with Philip and the CARTA team. And that was quite successful. This was the department of energy project for creating the high damage energy maps, as Philip mentioned. And that really helped us understand that there are even subtle variations when you try to think about how the efficiency of transit vehicles could be affected by the road that it is traveling and the traffic in which it is traveling, whether the weather is cold, whether it is hot that day. And we collected data, and through that, we train models that can help us estimate what will be a better assignment of vehicles to the cities. Because look, the overall goal was to actually make the system more energy-efficient. And that led to our next project where we started looking at that, yes, we have been looking at the energy efficiency, but the problems could really go a little bit beyond and we can actually ask, "Can we take a look at the whole system together?"

Abhishek:

And that's a very complex problem because as Philip mentioned, there are different modes of transportation, there are bike shares, there are paratransit, there is on-demand transit, there is actually the fixed lines. And we have to really try to find out if there are inefficiencies that exist and if there is a way that we can determine optimal schedules that are better for everybody for the community itself. And that led to effectively two projects, one is a project that we are going to talk a little bit more in depth today, that was the National Science Foundation Project that focused primarily on the micro transit site. And then the other project that was looking at really the integration of the paratransit and the fixed line and try to improve the energy efficiency of those two modes of transportation.

Marcela:

Awesome. I have a little bit of experience with electric buses. So I know the conundrum with the cold and warm weather, so that sounds like a really useful tool to have because being in the mountains, that cold weather can really be a killer to efficiency. So it's important to be able to strategize and deploy efficiently. But that was a really great segue into ~~our next question, and it was about~~ the use of artificial intelligence to juggle what you, Abhishek, called the logistics challenge of integrating 21st century transit opposing goals, keeping on schedule a mid traffic and accommodating dynamic stops. So what does that project mean for transit operations at CARTA? And Philip, you can start with this question.

Philip:

CARTA as many times at agencies has been struggling with either a flat or potentially declining ridership, especially in smaller and medium-sized cities. So we've been working on a system redesign project for the last two years and looking at ways in which we can modify our fixed routes with changing demographics, leverage new technology that's providing micro transit opportunities and looking at technology to support a more advanced solutions sets with partners such as Vanderbilt. Essentially, we're solving the problem of, with a constrained budget, how do we offer a frequent, useful transit service while maintaining a large geographic coverage area? And then balancing those resources quickly turns into a very complex solution set. And that's when we turn to our academic partners for that support, which we're very excited to have the level of talent that we have working on solving these problems for us.

Marcela:

Yeah. I understand that that juggling, especially with the constrained budget, considering transit funding for the past, well, forever, but providing that service and serving the changing demographics, like folks moving back into the city, as well as a point that someone made to me while I was a transit planner, and it's that long-range planning ~~definitely~~ doesn't match how quickly our communities are changing. And you can spend a lot of time on a longer age plan, and as soon as you're done with it, you're like, "We've got to change it." So yeah, that dynamic ability to change and to modify the system, I think, is going to be essential. And with technology changing the way it is, I think transit planners and general managers going to have those tools at their fingertips just with the amount of innovation. So I was Abhishek, did you have anything you wanted to add to this question as well?

Abhishek:

Yeah. So actually to add to this question, one of the things we also have to try to look back that what Philip mentioned is, and what Marcela, what you mentioned is a fundamental problem. The fundamental problem is that there are fixed resources available, they are not growing infinitely, and there are always stresses on the system. And there's always, as you said, the demand of the transit keeps changing. And it changes dynamically. The traditional ways of doing long-range planning model gives you very statistical long-term model that sometimes may not really be very accurate when you look at short-term differences. So let's take a very, very simple example. We did a study last year specifically as the pandemic was sort of raising and people were getting used to the new reality that we are in today. We saw that there was a big decline in the number of people that are using transit.

Abhishek:

Now, at the same time, the transit agencies all over the US and actually in the world, they were also figuring out how to deal with these problems and where to really structure the routes. So this is a classical problem where you have a certain set of demands that you have to fulfill, you have a certain set

of resources, you don't have infinite resources, and you really need to match where to put these resources so that it's most impactful for the city, typically, solving this problem is what we may sometimes call scheduling or sometimes we may call it an optimization problem. And almost everybody who has actually done some prior work in math and engineering, they would know that these classes of problem could be formulated. If I give you all the data, you can formulate the problem and solve an answer for a day.

Abhishek:

Now, the problem becomes, Marcela, as you mentioned, the demand changes from day to day. So you have basically two problems here. One, you have to continuously keep estimating what the demand is going to be, and at the same time, you have to come keep coming up with a proximal answer of how to meet the demand. And this is where the complexity hits you. If you look at any of the current software that is available to transit agencies, most of these softwares are built with very static models in mind. And also sometimes when they are not, they have built-in hidden heuristics. It's almost like magical cheat codes that when you do some things, it will work out the result. And most often than not, what really happens is that the schedules are designed by human experts because of all the long range experience that they have, they know what works, what doesn't work. But as you scale this up, this will not go on forever, this becomes really problematic.

Abhishek:

So one of the approaches, and this is, again, the approach that has been going on in some of the other areas in the world, just take an example of the AlphaGo. This was a game software that was designed by DPI, a company DeepMind, and they tried to make sure that they can play it against a human player. The software, and it can defeat a human player in go, which is actually much more complex than chess. It's a very, very complicated problem. If we try to solve this with this kind of our estimating what this human player will do, and then trying to optimize, it could just not have worked. That's where they started bringing in techniques of artificial intelligence. And artificial intelligence is a very complex word that sort of encapsulates a lot of things. At the end of the day, it could be summarized at a very simple way, let's machine strategize and try to not only figure out what is the best answer, but also train the machine to be able to search for the best answer.

Abhishek:

And when you do that, then almost you have trained an algorithm that can look for the best algorithm to solve a problem. And that's what we are trying to do here. So for example, if you are going to try to figure out that there are calls coming in, and you need to actually schedule a number of runs on the buses where these buses will actually pick people up on demand, how many buses do you need? If a query comes in in real time, should it be a new bus that should be released to pick a shuttle that will pick this person up, or they should be assigned to a shuttle that may be nearby. All of these little, little decisions add up, and that's what we're trying to build in our AI algorithm, that it will start helping out and figuring out these problems and these solutions.

Abhishek:

Now, one of the complicated thing when we do this is we make assumptions. This is a very complex promise that we make, a number of simplifying assumptions. So one of the assumptions could be okay, how long will somebody wait for the bus to arrive if the bus gets delayed. This is where the role of a community or social scientist person comes in because they really would want to understand from the

community itself, what is an acceptable answer to this question? We, as scientists or computer technicians, should not try to impose an arbitrary constraint on the system. And actually, this has resulted in a number of previous micro transit failures all over the world. Micro transit is something that has been tried again and again in a number of places. But often, it fails because it doesn't justify the community's expectations. And it tries to put constraints on the community which they don't want.

Abhishek:

So for example, there is a micro transit that is supposed to take you to the next bus on a fixed line or a rail, but it is running late and the rail is not going to stop for you. And now you're waiting in a station because the next rate is 40 minutes away. But if it knew where the rail is running and whether it is running late, it should have rerouted you. And that's an example. And this is what our AI algorithm is trying to do by the virtue of using these complex algorithms and giving it the ability to learn. We can give it a lot more data, a lot more environmental cues, lot more schedule information that even the uncertainty in the schedule information, it can learn about it. And that's what we are trying to build here.

Marcela:

Very cool. I really like that the human element of working with the social scientists because you're right, that these assumptions are based in things with public engagement, and that's always in the planning process is your ridership, like your constituency is always a variable, and transit needs to be responsive to the users and potential users. So I think that's really powerful. And what an asset to planning to be able to use all of this information is always told that data or transit has a wealth of data. So I'm sure that's really great for building these algorithms and understanding how they change. As you were talking, I was kind of visualizing how traffic patterns change throughout the day, but so many transit agencies have a static schedule for weekdays and then for weekends, but traffic is not static on the weekdays and it's not static on the weekends, it's constantly in flux.

Abhishek:

Yeah. And it's not just about traffic. So if you think about this and if we just focus on paratransit or on demand transit, if you can estimate what the short-term demand of an origin destination trip, that somebody wants to go from point A to point B, if we can estimate that, maybe we can schedule things more proactively because then we would say, if there's an 80% chance that there is going to be a request coming from a neighborhood, then we might send a different capacity vehicle compared to if we didn't know that. And now we have scheduled a lower capacity vehicle because we did it statically and now a call came, so now we have to send another vehicle while the first vehicle could have actually taken care of that. This is where the prediction is actually a very big tool in our approach. And this is where AI, when people are saying AI, what really AI, an actual intelligence is, learning to predict from the data and doing it strategically. So that's one of the things that we are building.

Philip:

Right. And we have to operate that in an environment under the constraints of a public transportation agency, unlike Uber, for example, which can modify pricing to influence supply, to meet on anticipated demand. So having that predictive capability is very critical to us.

Marcela:

Yeah, definitely. Paratransit is a very good example of that. And thinking about predicting trips, what that means for healthcare and getting people access to their medical appointments, just thinking about how sometimes paratransit trips, you have to book up to 48 hours in advance. And as we all know, life doesn't always work out in a way that you can plan 48 hours in advance.

Philip:

Yes, we are definitely interested in using technical applications to improve our demand responsiveness for both paratransit and our micro transit neighborhood shuttles.

Marcela:

What are some of the issues with coordinating fixed route micro mobility and paratransit services that hoping to solve with AI-based dispatching and scheduling?

Philip:

I mean, we've, we've touched on several of the benefits of coordinating our different types of services being more responsive. Chattanooga is a relatively compact city, but it has a fairly very geography with lots of ridges, river, streams, many areas without substantial sidewalk infrastructure. So the ability of people to actually get to a bus stop is often constrained, and we see opportunities to leverage these smaller vehicles to offer more flexible service and connectivity to our material fixed routes on major roadways. So lots of opportunity there, we think. We leverage any slack in our system and really create an ecosystem of transportation choice, in which public transit is a competitive alternative.

Philip:

So I mean, facing these challenges of offering a competitive solution in terms of time, comfort, convenience, no matter what mode of transport people are looking at, they're facing the same types of challenges and they want the same type of benefits. So we're, we're really hopeful that this collaboration can lead to a more competitive transportation landscape, and then combined with the community engagement piece of our research, really look at opportunities in which we can look at ways in which people might change their behavior.

Marcela:

I think that's going to be key for COVID recovery, knowing that ridership has dipped, and there's definitely core ridership of folks who are essential workers who've been using transit to get to their jobs. But to get back to where we were pre pandemic and also to continue growing transit for the stated goals of the involvement of the department of energy is getting more energy efficient travel out there, which transit is, I think, an integral piece of.

Philip:

Yes. I mean, our goal is really to make transit more competitive in markets ahead of the curve. So obviously, if you live in New York city or San Francisco, you have lots of reasons to use public transit from congestion, to parking costs, just the fact of having a place to store your vehicle, whereas in of the United States, those constraints don't apply. So how can we devise a competitive system in a marketplace such as Chattanooga that is replicable elsewhere is really what's driving us to find a solution ahead of the congestion. So you can't build your way out of congestion. So we want to get there ahead of time.

Marcela:

Very true

Abhishek:

So looking into, as Philip said, and as you mentioned, Marcela, also, one of the primary things is we need to be able to estimate demand. So you asked what are the issues when we start coordinating. And the problem is always going to be trying to understand what is the expected demand and how many number of people are expected to use the service. Now, this question is very loaded because on one hand, we are trying to estimate what is the baseline. And on the other hand, we are actively trying to design the system to improve the baseline because we want more people to use the service. So this is why we are training the model. We are also really trying to make sure that we, for example, remove the delays. We improve the coordination, the jump off points. So for example, suppose there is a region in Chattanooga where the current demand may be low. And when people try to request service, maybe that region could be serviced by an on-demand neighborhood shuttle.

Abhishek:

Now, if you think about it, if that on-demand neighborhood shuttle is being used and the person who is trying to use the service wants to go from that region of Chattanooga to completely, let's say, Downtown, where there are very frequent fixed line services. So one of the big issues comes in is that we need to take the scheduling of this on demand transit, and without much delay, we need to be able to, for example, transfer them to a fixed line, and that fixed line should take them to their final destination. And the goal here is that the net total travel time is still less than what they would have done if they would have been, for example, hit in the traffic congestion or if they have been waiting. So we want to make the service convenient.

Abhishek:

But the problem here is you have to deal with two possible subsystems. One is this neighborhood shuttle, and you have to schedule it. So whatever got them has to figure out what is the optimal schedule and for every possible schedule, it has to determine what is the likelihood or probability that it will be able to transfer this person at a stop to a fixed line. And if that is not the best option, then the question is, okay, what is the other possible mode of transportation? Should we take this person to the downtown directly? But maybe that's not the area of operation of the neighborhood shuttle. So these little, little problems add up. And when you are actually trying to figure out what is the optimal schedule, it doesn't just become the classical paratransit like neighborhood shuttle or vanpooling problem. It becomes an integration problem because now you have to integrate with the fixed line schedule, estimate the location of the transit bus and what is the likelihood that it will reach a particular stop at a particular time.

Abhishek:

So see, you are not doing almost traffic forecasting, estimating the delay of the bus, and with that delay, trying to integrate your schedule and then come up with an answer so that you can give up this answer to the person who called into the neighborhood shutter system and then say, "Okay, your best itinerary is this. We will take you to the stop, drop you, and within two minutes, another bus will come and you can hop on the bus and you can reach your destination." Doing this integration is very tricky because this requires not only the demand estimation, it also requires traffic forecasting, it requires estimating

the delay of operation on the whole system, and this is what we are solving. So these are some of the issues.

Abhishek:

One of the approaches to do this as we create lots of scenarios. So we start with simulation. We collect lots of historical data, and then figure out within, if it rains today, maybe the expected delay will be this. If it actually snows today, the expected delivery is something else. And then start creating models and use those models to plug and approximate these differences to create a full schedule of the system. And that's what we train the AI system with. So the idea is that later on, as more information, daily information is coming in, it is figuring out what is weather today, what is the traffic patterns today, today is Monday, what is the time right now. I expect a call, and when the call comes in, it will say, I expect the schedule to work like this, and it gives the schedule to a person.

Abhishek:

And again, you have to be very competitive because if you make a mistake, you can only make a mistake so many times. People will stop using the system. So you have to be correct. The chances of making a mistake should be very low. And that's what we have to do, we have to develop our algorithms in a way that they have been trained very well. And we believe we can do that.

Marcela:

That's amazing. That is so many considerations and so much information to put together. But the product at the end of the day is so meaningful. I think what Philip described as the ecosystem of choice and putting all of these pieces together for a seamless ride and seamless mobility, I guess, to get across town and really just to coordinate all of these different pieces so that people can make their way to where they need to go. Yeah, I'm really, really excited to see everything. I'm visualizing it in my head and I'm trying to like put this web together and then I'm like, "That is a lot of moving pieces, so I will leave that to the computers and to the researchers." So ~~our next question is just~~, tell us how the project is going? What milestones have you met and what are you looking forward to achieving in the next year?

Abhishek:

One of the things I mentioned is that we have been very fortunate to also get interest and participation from Nashville WeGo. So even though initially when we wrote the project, WeGo was not part of it, but during the COVID-19, we started talking to them and realized they also have very similar aspirations. So actually, we have been studying these things together. So one of the big things that has happened is that we have created a collaborative committee where people are actually talking, and we are initially finding out what data we have. So initially, the first milestone that we have met is that we have created a data architecture where we can fuse all these different data items, and we have started training demand estimation models. So we can now, to some extent, predict the likelihood of the occupancy on a particular route at a particular time, whether it will be greater than X or not.

Abhishek:

And actually there is a side benefit to this where this also benefits is telling the transit agencies like CARTA and WeGo what is the likelihood that there'll be so many people in the bus in these times of pandemic, that it might not be possible to socially separate yourself. So that is the side benefit. We never started thinking about that, but not at the time we are in the ability to predict the occupancy is allowing us to actually do that. And we are building some dashboards. We have already deployed them

and we are giving this information. And we are continuously improving it so that it is of use to the transit partners. The other thing which is already maybe making a lot of progress is that in order to train any AI system, AI system learns by mistake. So the way it does is it takes a set of actions in a certain context, and then you tell it that this action is no good.

Abhishek:

And the way you tell it is by divided something which we call a reward function. So it's like a mathematical function, which it tries to score better and better and better and better and tries various strategies. So of course you can't do that in real-world because A, it will be too slow and B, it will be very bad for people. So you have to do this in simulation. So we have been fortunate that we have been able to start assembling a team that is building the simulation based on the real data set. And right now, we are looking at the Chattanooga region. We have a simulation that can simulate the traffic in the Chattanooga region and the transit patterns in the Chattanooga region. From there, we will actually start validating whether the trajectories, the performance that the submitter is telling is very similar to the real system, and that's where we start actually training our AI algorithm.

Abhishek:

Now, we have also started developing certain baseline, which is the classical optimization based approach for these, which is typically very slow and which doesn't deal with a lot of uncertainty, but with Cornell, and Houston, we have been starting to actually develop these road algorithms. And then we will start comparing these algorithms to the answers that our AI systems have given. So that's kind of where we are right now. Now, of course, where we want to go is to be able to show for certain region of catalog within simulation that other approach may provide better answers than what is the status quo right now. And that is what we need to be able to show as evidence before we even try to pilot the system in real time.

Marcela:

Very cool. That's a lot of progress. And I think I'm glad that we have the technology that we do to work across. You mentioned Cornell, you mentioned Houston, University of Washington. It's amazing what we can bring together now that we have such connected devices. And Philip, from the CARTA side, what have y'all been working on and what are you looking forward to, especially what do you think a pilot would look like?

Philip:

We see an opportunity, as we deploy micro transit technology in certain zones, to be able to expand capacity by leveraging any slack in our paratransit vehicles, and then through a community engagement effort, really gauge what's needed to transition people to using public transit for those who aren't using it now and how to improve service for those who are currently using it. So we see us very much in the near future are testing this on the street. With our other projects with Vanderbilt, we have an opportunity to reduce our energy costs, which those funds then can be reinvested into service operations. So definitely some direct benefits coming online this year and in the future.

Marcela:

That's great. Wow. I'm going to have to get back to Chattanooga. From a rider perspective do you think that it's kind of all behind the scenes or will there be any information going out to riders?

Philip:

No, I think we'll definitely be engaged with the public. And this is definitely needed information and behavioral modification type campaign. I mean, public transit opportunity, essentially 30% of our residents don't drive a vehicle, and that's either due to age, economics, disability, or choice. So public transit serves a fundamental role in providing access for those individuals and then provides a choice for many other people to choose the right tool for the right trip. And whether that's from walking, micro mobility, shared bikes, bicycles, walking, public transit, or driving your own automobile and finding a parking space, along that entire continuum, we want to provide an informed opportunity and whether that may be a situation where we're offering subscription services, providing mobility on demand or mobility as a service, lots of opportunities out there for us to transform the landscape and inform people's choices.

Marcela:

Yeah, definitely. And yeah, enhance their choices and know that transit is there for them to get around town.

Abhishek:

One thing, Marcela, I can add is, as you said, for people who are really interested in performance metrics and let's say, want to play with the data and take a look at the data, we already have made certain dashboards, for example, for the energy and the occupancy available on our website. The smarttransit.ai website, if you go, you will find the dashboards. But these are just preliminary. You can already see where our vision is. We want to make sure that such data is available to the public in a form that if they so choose, they can start analyzing very, very simply how their system is performing.

Marcela:

I do love a good data dashboard, and that's really great to have that information out so folks can see how their agency's doing out of curiosity and for research purposes. I forgot to touch on the co-benefit of passenger load information since that's been key, I think, for a lot of writers is they make the decision of whether they will ride or not considering social distancing. I know agencies across the country have introduced passenger load limits, and having that information is pivotal for a rider that sees a bus coming up, and it's almost full and lets them make the informed decision on how they're going to take their trip. And it just empowers a user to make informed mobility choices.

Abhishek:

Yes. And this is something which we are actually actively working on with some of the other partners that trying to bring this data. And remember, I earlier talk about a problem of estimating the likelihood that the number of people on a particular bus on a particular trip will become greater than a certain number. And this is tricky, we want to make sure that the models are good first, but once they are good enough, then we want to make the data available to the public.

Marcela:

Very excellent. Data transparency is amazing. How did the relationship between CARTA and Vanderbilt University begin?

Philip:

CARTA has been involved in a lot of initiatives. As I mentioned, in addition to operating public transit, we launched our public bike share program, an electric vehicle car share program. And through those efforts, we've been engaged with a lot of community partners, one being the enterprise center, which is a non-profit city supported agency designed to leverage Chattanooga's opportunities as a national test bed and living laboratory. Originally built around our fiber optic internet service as a tool to attract research and other opportunities in the city. That agency actually just introduced us to Dr. Dubey and the Vanderbilt team and University of Houston, and we just started exploring ideas and looking for opportunities to do joint research. And so this opportunity to bring theoretical research into the practical and living laboratory type environment has always been attractive to us. As a planner, I always look at planning is great, but it's really the implementation that's the fun part and making things actually happen and improving our community. So that's how we were introduced, and it was just an opportunity meeting that has led to lots of work.

Marcela:

Wow. That is really cool. As we're talking, I'm visualizing when I was in Chattanooga recently, and I remember using the bike share and thinking it was very useful from getting... I think I was going from the Chattanooga Choo Choo across to the North Shore. And it was very fun. I felt very safe using the bike share and getting around. And just the amount of connection points, like getting from the electric bus shuttle and then biking around town, it's nice active transportation. And seeing TVA there and you just kind of constantly reminded of the innovation that takes place in Chattanooga, I'm a huge fan.

Philip:

That's great to hear. That sums up what was, I think, our objective in creating this ecosystem of choice and just what you described. So that pleases me greatly.

Marcela:

Yeah, definitely -has been around so long and that it's continuing, so very exciting. Abhishek, do you have anything to add on the partnership between CARTA and Vanderbilt University?

Abhishek:

Yeah. So it has been great actually working with Philip. As he mentioned, we met during the enterprise center. And actually, it's funny because we have had some checks a little bit before because around 2016 and 2015, I was part of a program called Global Cities Teams Challenge that was coming out of National Institute of Standards in the United States. And we had a small funding from National Science Foundation and we created a program called transit hub. It was a small application that told people about the estimated delays of the bus and how late the bus is running. We tried this in Nashville. I was presenting, and a long time ago, I actually had shown it to Philip. And that's how Philip actually knew me. But we never knew exactly okay, what's the next step, how to move forward. And then the meeting at the enterprise center happened and we're like, "Okay, I think there is lots of synergies and we need to try to look together."

Abhishek:

And then the opportunity of department of energy's vehicle technology office call came, and we went after it. We actually wrote a proposal to make public transit, more energy efficient. And one of the observations was let's really try to monitor the buses in real time and try to see how they're performing. And that was the first project, and that success led to these projects. One of the things that I will just

mention, as Philip said, that, yes, it's actually not only what Philips statement was that he wants to see the things in implementation, this is precisely one of the reasons my team and actually a lot of other academic researchers these days are trying to partner with the communities. Because we, typically as engineers, if you think about it, yes, I'm a computer scientist, I'm a professor of computer engineering, but at the heart, I'm an engineer. And so are my students who are actually learning, so are my teammates.

Abhishek:

We want to build things and we want to see the impact of what we are building. If we do not partner with the community, then it's really hard to see the impact. And what is the best way to show that our algorithms work than partnering with a community partner like Philip, like CARTA, and show that yes, we can actually solve a problem. And it is not just a one way street, actually trying to really understand what the real world problems are because they are much more difficult to solve, then made up to critical problems. And that is the information that we get from somebody like Philip, who really keeps us real, that what you are thinking is a fictitious made up problem. Let's start thinking about the real issues here.

Abhishek:

For example, the integration of the two fixed lines and on-demand transit. And that's where you will find, as soon as you start putting the uncertainties of traffic, that this is not a problem that could be solid. If you can pick up any of the paper that does vehicle routing problem, which is the on demand transit, they cannot handle that problem. And that's what we wrote in this new grant proposals that we have, and we say, "Let's try to solve it." So what I would say is this is a synergistic partnership that really helps on both sides. And I'm really glad to be able to work with people like Philip on that.

Marcela:

Yeah. I agree with everything you just said. And honestly, you took the words out of my mouth for the next question because it's going from a research project to operational reality. I think that's really the beauty of all of it is you, your research team, your students are all working on this problem, and at the end of the day, it has meaning to the people who live in Chattanooga that use the transit system. And that's the best part, I think, of academic research is seeing your work in operation.

Abhishek:

And I think that's what being an engineer means. I sometimes try to explain to my kids what's the difference between an engineer and a scientist. And I'm like, "Yes, engineer is a scientist who is building things."

Abhishek:

Again, we also have to remember that engineers don't work alone. And that's why we have this team. We really need support of a lot of disciplines to be able to do what we are doing. Otherwise, we will build something that nobody will use.

Marcela:

The input from all of the different disciplines, all the different perspectives from people, all of that is critical. I think the more people you can have at a table with diverse perspectives means you come out

with something even more powerful. Great. So what advice do you have for other agencies looking to partner with universities or non-profits or others for federal grant opportunities.

Philip:

Obviously executive level of support at the organization is critical. Strong coordination across departments from operations to maintenance and marketing is essential. I mean, there's great opportunities out there, but in a public transit environment, it's often difficult to carve out excess capacity necessary to do research projects and experimentation outside of your quarter needs. We're a very time sensitive operation. Every day's a new day. We have commitments to meet and buses to run. So having the available resources and to recognize the potential benefits of this research I think is very important. I've been very fortunate at CARTA to having the time and resources and flexibility to invest the time necessary with our partners to explore this research and then bring it back to the agency and work towards implementation. So that level of flexibility and recognition of the value of the research partnership I think is the critical element.

Marcela:

That's so true. When you're juggling all the other things that happen in transit, it is great to have time and all the things you described, coordination of departments, the executive level support to pursue these kinds of partnerships. Because like we were just saying, when you have these different folks at the table conversing, you can solve some pretty dynamic problems. I think that there's a lot of talent in the world that doesn't make them impossible to solve.

Philip:

Yes. And having really smart researchers at our disposal to help us do it as a huge benefit.

Marcela:

Abhishek, do you have any advice for transit agencies on how they could approach folks in academia, universities to pitch maybe some of their problems? What do you think, from your perspective, is a way that they can get in contact with maybe their local university to try and do something like what you and CARTA are doing?

Abhishek:

Yeah, I think it's a great question. So of course, there has to be a lot of support at the transit agency itself, as Philip mentioned, because those are the challenges. But other than that, it's really trying to find local university partners because the local university partners would actually understand the problems. And what the transit agencies have to realize is that the university partners are actually looking to partner because they want to find a real target for their approaches. And they need to together start taking a look at programs like National Science Foundation, Smart and Connected Communities, there is the Department of Vehicle, Vehicle Technology Office. They need to look at these kinds of programs to see whether they can actually pitch a joint project. Because at the end of the day, this always becomes the problem of funding and only work together if there is some support and money behind it.

Abhishek:

So often, some of the big agencies, like really, really big agencies, big cities can put some funding from their side to start the partnership as a seed. But typically, you need the seed from federal side. And in order to really do that, you need to at least spend some quality time together to define a neat problem.

And this all happens typically locally. But always it's welcome. You should go back and talk to other people who have built successful partnership to see if they can help. Otherwise, local partnership is always very unique and helpful.

Marcela:

I think the local part is key. And again, what you were saying about universities are really looking for this type of partnership because it provides a live living laboratory that has real impact for the community it's located in.-Well, the power of universities, as local partners, has immense benefit. And it's just a powerhouse of knowledge that's in communities. ~~Yeah, that's great.~~ And then the next question is maybe geared towards communities that don't necessarily have a Vanderbilt or a University of Tennessee at Chattanooga or a Georgia Tech in their community, do you have any advice for agencies that may want to do a scale down research project and ~~maybe~~ even community colleges are partners there?

Abhishek:

~~So~~ what I would say is that you don't need Vanderbilt or University of Tennessee Chattanooga always. As you said, community colleges are there. There is a lot of students who are looking for internship opportunities. Maybe those opportunities could be used to give defined problems for those students to solve. Also, there is definitely benefit in national conversations. So there are associations and groups like Metro Labs. Like in Tennessee, there's a group called TennSMART, which is a consortium of like-minded organizations and industry trying to come together to solve the mobility challenges of Tennessee in the region. There are a lot of such organizations. And I think trying to find an organization and trying to start a conversation with them will also help. It also would help to try to maybe find out, if not exactly the college nearby, if there is some other like-minded transit companies that have done something and start having a conversation with those transit agencies.

Abhishek:

So there are a lot of things that could be done slowly and slowly. And one of the things we have to also understand is we don't always have to reinvent the wheel. If a problem has been solved somewhere else, then the goal is to make sure that knowledge is transferred. And the knowledge should not always be transferred in a way that it is a package solution that you will have to buy from us. Sometimes, and this is the beauty of open source software and open source revolution that we can make this available in a way that somebody can then try to apply to the different transit agencies. So I think these are some of the ways that you can actually make progress if it's a smaller agency and if they're not too many colleges around them.

Philip:

I would add even at federal transit administration, for example, their mobility on demand sandbox program has brought together a variety of projects from around the country. And so just tapping into that knowledge share can be incredibly valuable. And Abhishek touched on the opportunity between commercially-available packages and solutions that are more open sourced. And that's a problem that we look at in that there might be a particular solution that's commercially available. But especially if you're a smaller agency, it might not be specifically tailored to your needs and or it might be very expensive. While the alternative is looking at open source or academically researched and developed solutions might be better suited to your needs, but then there's always the concern of long-term

sustainability and support down the road. So I think balancing those opportunities and finding a good fit between those opportunities is important for each agency to look at.

Marcela:

Yes, it's very true with open source versus maybe some of the white label solutions that are out there as far as software and CAD, our goal is to provide transit agencies with the knowledge and tools that they need so that they can replicate. And just like Abhishek was saying, not to reinvent the wheel, but not necessarily to take another agency's solution line by line, but to be able to tweak it to fit their needs and have the right questions to ask to make sure that a solution that they identify fits what they're looking to solve. And ~~like~~ a slight little N-CATT plug is the conversation around open source software. We're doing a series of guidebooks right now, and one of them is focused on software.

Marcela:

And there's a pretty extensive conversation in that guidebook about the pros and cons of adopting an open source software where the cost is less, but maybe it doesn't fully fit your needs versus something that's more costly that can be customized. And finding just the happy medium that fits your budget, that fits your requirements, I think all of those are really important questions to ask, especially from the transit agency point of view where you have to go through the procurement process, and that's a whole process. And you probably don't want to go through it year for year to find the perfect solution. So the closest you can get to something that works for your agency the first time around is good.

Philip:

Exactly.

Marcela:

Do you all have any parting words for the Next Stop Transit Tech podcast.

Philip:

We just appreciate the opportunity to share our story. And if we can provide any information to any listening agencies, we're always happy to share and help out in any way we can.

Abhishek:

I'll say the same things. Thank you very much to give us opportunity to share what we are doing. A lot of our information, we will try to make sure it's available openly. It will be on our website, the smarttransit.ai. And as Philip mentioned, if there are questions or there is up requests, we will love to actually talk to people to try to provide what we have, provide our experiences, and feel free to reach out to us.

Marcela:

Well, thank you for joining us. I'm really excited to be able to talk to y'all and be able to share a little bit more about the work that's going on in Tennessee. Like I said, huge fan. Chattanooga, also a huge fan of Nashville. So I'm excited to hear more of your story and to share it with other transit agencies that are listening to our podcasts.

Abhishek:

Thank you very much, Marcela.

Philip:

Thank you.