NEEMA NASSIR: Let's go ahead and start. Good afternoon, everyone. My name is Neema Nassir. I'm a post-doctoral associate at Transit Lab, MIT. I've been invited to give a few lectures in this course and basically participate in delivering the course material for this course. I will be talking in this session and in the next session on Short-range Planning Practice. And then I'll be back again in April and in four sessions in April, lecture number 13, 14, 15, and 16 dealing with vehicle scheduling, crew scheduling, network and root structure and high ridership corridors.

So let's go ahead and start. In this session, we are going to talk about short-range planning practice. And basically, I will give a brief set of definition and concepts and introduction to the planning activities that are usually made at transit authorities in the US and also worldwide. And then we will briefly talk about the measures and the standards and guidelines that are published and used by transit agencies to plan their service based on those. Then we will also talk about current practice and critique of the existing systems. Probably we will cover icon 1 and some material in icon 2 this week. And then the rest will actually be delivered to you in our session next Tuesday.

So the planning decisions and the planning activities that are usually done at the transportation planning agencies and public transport planning agencies usually can be classified into four different type of decisions depending on frequency of decision-making and the need for making decisions and the scope of decisions-- the scope of changes that are related to the decisions that are made with each activity. These planning activities are divided into four different classes-- long range planning activities, medium range, short range, and control. Long range planning activities basically include major capital investment-- major improvements to the infrastructure-- which would include construction of a new station, a new rail line, a new bus way to the system.

Or it could also be related to and as a result of major institutional changes and changes to the, basically, financial resources of the organization. The decisions that [INAUDIBLE] involve long range planning are usually driven by political and economic considerations. And basically, the type of analysis and the type of planning that is done in long range planning activities involve projection into the future and prediction of demand and prediction of situation in the future. Therefore, it requires a comprehensive analysis usually for any strategic planning of interactions between changes in land use and interaction between land use and demand in the future. And it basically needs to capture or have, like, an insight into the future of the network and of the region.

The next range is basically or the next class of planning activities is basically the medium range activities. Medium range activities include bus network structure design, network size design and improvement, fleet size, fare policy and technology. It basically involves incremental or medium improvement to the system and to the transit service. One point that I need to mention about the long range and medium range is that these two, although are really important in the planning practice for transportation systems, but these decisions are usually done at the upper level-- at the higher lever than the transit authority. For example, long range decisions are usually done in collaboration between NPO's metropolitan planning organizations, state departments of transportation, and transit authorities. So the transit authority is not the final decision maker in that case.

And it needs close interaction and close collaboration with the higher level organizations and governmental agencies to make the final decisions. So that's about the long range. Medium range is also somehow similar. It usually, for example, the decisions that are related to the network structure, although there is a lot of interesting research going on in universities that deals with optimization of network design and optimization of the structure of the network, because what happens in practice is that usually in the networks that we live and in current cities, the actual layout and structure of the network is already given. And it's usually rare or impossible that we start from scratch and start to design a network from scratch to begin with.

So therefore, what we usually observe is incremental changes to the network and addition or elimination of some routes from the service and basically, decisions that are related to that.

AUDIENCE: I have a question.

NEEMA NASSIR: Yes, please.

AUDIENCE: In terms of fleet size, could that come as a request from the agencies? Like, an agency says, we have a bus line. It's at capacity or over capacity. We need more buses. Could it come, like, from a request to the higher level?

NEEMA NASSIR: Yes, definitely. Yeah, but it eventually requires the interaction on those, so securing the funding from the upper level governmental agencies-- so yeah. So the reason that I'm explaining this is that I'd like for you to understand why we are focusing on short range decision-making and short range planning practice in this course. That's mainly because the bulk part of activities at transit agencies is related to short range planning and short range decision-making. So what we mean by short range decision-making are decisions that are usually made more frequently than a yearly basis.

And they basically entail decisions about the structures of the route-- layout of the route-- layout of the stops-- and basically decisions about the frequency of service-- timetable-- and vehicle and crew scheduling. Despite the top two classes of decision-making that are usually driven by political and economic considerations, short range decision making and control activities are usually basically driven by cost optimization. And these are basically tactical decisions as opposed to strategic decisions that are usually in the long range and medium range.

So then there's real time and control decision-making, which is basically usually done currently in using expert decision and expert activities. There is an ongoing effort in the technology to improve the quality of control-- ongoing research to use real time data and improve the real time performance by using real time control. This includes revisions of the routes. That could be the case in reaction to incidents and disruption situation. It could also relate to holding and dispatching decisions-- thank you-- that could actually be used to improve the effective capacity of the system by trying to regulate-- have a better frequency, basically, in the service.

So similar to the typical planning problem, there are major elements in planning for public transportation and particularly in short term and short range decision-making. It includes data collection similar to what you guys have done in your homework assignment number 2. Collection of data on demand, collection of data on supply, and interaction of supply on demand is an essential part to be able to make decisions and make them basically reliable and actionable intelligence for the decision-making process. Then there should be analysis on identification of potential problems and identification of opportunities to improve the situation. And then there is the creative part of design of options, solution, and strategies to address the situation. And then typical to any economic analysis, there would be an element of cost and benefit estimation to be able to justify the project.

So in terms of operational planning process or in another term short range planning process, there are multiple stages involved in the work. And usually, what happens is that in practice, it is proven that the planning procedure can be decomposed into sequential decision-making processes. And although it is possible to formulate all of these decisions into one gigantic optimization problem and solve it for all the decision variables that you need to basically address, however, the practice has shown that there's a nice way of decomposing the process and to solve problems and solve them sequentially in order to make sure that you're satisfying all the constraints to the accurate level and you're gaining the-- you finally get a realistic optimal solution for your planning practice. Considerations regarding policy constraints and some of the economic concerns are usually difficult to formulate into optimization problems. But there are published guidelines by governmental agencies that you can basically follow and make sure that at least the top two level of the decision-making processes and tasks here are basically done to the satisfactory level.

So let's go ahead and start and review these tasks. There are lectures in this course that are dealing with each one of these tasks and components in planning. But in this lecture, I'll just briefly go over these different components as an introductory part of the course. So for every optimization problem or in this case planning process, we have a set of inputs-- constraints-- basically, that you need to satisfy. And then there's an objective function that you need to optimize-- so inputs.

So the first component of the planning and practice here is bus route design. This includes design of layout of the routes and layout of the stops. And basically, the input into this task includes constraints that are related to right-of-way roadway constraints, like if there is a river in your network, there's this connectivity. There are bridges-- tunnels. So these are the kind of constraints at network level that you would like to satisfy. And there's also demand constraints in the network that you need to consider for this task, like, you have a sense of what's the demand from certain suburb to the downtown area. And you basically would like to have a route system that kind of can address that demand and satisfy that demand.

Then the solution to the design component and that task [INAUDIBLE] out of routes and layout of the stops that are basically resulting from the first component, and then the set of routes and stops will be input into the second task, which is setting timetables. This task includes finding frequencies for the routes and from that identifying and defining-- basically, generating the timetables based on frequencies. There are usually considerations related to policy headways, policy frequencies, and capacity frequencies that need to be addressed in this task. But again, this task is also somehow dealt with using the existing guidelines and just satisfying these guidelines. The input and other constraints that are considered for this task would be level of service guidelines, and again, the demand constraints in the network.

Then from the set of timetables, what will be resulted here is the departure times that was scheduled for the service. So the first two components of row 1 and row 2, basically, are dealing with satisfying the demand and satisfying the guidelines. But once you go beyond the first two components, it becomes to the level that you know kind of what's the service you want to deliver. And then you're dealing with tactical decision-- how you can optimize the cost of delivering this service and improve efficiency. So did the third row here basically deals with the departure times that are given for all the routes in the network and for all times of day. And then what you need to do is how you want to allocate your resources in terms of allocate the vehicles to the system to make sure that that service is going to be delivered on time.

So that would be the task of vehicle scheduling input into that task or constraints that are involved or running times on different segments of the route and also the departure times that are given from upper level decision-making process. And it will eventually result into a schedule of given buses in terms of what are specific trips they need to serve and what's the sequence of these trips. Then the output from that decision with the vehicle schedules into the task of scheduling for drivers, this task also include input from operator and basically work union constraints, like maximum shift hours and, for example, like, break times and lunchtimes and maximum separation between two shifts. And there are rules and regulations that are related to that. And this task, again, is a task of allocating resources to minimize the cost of scheduling drivers to deliver the service. And the result would be the schedules for the crew.

So then these decisions can be looked at in another way, too, like, we can further classify these decisions into service planning decisions and operational planning decision. Service planning decisions would be the decisions that define service as it is perceived and understood by public. This is basically the part of service that is visible to the public. And then there are decisions that are related to operations, which basically defines how operations occur to produce the service. This is somehow a black box to the passengers. And yeah, basically, the passengers should not really care what's the vehicle's schedule and what's the crew's schedule that is assigned to the trip, as long as trip is being delivered as it is scheduled.

So in terms of other characteristics of these decisions, we, basically, for network design frequency setting time table development, vehicle scheduling, and crew scheduling, the decisions that are involved in planning, basically, starting from top to bottom frequency of decisions, basically are increased. And the scope of decision-making into the future is basically become limited and smaller. And also, the decision-making in the network design frequency setting and timetabling is basically made based on guidelines and standards. And decision-making on the lower level-- vehicle scheduling and crew scheduling-- is made usually based on optimization of cost. And then given the nature of the decision-making, the tools that are used and the techniques that are used for solving these planning decision-making processes are basically ranging from judgments and manual analysis that is more dominated into computer tools that are basically designed to solve optimization problems for minimizing the cost.

So similar to the classical evaluation structure, when you're dealing with planning questions and planning projects or planning alternatives, there's this structure that starts with goals, objectives, measures, and standards or guidelines. So let's just make a quick practice and define a goal and then define objectives for that goal, and define measures based on that, and see how a standard can be defined to make that planning decision acceptable. So let's define a goal.

Does anyone have any suggestion? What is an important goal for public transportation system?

AUDIENCE: Maximize ridership.

NEEMA NASSIR: Maximize ridership, yes. So let's say you want to maximize ridership. That's your research problem, right?

AUDIENCE: [CHUCKLING]

NEEMA NASSIR: [CHUCKLING]

AUDIENCE: [INAUDIBLE]

NEEMA NASSIR: Right. [LAUGHTER] So then in terms of objectives, what would be an objective that we can define for this? I would say probably the peak hour demand could be one objective or peak hour ridership in certain corridor. Let's say peak hour ridership per weekday per month.

Well, peak hour ridership would be the objective here. And then the measure that you would define would be peak hour ridership per weekday per month. And then the standard that you want to define would be something that not only captures the demand side, but also the supply of the system, too. So you would come up with probably, like-- I would, like--

AUDIENCE: Riders per vehicle-- riders per mile-- per hour.

NEEMA NASSIR: Yeah, exactly. Or let's say, like, 60% of capacity. Like, your standard in this case would be your peak hour ridership should be greater than 60% of capacity. So this was just an example that we tried to work out one practice for evaluation structure. But let me give you another example that is actually used in the practice.

So assume that we are considering the goal of reliability in the transit system. The goal of reliability would be considered one of the main goals because if we have a reliable public transport system, you can secure and you can guarantee a body of demand in your network that can rely on your transit system and basically adapt to the lifestyle of using public transport. And that's beneficial to the system from different perspectives. So the objective that we can define for reliability in this case would be possibly-- can you come up with some objective that we can define with the goal of improving reliability?

AUDIENCE: On-time performance.

NEEMA NASSIR: On-time performance, yes. So on-time performance would be the objective. And then we need to define a measure for this to be able to measure that objective for each one of the scenarios and for each one of the alternative plans. So what would be a measure for on-time performance?

AUDIENCE: Characterizing with our car driving [INAUDIBLE] within a certain amount of time.

NEEMA NASSIR: Right, yeah. So let's say percentage of on-time arrivals. So we would say percentage of on-time arrivals, and we would define on-time arrivals to be between 0 and 5 minutes of the schedule. And then the standard that many of the agencies use to measure this would be 90% or 95%, basically.

So this way, the transit agency can go ahead and evaluate the performance of the operators of the system who basically are running some part of the service and come back to them and say, OK, your performance in terms of reliability has been acceptable or not. Please.

AUDIENCE: [INAUDIBLE] something [INAUDIBLE]. Or would it be just standard operating procdedure they were planning as well. And their reliability was somewhere around 80%, and now the goal is to achieve a 10% gain.

NEEMA NASSIR: Mm-hm.

AUDIENCE: And comparing that with the previous one would be a benchmark again.

NEEMA NASSIR: Yeah, exactly. So another measure would be percentage improvements as compared to baseline. And then the transit agency can define a standard of at least 10% improvement to the baseline should be required for reliability. Yep, thank you. So then one other interesting point that actually comes to mind looking at the existing guidelines is that on-time arrivals are usually defined for 0 to 5. That basically means that you consider a bus that is late by two minutes to be on time. But a bus that is early by one minute is not considered to be on time. Does anyone have any comments about this-- why we do not consider early arrivals on time?

AUDIENCE: I think misconnections for people who expected to be there at a certain time, but--

NEEMA NASSIR: Right, yeah.

AUDIENCE: --they left.

NEEMA NASSIR: Yeah, yeah.

AUDIENCE: [INAUDIBLE] connected.

NEEMA NASSIR: So it can be proved that based on typical assumptions about passenger arrivals, early arrivals of buses and service is usually more negative as later arrivals. Let's make an example here. For example, let's assume under uniform arrivals of passengers-- let's assume if this is my scheduled arrivals over the axis of time and this is my number of passengers waiting in the bus stop under uniform arrivals, [INAUDIBLE] you have some accumulation of passengers that are waiting at the stop.

And then what happens is that if one of these buses are early-- let's say it basically arrives at this time-- what happens is that the amount of time that we are saving due to this arrival is basically less than the amount of time that will be added to our waiting time for the next trip. And that's because the number of people who are experiencing this is a little higher-- number of people that experience it, saying, the additional waiting time is higher than number of people who are experiencing the early arrival. And it cuts to their waiting time. So if you compare these two areas, that basically tells you you're basically having a loss or having an increase in waiting time if your service is early.

And then the situation becomes worse-- indicates that you suggested-- when people are coordinating with the system-- for example, it is assumed that-- and it can actually be proven by looking at the data, too-- people make the transition to coordinated behavior and coordination with the schedule as the frequency of service increases. For example, for a service that is scheduled to be delivered every half hour or every one hour, it is expected that passengers are coordinating with the system and coordinating their arrivals with the departure of the buses. But when it comes to more frequent service, then we will have more uniform arrivals. So in that case, what we would observe is that passengers arrivals would resemble something like this.

Well, it has to go up to here, the original case. And then in that case if your service early by five or 10 minutes, you will have the main bulk of your passengers who need to wait another headway, basically. So this should be actually added to your computation, too. Is there any questions about this?

So in terms of the advantage of guidelines in transit planning, one of the main purposes of these guidelines is to communicate to the public the rationale and the logic behind your decision-making and behind your allocation of resources to the system. It also gives you a consistent and fair basis for decision-making. And it is somehow gives you a tool to justify your decisions and also a tool to make sure that your decisions are fair and justified in nature. It also gives you the opportunity to balance the improvement and the investments to the network and gain a uniform level of service improvement for efficient service.

So the guidelines that are existing in the literature and in the practice, basically-- in the state of practice-- are dealing with the design of service and with the delivery of service. So the design of service basically dealing with variables that are related to spacing and density of stops, spacing and density of trips, and frequency of the service as it is designed and as it is in the schedule. So there are guidelines related to that. And there is also guidelines related to how you deliver or how the transit agency delivers the design service and how the performance actually took place.

So the main factors of service design and service quality from the passenger's perspective are basically reported by transit capacity and quality of service manual of the Transportation

Research Board. And it basically includes frequency of the service as one of the main aspects or factors that are defining the quality of service-- waiting time, reliability, and access. This is access over time and also access over space. So why do we again have both frequency and waiting time in here? So if frequency and waiting time are kind of interrelated, how come there are two separate items here on the list here? Does anyone have any suggestions about this?

So let me go ahead and explain how I understand this. Frequency of the service is important not only in terms of the waiting time-- that could be associated with that-- but also when it comes to lower frequency system and longer headways. The waiting time is not a function of frequency anymore. It basically, as we discussed, the waiting time could actually be independent of frequency. However, in those cases, there is a burden of coordination that is imposed to the passenger. So if you have to coordinate your arrival, for example, in the morning from home to work, then there is some sort of inconvenience that is imposed to you to basically make it to your coordinated schedule. And then waiting time is also important because if the service is frequent but at different ranges of frequency, you may experience different waiting time if the process of arrivals of passenger is assumed to be a random process.

Then reliability as we discussed is one of the important features and one of the important aspects of the service. It usually is a measure based on on-time arrivals of the service. And then the next aspect that is important is access to origins and destinations. This access can be interpreted in two ways. We can look at access in terms of space and in terms of time. Access in terms of space is closeness to the bus stops and closeness to the service from origin and from the destination. Access in terms of time would be the span of service-- when you like to travel-- and basically, what is the service time and available times of service.

So yeah, as I mentioned, most agencies have guidelines covering a span of service. For example, MBTA has this guideline that for weekdays, you need to have service from all suburbs into the CBD area with-- at least, like, at latest, arrives at 7:00 AM. So you need to basically be able to cover between 7:00 AM and 6:00 PM as your services span in MBTA.

For TransLink, it's also somehow the same. You need to-- basically, minimum service guidelines to ensure that 95% of trips listed can be completed in the time span given below. Like, from any point to downtown Vancouver, you need to have service that can actually arrive in downtown Vancouver by 7:00 AM, for people who should start their work at 7:00 AM. And then there's also trips in the evening. And it basically says earliest departure time of mass transit trip in the evening from downtown Vancouver to any town center needs to be midnight for people who basically would like to enjoy the nightlife in the downtown area and then use transit to go back home.

So in terms of route design and in terms of layout of routes and stops, there are also guidelines that are addressing this decision. MBTA has a policy objective to provide transit service within walking distance, which is defined a quarter mile of all residents that are living in area with population densities greater than 5,000 people per square mile. That's basically an interesting guideline. It considers two different variables. One is the population density. And the other one is the density of the stops or vicinity or walkability of transit in areas that are populated with densities greater than 5,000 per square mile.

So in terms of comprehensiveness objective, TransLink basically has very comprehensive guidelines related to basically a set of different performance measures and goals. Let me read from these. At least 90% of our residents and employees in urbanized development areas should have a walk less than 450 meters to a bus stop. So this is related to access over space. 98%--

AUDIENCE: When they say 90% of residents and employees, basically they're looking at that person twice. The person is on one end, a resident, and on the other end, an employee.

NEEMA NASSIR: Right, yes.

AUDIENCE: So it's-- OK.

NEEMA NASSIR: Yeah, you want to consider both ends of the trip, right? And these percentages are a little tricky. Sometimes they're counting the number of people-- number of residents. Sometimes they're counting OD pairs. Sometimes they're counting passengers. So it's a little tricky to interpret these correctly.

So the second one basically says 98% of all peak period transit trips to and from downtown Vancouver should require no more than one transfer. That basically is 98% of people who are traveling from and to downtown to the suburbs. And so it may be a little difficult, especially in the absence of AFC data-- Automated Fare Collection system data. It can be a little tricky to measure these objectives. What's usually done, basically, is people go out and basically ask from transit riders about their origins and destinations. It's called Public Transit Origin Destination Survey that is usually done on board. Do you have a question? OK.

So the second measure here relates to connectivity in the network. The third one is 95% of all peak period transit trips to the nearest town centers should require no more than one transfer. Again, this one is also related to connectivity of the network. And fourth one is all trips between one town center and adjacent town centers should require no transfers. Again, this one is a guideline on connectivity. And then again, the last one is also on connectivity. It basically requires that 95% of all peak period transit trips to major regional activity centers and gateways should require no more than two transfers. OK, so any questions or comments about this?

AUDIENCE: Yeah.

NEEMA NASSIR: Yeah.

AUDIENCE: In terms of one connectivity between one town center and adjacent town center, definition of a town varies from place to place.

NEEMA NASSIR: Mm-hm.

AUDIENCE: I know that specifically Vancouver has rather large suburbs-- like, suburbs of 100,000 people-- 200,000 people. So you actually have a few municipal entities for a large area.

NEEMA NASSIR: Mm-hm.

AUDIENCE: But you can have areas where that condition would be a little bit too strict if you have, let's say, the Boston area, which is generally slightly smaller suburbs and more suburbs to connect.

NEEMA NASSIR: Right, yeah. So some of these may actually be a little tricky to measure and to quantify.

AUDIENCE: Yeah. And they're able to compare.

NEEMA NASSIR: Right.

AUDIENCE: Yeah, when I see these numbers, then I try to think about equity, and, like, the 10% that is not 450--

NEEMA NASSIR: Right.

AUDIENCE: --is it from that or--

NEEMA NASSIR: Yeah.

AUDIENCE: --a bus station--

NEEMA NASSIR: Right.

AUDIENCE: --[INAUDIBLE] the 5% .

NEEMA NASSIR: Mm-hm.

AUDIENCE: So how do you navigate these types of trade-offs in the face of equity.

NEEMA NASSIR: Right. This is a really good point. Some of these percentages, I think, are related to random variables. And those are somehow acceptable because that's when you try to define a confidence interval. But when it comes to cases like this, it is not a random variable anymore. It's basically like a special variable that constantly requires a certain amount of connections to the downtown area, right? So that may be one of the loopholes of this guideline.

That's a really good point because one may argue that if 95% of my OD pairs are connected with the minimum connectivity requirement, what about the rest of 5%? Does it mean that all people who live in that 5% area will have to go through the unacceptable connectivity situation? So that's a valid point. And thank you for bringing that up.

AUDIENCE: Does Vancouver actually achieve these goals? It seems kind of implausible-- kind of difficult to--

NEEMA NASSIR: Right.

AUDIENCE: [INAUDIBLE]

NEEMA NASSIR: Yeah, well, these are basically usually for projects and plans that are being proposed for-- or like small start projects or for improvement plans. So I think what they try to do is to make sure that the ones that are being accepted and being implemented would satisfy this. But I'm not really sure if the existing network satisfy all these conditions or not.

AUDIENCE: Yes.

AUDIENCE: Sorry, is TransLink the name of the agency that runs the--

NEEMA NASSIR: Yes, right. Yeah, right. OK, so any other questions? All right. So then TransLink guideline on route design is very interesting, too. They have really interesting logic to validate the design and the improvements that are proposed for route design. So what it says is that deviations from the most direct route must have walking time savings for customers on the added route section greater than the increase in total travel time for through passengers. So does anyone have any interpretation-- quick interpretation-- on this guideline?

AUDIENCE: The only reason is [INAUDIBLE] a major destination where people [INAUDIBLE] or otherwise people are going straight and what [INAUDIBLE] people on buses. So the second to the last stop on the route, may be you make that deviation to have people on the bus [INAUDIBLE] traffic [INAUDIBLE]

NEEMA NASSIR: Right. Yeah. Right. You have a comment, too?

AUDIENCE: [INAUDIBLE]

NEEMA NASSIR: Right, yeah. So if you look at the problem or look at the situation from the perspective of system and from the perspective of total travel time in the system, what they basically are requiring is that, for example, let's assume that I have a suburb here. And then this is my downtown area. And there is a route here that has multiple stops. And then there's another suburb here, which, in the original plan is being served by this route. However, it requires a walking link to different stops.

What this guideline basically requires is that if the total travel time for all passengers for traveling from here to here and for all that are traveling from here to here is going to be increased, then you cannot justify an additional detour here to serve this area, meaning that if the total travel time saving that is done on the walking time of these people is not as much as total increase in travel time of people that are traveling from this suburb to this suburb, then you cannot justify the design or the re-route.

So in terms of guidelines related to a schedule and guidelines related to frequency and timetable, we basically, in practice there are two main components-- component that is related to the policy of design and components that is related to the crowding situation. Policy of design basically dictate a minimum headway or basically a minimal frequency or maximum headway for the service. And that's basically the case when there is no crowding situation. However, in the main corridors and in peak directions, we usually would go beyond the service of policy headway because we need to accommodate the demand. And that's basically how the maximum passenger crowding guides come into play.

So in terms of the actual guideline on policy of headway for MBTA, we have maximum headway on all local bus routes should be 30 minutes in peak and 60 minutes at other times. For express routes, there should be at least three trips in each peak period. So let's discuss a little bit more about this. Why do you think that we need to have a policy headway-- maximum policy headway? If we are considering the demand and we are trying to satisfy the demand by number of vehicles that we are assigning to the route, then why should we care about a minimum? Do you--

AUDIENCE: Because if the demand is really low, that person-- you can't make him wait forever.

NEEMA NASSIR: Yeah.

AUDIENCE: You'll have to serve him equitably.

NEEMA NASSIR: Exactly, yeah. Again, the equity issue and the accessibility issue, basically.

AUDIENCE: And there are also, you know, still elderly people who don't use smartphones to coordinate their arrival at the bus stop when the bus is coming.

NEEMA NASSIR: Right.

AUDIENCE: And you don't want to make them wait indefinitely.

NEEMA NASSIR: Right, exactly. Right. OK, and then when it comes to considerations related to the crowding, we have guidelines about maximum crowding and maximum expectation of crowding that would dictate a minimum frequency for the service. For example, for Green line, the maximum passengers per car should be no more than 225% of the seats in the peak period. In the off peak, the maximum passengers should be no more than the seated capacity, except in the central subway, which can go up to 140%.

Yeah, so here is the TransLink guideline on frequency objective. It basically defines different headways based on time of days and based on modes of transit that the transit agencies and operators of the system need to satisfy. So in terms of guaranteeing that the load and the crowding situation is addressed in the guideline that is related to frequency, there is some analysis that is done to make sure that your frequency is high enough that your crowding situation does not exceed a certain level. Why do we care about the loads and the crowding situation? The first reason is that we do not want to frequently deny to board. That would yield to increased travel time. And we would like to basically avoid higher dwell time that is associated with higher number of boardings-- alighting number of wheelchairs on board-- that would eventually, again, increase the running time.

For example, in the acceptable-- in a regular standard 40-foot bus the acceptable load of 70 passengers are considered. However, the average that we estimate based on our design should not exceed 55 passengers. So that's the case of indeterminacy and the confidence intervals that we kind of allow in the analysis. However, it's a little different with the equity issue that you mentioned in this case because you want to make sure that to a certain degree of confidence your system is performing at an acceptable crowding level. The variability to demand could actually relate to bulk arrivals or group arrivals that may happen at once due to exchanges from different service. Or it could actually relate to the variability in the headway or variability in the nature of demand based on day of week, based on seasonality, based on the weather condition, and so on and so forth.

Then the other objective in the guideline of TransLink is the objective of comfort. And it basically deals, again, with the crowding level or the design crowding level or crowding averages that we are basically computing as objectives to be tested for this guideline. As you can see again, for different peak periods and different type of vehicles and type of service, there is published numbers in terms of the averages or computed averages for the maximum crowding levels.

So look at these numbers. Does anyone have any idea of why some of these numbers are larger? For example, for peak 15 minutes in AM and PM peak, you would allow an average of 60 passengers on-board. However, when it comes to computations of peak 30 minutes, you would only allow 55.

AUDIENCE: You don't want people to be left behind because of frequency of the services. Knowing that there maybe another hour or service is another five minutes.

NEEMA NASSIR: Right, yeah, that could be one reason that actually yielded to this design. Any other thoughts or suggestions?

AUDIENCE: Yeah, the 15 minute peaking limit allows you to have one very full vehicle that sort of would skew the averages [INAUDIBLE] and could moderate that.

NEEMA NASSIR: Yeah.

AUDIENCE: [INAUDIBLE]

NEEMA NASSIR: Yeah, exactly. Yeah, please.

AUDIENCE: Is this like-- could be, like, a chicken or egg problem where the ones the routes were needed with peak 15 minute headway are ones that you will expect a lot of people. Or is it the other way around where you see a lot of people, and then you make it [INAUDIBLE].

NEEMA NASSIR: Yes, right. Well, yeah, that's exactly one of the considerations in design of a frequency and design of a schedule. So if I want to reward-- what Ari mentioned-- if you're computing your average over 15 minutes and then you're computing your average over 13 minutes and you're observing a higher crowding level over the accepted level, then if the situation becomes more critical-- if you're computing over 30 minutes, it's more critical than if you're computing over 15 minutes. So if you observe an average of high crowding level for 30 minutes or for a longer period, that is a sign of a higher actual average of crowding level. Yeah.

AUDIENCE: It's funny.

NEEMA NASSIR: Yeah, maybe you explained it better. I shouldn't have rewarded you. So the other objective that TransLink covers is basically the comfort situation. This is one of the interesting ones. And I do not really know how it's possible to measure this for a design. It's probably usually being used in evaluation of the existing service. It basically deals with number of minutes that you expect from passengers to be standing-- maximum number of minutes of being standing on board. And there's a level of compliance that is defined for each one.

For example, you would allow no more than 95% cases that passengers would have to stand more than 20 minutes on the trip. So I can imagine if you have an existing system and if you want to measure this, you can go out and survey these numbers and compute averages and compute the distributions. However, if you have a design which is not in place, does anyone have any thoughts how you can come up with some sort of estimation for this case?

AUDIENCE: [INAUDIBLE]

NEEMA NASSIR: Yeah, simulation could be one possible way of doing this. Simulation of demand could be one possible way of doing this.

AUDIENCE: You could check, like, if it's a train-- I saw the Sky Train there, you can see where the train fills up and then assume that everyone else-- everyone that boards the train afterwards-- if you know how many people are boarding-- if you have--

NEEMA NASSIR: Right.

AUDIENCE: --data to do that, then you can assume that everyone who's boarding after is standing. And then you can see how many of them have 20 minutes or more left on the journey till the train [INAUDIBLE]

NEEMA NASSIR: Exactly. That's a good idea. So what you're suggesting is to generate the load profile for the line. And whenever the load is over the seating capacity, you measure the time period on that. So that's a good idea. Right. So in terms of for Toronto Transit Commission, the loading standards is something like this. For different types of vehicle, you would allow different averages for your design. So there is also one interesting point here. Why do you think for low frequency service you would allow a lower crowding level or a lower average ridership?

AUDIENCE: If it was that crowded, you would want to add frequency to better serve people riding.

NEEMA NASSIR: Right, yeah. That could be one good answer. The other reason that I can imagine is that if it's a low frequency service and if someone is denied boarding to a low frequency service, they have to wait longer. So we would allow a little bit of a slackness in the design, so we would avoid a situation like that.

OK, so let's stop here. And then we will continue through the rest of the guidelines, particularly with reliability of service next week.

AUDIENCE: So there's a question there?

NEEMA NASSIR: Right.

AUDIENCE: I was going to ask is there a reason why we use so many Canadian transits?

NEEMA NASSIR: Sorry?

AUDIENCE: Is there a reason why we use so many Canadian transits?

NEEMA NASSIR: That's a good question.

AUDIENCE: Their public transportation is better.

NEEMA NASSIR: Yeah, better-- probably the closest place that has better public transportation. [LAUGHTER]

AUDIENCE: [LAUGHTER]