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**GABRIEL
SANCHEZ:**

All right. So let's start with a quick introduction my name is Gabriel, Gabriel Sanchez. I am a lecturer and research associate in the transit lab at MIT. We're over at Building 1. My office is in room 1235. And that's where office hours are going to be every Tuesday at 11:00 or by appointment. Send me an email-- can you hear me at the back? Yeah? If you want, you can send me an email. And we can arrange for office hours if you have any questions about homework or anything about lecture.

So speaking of OpenCourseWare, you should have all seen some notices up as you came into the room. We're going to be recording the class this semester. So that we can share it with the world. So I think you're all good-looking people. But if you are anxious or nervous about being recorded, there a back burner over there won't be-- it'll be a blind spot in the cameras.

Any recording of your faces will be completely incidental. That's not our intention. It's not to record you. The camera is pointing at me. And we're going to look at the slides. If I move over to the sideboard and you are a, then you'll be recorded. So please don't let that intimidate you. Participate as much as possible and make people feel that they're in the classroom with you. So we're welcoming people for years to come to this class, people in the future. Let's look at the syllabus.

This class meets Tuesdays and Thursdays at 4:00. You're here. You found the room, 2131. The final exam date and time will be announced. I usually have the final exam in the same room as we have lecture. So if it's available, we'll have it here. The time and date is pending. Office hours, as I said earlier, are on Tuesdays at 11:00 or by appointment. You can send me an email. You have my email up at the top.

You probably read the course description. So I'll skip that. And we'll get into that when we start talking about introduction for today's class. We'll have five problem sets. And they will carry a weight of 65% of the grade split evenly. A fifth of that 65% is going to be for each of these assignments if that makes sense. And then 35% of the total cost grade will be the final exam.

There's just one final exam. There won't be a partial.

And regarding attendance, I'm not grading attendance. But I do consider it, especially if you're in the fence at the end of the class. I'll be more generous pushing you up if you have participated actively. Now, let's look at the course schedule on the second page. In this class, we have 26 lectures. They're numbered on the left column. And they are divided into four themes. The first three lectures are introductory. So it's a theme of introduction to public transportation systems.

Lectures 4 through 12 are on data analysis and modeling. So you'll see that we cover data analysis techniques and different models-- cost modeling and ridership forecasting. Lectures 13 through 15 are on service planning and operations planning. That's when we get into scheduling and you really understand what it takes to plan transit service and what drives costs.

And then after that, all the remaining topics are on the more general theme of strategy, policy, and other advanced topics. So that's to round out what you know by that point. If we have changes to the schedule such as a snow day, we will publish that on Stellar.

OK, on the back, we have a little description of what OpenCourseWare is. I think most of you should know what OpenCourseWare is. It's an online system to share classes at MIT with the rest of the world. And so we're recording as I said. And the spot on the back is the blind spot if you want to avoid being recorded incidentally. Normally, no matter where you sit, you won't be recorded. Maybe you're the back of your head might be but not your face.

In terms of readings, we have a few relevant books. Some of them are reports. And they are posted on Stellar. Please raise your hand if you don't know about Stellar or not familiar with the Stellar. We have one, OK. Are you from-- you're not from MIT, right? OK, so send me an email so that I can give you access to the site. It's a website where we share all the materials and homeworks and such things.

So some of these books such as *The Transit Capacity and Quality of Service Manual* is already posted there. So it's a PDF you can download to your computer. There are also three books. I'm not expecting anyone to read these books or to buy them. I brought them. Please pass them around. If you're interested because you really like this topic, you can go ahead and buy them or borrow them from somewhere. I think they're in the libraries. So you can also get them there.

So just how you can flip through them and have a look if you want. But as I said, we're not expecting that you read them or buy them. They're not really necessary for any of the homework that we're going to have. So it's supplementary. And finally, an acknowledgment.

This course is Professor Nigel Wilson's course. And I lecture it. But most of the material that we have in this course is provided by him and follows of a long history of teaching 1258 in the way that we are teaching it here at MIT. It was his creative process that led to this. Do you have any questions about the syllabus before we get started with the class? Any questions about what we plan to cover or what the style of this course will be? OK.

In terms of homework, the first one, which I passed out, is for you to work on individually. If you don't have a copy of that, please get-- it's one sheet in the front. And that's due a week from now. It'll be your St. Valentine's present for me. And please let me know if you have questions. It should be a straightforward homework. There's a reading that you do. And it's on Stellar. And then without reading, you should be able to answer the questions on this homework.

After this, you will have some assignments that are worked in pairs or in bigger teams, especially ones regarding data collection and service planning and operations planning. So there's going to be a lot of teamwork. And I will send the survey. I will post an announcement on Stellar, which should reach you by email, regarding a survey where I ask you in more detail about your interests and your background on things like programming and optimization, which are things that are not necessary for taking this course.

But at some point, they might bring in interesting perspective in the homeworks. So I try to distribute that talent evenly across the groups doing homeworks so that everybody has a chance of getting that perspective. But don't worry if you don't have that experience, it won't affect you.

All right. We're ready to start. Do you have any questions before we start today's lecture? OK, so today's lecture is the sort of introduction to the course. And we'll talk about the current status and recent trends of the public transportation industry here in the US, what influences those trends and that status. We'll have a critical assessment of where we are and the things that we'd have to do to increase the role of public transportation if that's what we want.

We'll talk about arguments put forth in support of public transport and, in some cases,

rebuttals for them. We'll talk what future influences and ingredients for future success. Let's get right into it. If we look at the transit industry right now. We have ridership patterns that are increasing but moderately. And they remain small. Public transportation in the US and North America remains a small percent of the total mode share. Because most people travel through using private autos or modes like that.

Now, there's a strong financial support from our local government, local state, and federal in terms of funding and providing funding from tax revenue. There has been significant growth in the number of new rail starts in the past 25 years-- so new systems, new metro systems, new light rail systems. And we'll talk about why that is, that it has to do with the funding structure here in the US.

There's been also major rebuilding of many older systems. And that has to do with the same funding incentives, which is not necessarily true in Europe and other parts of the world. Institutional innovation has been quite slow. But there's a growing recognition that, with the new modes of transportation and where we are and where we're going in terms of trends, we might need to rethink some of that institutional structure. And we'll get into that later in the course.

So if we look at the trends in modal split-- that's one of the first things that I mentioned-- over the last, say, four decades, we see that auto is steadily above 80% in the whole US. So it is the dominant mode for transportation. And these are journey to work. So this is the morning commute to work from home.

Transit, on the other hand, floats right around between 2% and 3%, sometimes a bit lower. And what we can see is that in the 1990s-- in 1990 and 1995-- you see a slight dip in public transportation use and some increase in private auto use. And since then, we started a recovery towards lower auto use and slightly higher public transportation use.

Walking is the same pattern as transit and bicycling also similar. But these are very small components-- very, very small modes. References for this, if you want more details, are listed below. In terms of ridership in absolute terms, you see that, in the last four decades, we've had an increase, so especially in rail.

So if you look at the dark teal right here, most of this increase that we see in the last 10 years is from rail. These are only public transportation trips. So having rail here in that we're talking about metro and subway, we have bus here and then [AUDIO OUT] all other modes. But it's all

other transit modes. So make sure that you understand that.

We're talking about light rail. We're talking about ferries, other forms of public transportation, not private auto. But this is in absolute terms, not in relative terms in terms of mode share. If we look at recent trends from 2004 to 2014, we see an increase in public transportation that is quite high, especially when you compare it to the population increase.

And when you compare it to the change in highway vehicle miles of travel in the US at national level. So we see a 2% increase in highway vehicle miles traveled and about 9% increase in population and about 21% increase in public transportation use. So it's been especially recently. And you can see a dip due to the most recent economic recession, but a pretty healthy recovery after that.

And part of what's driving this is that the population is increasing, of course, as it always has. But especially the urban population is increasing. This happening all around the world, not just in the US. In fact, it's happening more outside of the US than it is here in the US. If you look at the UN projections for population increase, most of the population increase in the world for the next decades is projected to occur in urban centers and in Metropolis.

So in fact, the population change estimates say that rural population is actually going to decrease by 2050. So not only are you going to have the natural rate of population increase that mostly will happen in cities, you're also going to have people moving away from rural areas into cities. And why is that? Well, why are people moving into cities? And why is this happening more and more? We have some volunteers? Yeah.

AUDIENCE: [INAUDIBLE]

GABRIEL Sure. So access to jobs is a big one. Yeah.

SANCHEZ:

AUDIENCE: [INAUDIBLE]

GABRIEL OK, so it's more than that. But yeah. So there are more cultural activities and sports and
SANCHEZ: museums and all sorts of-- MIT. So cities-- when we talk about agglomeration benefits-- I know we've heard that. But cities bring together health care, education, jobs, and people.

And so when you live in a place that has a high concentration of these things, you have more

access to those things than if you were to live outside. And that's true for people. It's also true for businesses. A business that is looking to hire talented people from universities and have access to, say, airports and other businesses that provide services to them are more likely to find that in a big city. So this is part of what's fueling these trends.

And in big cities, we also have a problem because of the high densities of high traffic. So if you're looking at traveling by private auto, you're going to have congestion. And in that setting with high densities and high traffic, public transportation becomes more competitive of a mode.

But we also have to consider the negative aspects of public transportation from the passenger's perspective. You have to wait. It doesn't pick you up at your door. And it doesn't take you right to the doorstep of where you're going to. So it's these tradeoffs. And when there is enough traffic and the densities are sufficiently high, then public transportation can become very competitive from a personal decision-making standpoint.

In the US, going back to the US context-- and this comes from the APTA Fact Book. They publish this every few years. And they always-- so this is the 2015 publication for two years before that. So with data from the American Community Survey from 2013. And if we rank the sort of largest US cities and metropolitan areas really by size and then we look at their transit mode share, this is what we get.

So the biggest one, by far, in the US is the New York metropolitan area. And right below that, we have San Francisco, Washington, Boston, Chicago, Philadelphia. And then you start seeing a decrease and a pretty rapid decrease in the percent of workers in those metropolises that use transit to commute to work.

So the question is, why is the mode share so much higher for these first few cities? What do those cities have in common that the cities below them don't have?

AUDIENCE: They have an old rail structure.

GABRIEL OK, so that's a good idea. Yeah. Over here.

SANCHEZ:

AUDIENCE: I mean, they have very, very high population densities. New York is like 70,000 people per square mile and Dallas is probably like three.

GABRIEL OK.

SANCHEZ:

AUDIENCE: They have expensive downtown parking.

GABRIEL Yes. Other ideas?

SANCHEZ:

AUDIENCE: They're all older cities.

GABRIEL And it's also related to the fact that you have older systems. So in fact, those first few-- those
SANCHEZ: first six that I've mentioned, say New York through Philadelphia-- are the oldest systems in the US. DC is newer. That's right. But most of the ones below them are newer, even newer than DC.

So these are cities that had an urban fabric that was created and developed and densified before the US road infrastructure was developed as it is today. And therefore, the densities developed at a higher level. And they already had public transportation serving those sort of OD pairs in those cities. So it's sort of a cyclical virtuous cycle that sort of makes public transportation at those places more efficient and more competitive than the private auto.

Any questions about that? If we look at so the transit share modal split for home-to-work journeys, this is a little older. This is a study that was completed with data from the year 2000. And we have different numbers here. But I just want to focus on these five biggest public transportation systems or big cities. And we see the mode share in each of them for a car and for transit in 2000 and transit in 2013.

So we can see that, although in Chicago it mostly has stayed around the same, in New York and San Francisco and Washington and Boston, it has increased. So there's been an increase in the transit mode share. Population has increased in these cities and so has the public transportation mode share.

In terms of public transportation funding. So how will these systems that are expensive to run get funded-- and expensive to build get funded? So the first thing to note is that, in North America, there's a tradition of dividing the expenses and the expenditures of public transportation into capital expenditures and operational expenditures. That's not true elsewhere in the world. But it is in North America.

So when we talk about capital expenditures, we're talking about building new systems,

extending systems, procuring new vehicles, rolling stock, repairs, and things like that.

Operating expenses are what you used to pay salaries of drivers, pay for energy or fuel to propel the vehicles forward, et cetera.

So another thing to note is that, if we look at operating expenses for example, about a third of the operating expenses are covered by fares. So when you use the system and you pay for it and you pay your \$2 or whatever it costs, you're only paying for about a third of what it costs the system to provide that journey for you on average.

It does vary from system to system. And in some parts of the world, these numbers are different. When we talk about local, state, and federal support or funding, this all comes from tax revenues. So this could be sales tax, especially when we're talking about local and state, and federal taxes, mostly income taxes.

In terms of capital expenditures, what I want to highlight is that the federal support is quite high, more than 40%. And that's much higher for capital expenditures than it is for operating expenditures. What would that encourage if you're a state or you're an agency and you're operating a public transportation agency and you get a lot of subsidy from the federal level--so not necessarily your constituents for capital expenditures, but not operating expenditures. What would that encourage you to do?

AUDIENCE: Build more and maintain less?

GABRIEL
SANCHEZ: Build more and maintain less. That's exactly right. So remember I said earlier there's been a lot of new builds in the last 25 years and a of major repairs in the last 20 years? This is why, because there's a lot of federal support for doing those projects.

And unfortunately, you build a bigger system and you have to now run it. And that comes from operating expenses, which are not as strongly supported by the federal government. So that also hints at maybe why the industry is where it is in terms of state of grid repair.

What influences these trends? First one, and the very obvious, is the suburbanization of homes, employment, and attractors. People moving away from cities to lower dense areas. Because property is cheaper and parking might be free. In America, low costs for car ownership and operation. So we have low fuel taxes in comparison to other parts of the world and low taxes when you buy cars.

There is an extensive urban road infrastructure that is much higher than it is in other parts of

the world. And there are many government policies that sort of support the road construction and maintenance and the use of roads and the private automobile and not necessarily to the same extent support public transportation. These include things like tax benefits that you can take on your return, parking requirements when there is new construction that, again, support the private auto.

If we look at suburbanization just focusing on the first point and looking at the same data set I talked about earlier, the 2000 journey to work, we have different numbers here. But what I really want to focus on is we have here-- this is like an OD matrix but by part of the city. So if you live in the central city or a suburb and you work in the central city or suburb, what percent of total trips are covered by each mode?

So we see that we have about 27% of trips are from central city to central city. And about 20% are from the suburbs to the central city, so people commuting inbound to the central business district in the traditional sense. Then there's the reverse commuters, about 9%, who are living in the central city and commuting outbound into the suburbs.

And then there is the suburb to suburb, people who live in the suburb and work in the suburb, not necessarily in the same suburb. OK, so that's interesting. That's how the trips are made. What happens if we look at the increase? What are the trends from 1990 to 2000 leading to these numbers?

Well, by far, the biggest increase was in suburb-to-suburb commutes. And if we look at the public transportation mode share, if you live in the city and work in the city, about 14% of trips are covered, are made by public transportation. It's lower. It's about 6% if you're going to or from the suburb. And it's much lower, 2%, if you live in the suburbs and work in the suburbs.

So if you just focus on three numbers here. 43% of trips are from a suburb to a suburb. The trend is that suburb-to-suburb trips are increasing. And that is the hardest thing to serve with public transportation. Why is that? Why is it difficult to serve those trips with public transportation?

AUDIENCE: Low density?

GABRIEL Why is low density-- why does that make it difficult to serve--

SANCHEZ:

AUDIENCE: Because then it's-- people that need access to stations, they're not [INAUDIBLE].

GABRIEL Well, you could put more service. You could put more bus stops and stations. So--

SANCHEZ:

AUDIENCE: But then there's not enough people to take it to make it financially viable.

GABRIEL Exactly. So did you hear that? So because you have low densities-- you have a sparse OD

SANCHEZ: matrix, as we say in transportation. You have fewer people that are going from any particular origin to any particular destination. When you don't have those critical densities, it becomes very expensive and very inefficient to deploy resources to move a lot of people when the demand for moving a lot of people is not there.

On the other hand, when you have dense corridors along which many people want to move, you do develop this competitive demand pattern that is very well served by public transportation. And it's very correlated with whether you are in the suburbs or in the central city because central cities are denser. And there are dense [INAUDIBLE] corridors in the city, and also from suburbs to the center. Any questions about this?

AUDIENCE: How would you-- I guess you wouldn't consider something like Uber pool to be covered by this.

GABRIEL No. This excludes things like the transportation network companies. This is traditional public
SANCHEZ: transportation. Yeah. OK, let's look at a few images, some GIS charts that were prepared by Mikel Murga who used to work in the transit lab. And he's an expert in modeling.

Here's Boston. And what we have, let's go back to the key here. It's based on the census data from 2010. And red means car. Orange is carpooling. So that might include this. Or it might include you dropping someone off. Blue will be public transportation. And walking will be green. So this is the center of Boston right here. MIT is right here. This big green area where a lot of people walk, that's us. That's MIT. The center of Boston right here. So lots of green, lots of people walking.

Lots of people who start their trips there and are going into Boston are also taking public transportation. You see a lot of blue. But as you start moving out of that center, you get more red. So this is supports what we just talked about. There are lower densities outside of the central business district and this denser Cambridge area right here, big university centers, hospitals, and financial district. So outside, there are lower densities. And there's also a lower supply of public transportation. So therefore, most of the commutes are made by car. And

therefore, you see more red.

You do see some places though where there's a lot of green or a lot of blue. And usually, they are close to a commuter rail line. So if you follow, the rail lines, you'll see that, along those corridors, there is a bigger share of blue. The same story in other cities-- Manhattan, of course, being the biggest provider of public transportation and the city with the most split for public transportation. A lot of green in South Manhattan. A lot of blue right around Manhattan. But as you start moving out, then you start getting a lot more red. Same thing, just more intense.

And then here's Chicago. Here's Chicago. Same thing. City center is right here. So you can sort of spot the city center of the city by how people do their journeys. Along the lake coast, you see a lot of trips made with public transportation. But as you start moving out, especially away from any rail lines because, along rail lines, you'll see some percent of people taking commuter rail into Chicago. OK, so any questions about this, this picture of mode split and how it changes depending on where you are and where you're starting your trip and when you're ending your trip?

No? OK. So here in the US, coming back, especially to the North American context, we have our car road system. So very highly developed, more than in other parts of the world. Many people own cars. There are 600 cars for every 1,000 people. The car usage is high. If you look at the-- it's 10,000 vehicle kilometers per person per year.

Compared to other countries, we have lower taxes, lower fees, lower user charges. So sales taxes are 5% to 8%. Users pay for only about 60% of the road infrastructure. That comes from tolls and from gas taxes. The fuel taxes here in the US are 10% to 20% of what they are in Europe. So it gives you an idea of where we are and why our policies encourage owning a car and operating a car.

Parking is another big one. I already mentioned this. So the parking supply in most of the US is free and widely available. So there are 380 parking spaces per 1,000 central city workers in the 10 largest cities. Outside of that, it's much higher. Everybody can park. About 95% of car commuters enjoy free parking. So if it doesn't cost you to own a car or to operate it and you can park free-- you can leave your piece of metal doing nothing and taking up real estate in a city with no cost-- then you might go ahead and do that.

So it's a highly developed urban road system. We have more roads, wider roads, longer roads than in other parts of the world, especially if we compare Europe. And we're talking here about the 10 largest cities in the US. We're not talking about rural areas.

What do people say when they're advocating for transit? What are the traditional arguments put forth for transit being good and therefore we should support transit, we should fund transit? The equity is a big one. So access for people who cannot drive or choose not to drive. So we're talking about elderly, handicapped, children who can't drive, poor people who can't afford to buy their own car or to use modes like Uber, for example. So that's the equity argument. And that's a very sound argument.

Congestion. So people say put public transportation to alleviate congestion. That's not such a good argument because lots of the studies that we've looked at, even when a lot of people do take public transportation when a new system is put in, the capacity released in the streets is usually very quickly. They demand it again. So that is not a very effective method, by itself, for reducing congestion.

If you tie it to other things like parking taxes or parking caps or tolls, then with a combination of an increase in public transportation supply and an increase in cost or disutility for taking the car, you can have an impact on congestion. Land use. So if you want a nicer, walkable city, then you should have public transportation. If you're driving your car from home to work, you're not going to stop. You're going to work.

And so when you're taking public transportation and you stop along dense corridors and you probably won't get dropped off immediately where you're going to so you might have to walk by stores and by restaurants, that's going to generate commercial activity. And it's going to support a land use that is of nicer quality than the car might do by itself.

Environmental. So if people say, let's put public transportation in because it's good for the environment. Well, it turns out that actually it's more effective to work on the car technology-- hybrid cars, fuel efficiency. It's a much more effective way to help the environment just because so many people drive. The mode split is so much. It's about 80% for a car. It makes a bigger dent to work on car energy efficiency. Same with energy. It has to do with the same things.

OK, other arguments. So economic expenditures for private autos may be used to improve local economies and quality of life. So we say we subsidize the private auto. Because people,

through their user fees, are only paying for about 60% of the costs. The remaining cost is coming from tax revenue that could have been spent on nicer cities and nicer public transportation systems.

And then there's the agglomeration benefits. If you want to increase the economic activity and the socioeconomic welfare of a city, then you can put in transit because it supports higher densities. So how would New York and Boston and San Francisco be or have developed if they didn't have their public transportation systems right now? They really would be nothing like they are right now.

If you took Manhattan and shut down all the metros-- and we've had these real-life experiments when hurricanes come around-- the city shuts down. You can't commute into the city without these systems. There is not enough capacity on the roads to bringing all those people in and to support that economy.

So there is a benefit to having these systems in. But because these investments were made sometimes a century ago, nobody is talking about or quantifying the benefit in assigning it to that system. So the contribution of earlier investments, especially in heavy rail, is not being valued. That has changed a little bit recently.

So when London was doing its economic analysis for Crossrail, a big metro system across the city, they did say, we need a long view. This is going to have benefits lasting many, many decades. We're not looking at a 20, 30-year horizon. We're looking at way beyond that. We want London to prosper and to become more dense and to have higher agglomeration benefits.

So other arguments are that transit decreases the external costs of transportation in cities. So when we look at things like accidents, you're less likely to be to get into an accident if you're in a bus than if you are driving a car. Impacts on human health. Any clue about what I mean by that?

AUDIENCE: Walking.

GABRIEL
SANCHEZ: Yeah. Walking. So you walk a little more. Yeah. There's the impact of if you have a lot of traffic and you're sort of sitting in traffic, you're breathing in dirty air. So if that's the case, pollution kills people slowly but at a higher rate than accidents and other things. So these are the impacts on human health.

And I did say earlier that public transportation by itself is not going to address that. But if you pair it with some policy that will curb the private auto demand and reduce emissions, then you can have an impact on health care, healthier costs from the government side and the human health for people.

So again, congestion, noise. We can reduce the noise of cars on streets. And climate change, global warming. Here's a nice picture of public transportation catalyzing sort of the urban fabric. So making cities more walkable just to highlight what we said earlier.

Critical assessment. So we've stabilized public transport in North America. We saw that, in the 1990s, we had an increase in the mode share of auto and a decrease in public transport and walking and biking. And now, that's starting to come back up. There are many new rail initiatives like Phoenix, Denver, and Salt Lake City.

And they are successful. And especially if we look at older systems like New York City but also at some of the not-so-old ones like Houston and Seattle, we see very successful systems that are being heavily used and are contributing to nicer land use and developing the economy.

Institutional change is occurring very slowly, maybe too slowly. Many things are changing in terms of technology, in terms of policy, in terms of what the private sector is offering. And the public sector is not catching up. It's not moving as quickly. So another challenge is the retention of political support. So yes, question here.

AUDIENCE: This is just North America?

GABRIEL This is focusing in North America.

SANCHEZ:

AUDIENCE: Because China, for example, is building a crazy amount of [INAUDIBLE].

GABRIEL But they also have a big increase in private auto. So both things are happening. So retention of political support is another challenge. So just keeping everyone happy and having those stakeholders in a political constituency happy enough to support you and not try to defund the public transportation sector.

Especially-- that's critical if public interpretation is much better at serving the most dense corridors and you're only benefiting people there. And people from, for example, the rest of

the state don't see a direct benefit. But they're putting sales tax into that system. That's a tricky thing politically. So that's another challenge.

So we expect to see continued growth in the periphery. So suburbanization. Health care is getting better. So the percent of people that are old and can't drive is going up. And so that might mean that we might need more public transport. Technology is changing. Telecommunications is advancing rapidly now with all the internet of things and sensors everywhere. We do get a lot of data. And we can start using that data to plan better systems and to analyze how people are using them. And we'll get to that later in this course.

The public has a higher expectation. Because you have a smartphone and you can know where the bus is, you sort of are more aware of the system. And you might start to demand higher quality service. And if other parts of the world or other systems are doing it and mine isn't, then I'm starting to expect that-- I know about it because we share all of this information through YouTube and the internet. So I want the same thing in my city. And I want the same thing in my system.

And then finally-- and this is very recent-- the transportation network company. So the likes of Uber and Lyft are making a dent on the demand and the mobile split. So this is somewhere in between where it's not your own auto and you're paying for something. You might be carpooling so in some sense it's public, but not really.

So the other challenge here is that a lot of these are startups that are heavily funded by venture capital. And they are spending more money than they can make through their fair revenues. So it's not clear how that will play out as the years go by and if they can keep their prices and remain as competitive.

So ingredients for future success. So again, speaking of the political constituencies, maintaining a supportive coalition. So making sure that you expand that base of people who benefit from public transport and make the case that, even if you're not directly using public transportation, it has economic benefit for you. So that's necessary if we want to move forward, especially with the government funding local and state taxes for example for public transportation.

Expand the definition of public transport. There is now a greater variety of services and more flexibility. And public transportation systems are starting to consider different vehicle sizes and partnering with transportation network companies to achieve higher efficiencies and just target

their supply to particular demands and densities.

A greater involvement of the private sector. So the use of transportation network companies is one example. But also partnerships with the private sector to operate bus service, so public private partnerships. And innovative financing and procurement techniques for construction of new lines or operations.

Aggressive implementation of new technology. So now, again, I said, more sensors, more data, better information provision. Tell your customers, your passengers where the vehicles are, what the reliability is. Make more effective decisions like real-time operations control to keep your system operating as you planned it. We'll have an entire election on real-time control later on. And you can improve your vehicle designs-- so all these things, right?

So when I refer to improve vehicle design, we'll talk more about this in the next lecture. We have cleaner technologies, more fuel efficient, more quiet. So technology can be used to improve the experience. And then there's the organizational change. So that needs to happen. And the public sector is a little slow in this regard.

So greater operating staff responsibility, accountability. In many agencies, we have the problem that it's not clear who is responsible for what. And so whenever some decision has to be made, who do you go to get that signature? Who approves it? You have to talk to several people in different departments. And it just gets slow. So even for the simple things, and sometimes especially for simple things, it's a little slow.

So also increased customer orientation. There's a culture, especially in the more traditional public transportation agencies, that you run service. And you don't really think about people and serving people as if they were your customers. But that's changing. Some agencies, the most cutting-edge agencies, are really treating people as their customers and doing marketing and reaching out to their customer base to run surveys, understand what makes them unhappy, use that information to make better decisions to respond to the feedback.

So that's the end of my introductory presentation. We're done a little early, which is fine because today is the first lecture. So if you have questions about any of what we talked about, please let me know. You might want to ask that question right now so that other people can benefit. But if not, you can also just come to me and we can chat. Yeah, so. Yeah.

AUDIENCE:

Do you want to say a few words about the assignment 1?

GABRIEL Sure. Well, I already did a little bit. So it's an introduction to cyclical transportation systems. So
SANCHEZ: your first task is to go out and go into Stellar. And I'm doing this on purpose. I want to make sure that you have access to Stellar because we're going to be using that. So go to Stellar. Look at the reading.

The reading is very introductory. And it introduces you to the idea of cycle time and headway and all these things. And that's how you think as an engineer of planning a public transportation system and determining how many vehicles you need to operate a service and the impact of running time variability on your system and the cost. So we're just getting our feet wet with a very simple example. And I've generated some data that you'll be analyzing in a very step-by-step fashion to sort of guide you through that process.

Later on in the semester, you're going to get real data, which is not going to be as nicely laid out. And you're going to have a more challenging task of actually planning service using real data. So this is an opportunity to get the concepts sort of ingrained and make sure you master them before you tackle the more challenging task of doing it with real data on a messier situation but on a more realistic situation.

AUDIENCE: How do you wish that we submit it?

GABRIEL On Stellar. I don't want any paper submissions. The other thing is-- so yeah. Please save your
SANCHEZ: files as PDF and upload them to Stellar. So the preferred format would be PDF. And the other thing you can do for this one is a spreadsheet. So if you want, you can work on a spreadsheet.

And just please be very clear about here's question 1. And lay it out clearly for me and explain. There's some explanation. Don't just plug and chug. Please explain your logic. A few sentences suffice. But explain why you chose to do this and what your calculations mean. And you can just send me the spreadsheet instead of the PDF if you want. And that could help because I can see your work. All right. He had a question.

AUDIENCE: Sorry. Yeah, this is sort of a semantic thing. When you said the success of the Houston system, what were you suggesting there?

GABRIEL Well, I mean, demand has gone up, right? There are many ways of measuring the success of
SANCHEZ: a system. But--

AUDIENCE: [INAUDIBLE] your bus system or is it that they built a rail system? Or--

GABRIEL

Just in general. I mean, it's a system that was put in. And yeah, it could be more successful.

SANCHEZ:

But people are using it. And it's having some impact on the city. And it's visible. So any other questions? All right. Class dismissed.