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NEEMA NASSIR: So good afternoon, everyone. Today, we are going to continue the discussion regarding short-range planning for transit agencies. And if you do not have the set of slides, the handout from last week, there are extra copies here. Please, you can take from here. OK. Thanks. OK.

So last week we-- last Thursday, we talked about the basic concepts in the practice of short-range transit planning, the level of service guidelines and performance measures that could actually be defined and used for the practice, particularly related to excess distances, services span, maximum load, convenience, and comfort measures.

Today, we will talk a little bit more about guidelines and standards related to reliability, and then we will talk about some of the useful performance measures that could be defined and measured for transit service. And then we will talk about the actual procedure of short-range planning for some of the agencies from which we have some examples. And then we will talk about some of the caveats that could actually be identified for those.

So let's start with guidelines and with the standards related to reliability first. So in terms of reliability, as we briefly discussed last week, most agencies have formal procedures for monitoring service delivery focusing on time performance. The on-time performance is usually considered to be zero minutes early and up to five minutes late. As we discussed, early arrivals is not considered on-time. That could be because early departures basically are not considered on-time because early departures could actually have a more negative impact on travel time.

And the other possible reason is that it's probably early departures are easier to avoid. When you compare later arrivals or later departures, possible reasons that could actually contribute to a late arrival could be the vehicle getting stuck in traffic, congestion, or due to high load and high dwell times, which is usually difficult to avoid.

But when it comes to early arrivals and early departures, the driver could actually slow down in the upstream segments to make sure that the arrival is kind of on time.

So about 2/3 of agencies-- there are different thresholds that are defined in terms of acceptable thresholds for the percentage of arrivals within this tolerance interval from zero to five minutes late. However, the usual practice is that about 2/3 of agencies report on rush hour, on-time performances of 90% and above. But in practice, this threshold ranges between 80%, 85%, up to 90%, 98%, depending on the mode of the service and depending on the situation, how the congestion level is, how the load in the network is, if there is right of way, like separated right of way for that transit service or not. So it is written somehow as specific to the system, but 90% is basically the threshold that 2/3 of agencies basically accept.

Most agencies also keep track and keep route level information on passenger complaints that could relate to on-time or late arrivals. It could relate also to denial to board or to the crowding situation. They would also keep track and keep information on missed trips and accidents and interruptions and disruptions, basically.

So when it comes to reliability, there is a need to explain this. I briefly mentioned this last week, that the services, the transit service is basically classified into two types. One is walk-up service, which is related to higher frequency service that is usually schedule-free and/or headway-based. Typically with a service that is with headway less than 10 minutes or some say less than 15 minutes, it's considered to be walk-up service.

For example, the T service in the central area of Boston would be considered a walk-up service. BRT systems are also, some of them are schedule-free and could be considered walk-up or basically, headway-based.

Performance measures that are related to reliability for walk-up service is based on headway, and it basically measures the regularity of headways. As opposed to service, which is scheduled that's basically based on published timetables and published schedule and delivered based on that, basically that's the service that is usually for longer headway. Headway is longer than 10 minutes, 10, 15 minutes. And the performance measure related to this service is usually being done or being measured based on punctuality of service, being late or early.

So again, a trip is considered on time at each time point along the route and on the performance window, basically. So usually, transit agencies, for each route they define certain time points, which could be major stops or stations but usually, they are less frequent. I mean

every three or four stops, there could be one time point that you measure the on-time arrivals and on-time departures from there.

You may have noticed, if you're on a certain bus, this is my personal experience, when I lived in Brisbane in Australia. There were some routes that at some time when you see that the bus is early, the driver could actually really slow down before certain points, and you could tell where exactly the time point is that the driver is trying to basically make an on-time arrival to those time points. So arrivals are measured at these time points along the route. Right.

So what are the actual standards and actual tolerance or thresholds that agencies consider for service reliability measures? One example is here from MBTA. MBTA, actually for walk-up service, which is the case for most of the T service, it allows basically actual headway of up to 1.5 times the scheduled headway at origins and at time points. And then at destinations, it also defines another measure that deals with the schedule's running time.

So basically, there are two hooks that it kind of measures the service based on those. One is the regularity of service. It doesn't allow or it wants to measure cases where headway is longer than expected, like 1.5 times the scheduled headway. And the other constraint is that the actual running time is between 0.8 and 1.2 of the scheduled running time.

So when it comes to actual headway, you can see that there is no lower bound to the actual headway. Does anyone have any comments why there is no actual lower bound here? Yeah, please.

AUDIENCE: Lower than scheduled headway just means that there's more service. And if that leaves a gap somewhere else, then that would be record-- that would count for over the schedule.

NEEMA NASSIR: Right. Yeah. Given that the number of trips are constant during the day, if you guarantee that there is a maximum headway, then on the other hand, you can kind of guarantee that headway is not too short there.

However, when it comes to scheduled service, then there is constraints on early and late departures, basically. So at origins, what MBTA considers, at origin terminus, considers on-time departures between zero and three minutes, zero minutes early and three minutes late. And then at time points, it allows up to seven minutes late. Does anyone have any comments about the difference? Why does it allow less late departures at the origin terminus?

AUDIENCE: Give us control at the intermediary terminus [INAUDIBLE] at the terminal.

NEEMA NASSIR: Yeah. That could be the case. or to put it the other way, transit agencies, when they schedule these trips and they schedule these vehicles, they allow a recovery time between the end of one trip and the beginning of the next trip. And that actually is there to kind of help with punctuality of service, and therefore, it does allow less tolerance on delay at the beginning.

But when it goes along the route, when bus goes along the route, it kind of gets out of control as you mentioned. There are not really good ways and good leverages to allow buffer to the running time.

And then at the destination, it's basically, MBTA allows up to three minutes early and five minutes late it should be obvious why it allows early arrivals to destination because it's the last stop, and we don't need to worry about arriving early to the final destination.

At the route level, there is one other guideline that, at the route level, 75% of time points must be on time. So although for the overall system, the threshold here was in the range of 90% or 95%, or between 80%, 85%, and 95%. But at route level, when you're looking at the on-time arrivals, it has to be larger than 75% of the time. So what will happen if it doesn't-- a certain route doesn't meet this standard? Is there any thoughts? Oh, please.

AUDIENCE: You could shift the schedule for that segment and republish it and add extra--

NEEMA NASSIR: Yeah. So you can increase, basically, the running time and make sure that you adjust the schedule in a way that can be delivered punctually. So that's what's explained in this slide.

So if you observe in some of the routes the performance in terms of punctuality is poor, then you can take a look at the historical data and historical performances in terms of running time, revise the running time from terminus to terminus and that will actually, you can basically revise that to be a mean of this distribution, assuming that the travel times, the running times are distributed normally. And go ahead, please.

AUDIENCE: I mean, if it's only a 5% probability that this will happen but it happens actually a lot more than that. It's probably a result of another factor, like drivers or vehicles or traffic or [INAUDIBLE] constructions [INAUDIBLE].

NEEMA NASSIR: Well, that's a good point, yeah. So there may be, for example, you know when there is shared right of way with background traffic, there's a lot of indeterminacy in terms of travel time, especially if the roadway is congested, and that could be one possible result for unreliability of

running time.

One possible thing that could be done is like dedicated lanes to the transit and kind of trying to improve the performance and match the schedule. So that could be one other way. But what I mentioned was that if this is the last thing that we can do and that we cannot basically improve the reliability of arrivals, we may actually allow a little bit of buffer to the travel time.

And that's not only by extending the running time to a job that we can observe, but also, you can adjust the recovery time between end of one trip to the next trip to the chosen amount that makes sure that a certain confidence can actually be gained in terms of on-time performance of next trip. In terms of the actual objective that TransLink has in place for reliability, again depending on different modes, TransLink defines different acceptance thresholds for given on-time definitions. And on-time definitions could actually vary as well as a level of compliance or the acceptance threshold.

So is there any questions about this? Any comments?

So there are some more detail measures and event measures for transit service. It comes to variables that are related to transit service supply and demand side. Quantities actually can be classified into three different groups, the quantities that are related to the service input, quantities related to service output, and quantities related to service consumption.

So service input is basically the resources that the transit agency is using to produce the service. Service output is basically measuring the produced service. And service consumption is how this service is being consumed and being appreciated and being used by the public. So different measures can be defined to measure the performance of transit system based on these quantities.

For example, you can look at only the vertices of this triangle, like what is the amount of labor, including drivers and maintenance? What is the capital cost of the fleet and infrastructure? What is the fuel consumption in the system? Or, on the other hand, you can look at the service outputs. It would be like a measure of the service in terms of how much service the system actually is producing in terms of vehicle hours or revenue hours, vehicle miles or revenue hours, capacity miles and service reliability. And then consumption of service, that is dealing with number of passengers, passenger miles, operating revenue, and operating safety.

But you can go one level up with playing with these measures and compute, for example, the

ratios of these quantities. So each one of these edges basically are dealing with the ratio of one quantity at one vertex as opposed to over the quantity of the other one. For example, what we are basically-- efficiency measures are basically dealing with how we are doing in terms of producing service as given our available resources or the consumed resources.

The service effectiveness basically deals with how we are doing in terms of giving service to public, moving public and producing mobility in the network over the service that we produce, how our service is appreciated and used and utilized. For example, a service that is poorly designed, for example, like every five minute trips overnight from a suburb to another suburb, it's a service, and it has produced vehicle hours and vehicle miles. It has consumed resources. However, it may not be appreciated because it's poorly designed. So that's the kind of the role of measures that are related to service effectiveness to take care of quality of design and quality of service, basically.

So and one other comment about this triangle is that the cost efficiency measures kind of dealing with the quality of the planning on the operational side, operational planning. How the optimization and how the tactical decisions are made in terms of producing the most service out of the existing resources. On the other hand, the decisions that are related to service planning could actually use measures that are related to service effectiveness.

So in terms of alternative measures, like benefit and cost measures that could be defined and used for short-range transit planning-- before we go into discussion of benefits and cost for transit system, there is one thing that I need to mention. What's happening in transit system is that they are usually not run, as you know, for profit and that's probably one of the main differences between the business model of a transit system as compared to other regular businesses, where they make decisions based on profit and based on the revenue over or benefit of cost or better benefit over cost.

What happens in transit agencies is that it can be thought as a type of benefit over cost analysis but the cost and benefit is a little bit different. The benefit is dealing with the public service and the amount of consumer surplus or the social welfare that you can produce, the mobility that you can produce. On the other hand, the cost could actually include the operating cost and also could include the revenue. It basically can be defined as operating cost minus revenue.

So when it comes to the financial unit of benefit and cost, the financial unit includes both the

cost and revenue. And then when it comes to benefit, what's usually being used as a measure of benefit is the service that is being delivered in terms of the social welfare measure or the mobility that actually is produced in the network. So once we discuss some of these alternative measures, it may be a little more clear.

So one of the measures that could be defined and really easy probably to define and measure is the revenue. Like, what's the fare box revenue? What's the total? The advantage that this measure would have is that it's very relevant to financial concerns. It actually, another advantage that it has is that it's related to willingness to pay and it could be used as a proxy of quality of service. However, the disadvantage that could be mentioned for revenue as a benefit measure is that it discounts value of reduced fare trips, discounted trips, concession trips. And it also has the disadvantage that it favors higher income passengers.

So if we want to look a little bit more closely at the nature of transit service and what should be considered as a benefit measure, we need to look at the mobility and try to measure the mobility that has been produced for the citizen, for the people living in the network. So we can count the number of passengers who have used the system and the advantage of this is that it reflects the number of people who benefit and it basically values each passenger equally.

However, the shortcoming of counting only the number of passengers is that it kind of doesn't reflect trip length. Not reflecting trip length basically kind of ignores an important component in mobility, which deals with access to opportunities. Which the access to opportunities definitely cannot decrease with the opportunities for mobility.

And then the other shortcoming is that it basically reflects on link trips and not journeys or link trips. So you basically double count passengers who are making transfers, although they may be traveling to one destination and there's only one opportunity at one destination or that will be actually one activity happening at the destination.

So one way to improve this is to measure passenger miles as a better proxy of mobility in the network. It has the advantage that it weights longer trips more and it's the best reflection of benefits related to mobility. Sorry about this. However, it's hardest to measure. Does anyone have any idea, comments about why it's hardest to measure? Why is passenger miles in the network hardest to measure?

AUDIENCE: A lot of systems don't have an exit. They only have an entrance stile.

NEEMA NASSIR: Exactly. So considering that we're using the data for passenger, like from fare card systems, many systems do not have the requirements of tapping when you're exiting the system. So that's something that is missing. So it requires some sort of inference of highlighting our exit locations to be able to measure the length of trip.

However, and the other disadvantage is that it could find favor higher income passengers. So any comments about this?

AUDIENCE: That assumes the high-income passengers, that assumes higher income people travel further. It's not necessarily the case.

NEEMA NASSIR: Not necessarily the case but in systems where you have distance-based fare structure, and when you basically have the entrance and exits recorded and you charge people by the length or number of zones that they have traveled, that could be actually somehow favoring higher income passengers because it is reasonable to assume that higher income people are less sensitive to the fare and so their decisions are basically kind of regardless of fare. So any comments? OK.

So then on the cost side, the measures that are dealing with cost, the net cost is basically cost of resources that are used to generate the service minus the revenue. And it's usually most directly constrained because that's exactly the amount of money that you need to secure for the service. The budget actually goes directly to the net cost. So that's the advantage.

However, the disadvantage is that it's hardest to estimate. Any comments about why it could be hardest to estimate as compared to cost? At least for designs, for the service that is not already in place, if you need to estimate the revenue and deduct that from cost to generate net cost, it would be a challenging thing to do, to come up with estimates of demand and predict the revenue. So that could be one of the shortcomings of net cost for designs.

However, it may not be that difficult when we are dealing with the existing service because revenue is basically already recorded by the fare box system.

And then cost could be another measure less directly constrained because actually, we need to combine that with the revenue to realize what's the net cost of the system? Again, it could be hard to estimate but probably not as hard when we compare it with net cost. Go ahead.

AUDIENCE: What is net cost?

NEEMA NASSIR: Net cost is basically cost of operation minus the revenue from fares. And the reason that it's

tricky to measure is that the revenue side is probably a little difficult to predict.

So the next measure of cost could be vehicle miles. That basically deals with the service that is produced. It's easy to measure because you know number of trips that are delivered to the system, and length of trips are known. So vehicle miles is probably the easiest measure to compute. But the disadvantage is that they only reflect 3% of the cost and that's probably the part that is correlated with fuel and with depreciation of the vehicles and with maintenance.

And then it also penalizes fast service, not [AUDIO OUT] traveled fast and on time as opposed to the model that is basically delivered in congestion and with long delays.

Another measure that is probably a little bit more closely reflecting our cost is the vehicle hours. And the vehicle miles and vehicle hours are basically the revenue miles and the revenue hours. What I mean by revenue, that's basically the miles that these buses and these vehicles have been in service from the start of their trip to the end of the trip. There may be some trips, like dead-ending trips, that the vehicle can should go empty from one location to another location to the next trip, and those miles and those vehicle hours are not counted here.

So vehicle hours basically, again, are easy to measure. And the other advantage is that it's related to more than 50% of bus costs. It basically correlates with the fuel consumption and with driving and operating cost.

So one of the cost effectiveness measures that MBTA uses for their system and for their decision making is basically net cost per each passenger that is using the system. And then they usually define this on a route basis. So the index I here could be net cost per passenger for each route, and then it shouldn't exceed three times the system-wide net cost per passenger. So this is basically going back to the triangle that we had. This is one of the measures that is dealing with resources that are used to the number of passengers that are using the service, regardless of what the service was.

So in terms of issues in setting up a short-range transit planning process, this slide mentions some of these issues, starting with the roll-off budget constraints in the process this could actually be related to before budget is set and after budget is set. Before budget is set, there is some indeterminacy in measuring the net cost and basically the budget that is requested in the proposal for a new service or for a change in the service. What's similar to any other

proposal that is usually done is that you try to find the minimum possible budget that you're requesting for what you're trying to deliver and that could be a challenging task.

And then after the budget is set, given all the indeterminacy that was involved in predicting the budget, then it's the issue of optimizing the resources and optimizing the budget to deliver and to gain the most out of the existing resources. The other issue with--

AUDIENCE: So in this part of the process, I wonder if it should be advisable to leave a margin of maneuver in respect to budget constraints normally you would have, even if you go for the minimum possible to get 85%, 80%, out of that, for political reasons or whatever reason there is.

NEEMA NASSIR: Right. So that could actually make the situation a little easier for people who are involved in planning and for the actual plans, right? So what Ricardo is mentioning is there may be some buffers or some internal-- some buffers in the budget and some flexibility in the budget that could actually be allowed when you're requesting the budget and when you're delivering the budget, delivering the service that could actually take care of some of the indeterminacy that is involved in the prediction of the budget and prediction of the costs.

So the next, possibly the next issue that is involved in the traditional or the existing practice for short-range transit planning is that we kind of have a set of standards and constraints that gives us lower bounds on some of the service measures. However, these constraints only give us an idea of what's the feasible solution space. It doesn't really tell us what's the optimal design and how you can basically optimize the allocation of resources to improve the ridership. And that could actually involve some of the art of the designers and the art of people who are involved in identifying opportunities within the standards and within the constraints and guidelines to address the situation and to gain the most out of the allocated resources.

Then again, when it comes to design of service, there is also this issue between the existing service and proposals and plans for additional service. As I mentioned last week, the design of service is never from scratch. There is always something there for good reasons and you may want to predict the existing service as much as possible because people are relying on the service. They probably have formed their travel habits and travel attitudes based on the existing service. So changing these services probably need to be really careful and thoughtful, basically.

However, when it comes to addition of new service, we may want to make sure that the new service kind of supports the existing service effectively and with all the overlaps and all the

misconnections are identified in advance and taken care of.

Issue that we will eventually talk about it later in another slide is that some of existing practice is dealing with short-range transit planning decisions dealing poorly performing routes. But the optimal design is not always dealing with changing the ones that are only poor, the only ones that are poorly performing. There may be some changes that you can do to well-performing routes to improve the overall system performance and the network level performance. So is there any questions so far? How am I doing on time? OK.

AUDIENCE: Professor Nassir, does the cost effectiveness standard work if they can't compare the cost effectiveness of [INAUDIBLE]?

NEEMA NASSIR: My sense is that it has to be in a modus specific, but yeah, but I can take that and-- Yeah. It makes more sense to be, yeah, because you probably cannot compare the effectiveness of a bus versus a train in terms of operating costs at least, right?

So this is the standard process of decision making when it comes to new projects and new proposals, service proposals, and changes to the existing service in Toronto Transit Commission. This gives you an overview of different tasks that are basically done to start with a set of proposals and to make the decision on which ones to be implemented and so on and so forth.

So if you look at the column on the right, it basically includes the decision-- it deals mostly with the decision making on the new service proposals. First, you get some requests from municipalities and some suggestions from the staff about new service proposals. Then, if these proposals are passing your system guidelines, then there would be two possibilities. If they are minor costs, they'd go directly to recommendation.

And if they are major costs, then you need to do a benefit cost analysis, and that basically includes estimation of ridership and estimation of costs and benefits. And then, once you have a better sense of benefits and costs and benefit/cost measures of the project, then there will be a comparative evaluation of alternative designs and alternative proposals. At this stage, there will be another input from changes to the existing system that comes into the comparative evaluation, which we will get to that branch in a minute.

After these projects get to the recommendation level, the staff makes a recommendation to the board, and then there will be a review and decision about acceptance or rejections of

some of these proposals. And then there will be an implementation of the successful proposals. And then there will be a probationary time to implement the successful proposals and then to, after six months, it will get back to the recommender team to see if it would pass the probationary period.

On the other hand, there is a set of proposals that are made to make changes to the existing service and that basically comes from two main streams-- one is a continuous monitoring of ridership and loads and the other one is the annual route efficiency review. And from this, then the staff actually identify service changes and assess the impacts on passengers. If the impacts are minor, it goes directly and it becomes implemented. If impacts are major, then these changes become into a form of a proposal and comes to the stream of comparative analysis that would be actually compared with new service proposals and follow the same procedure with that. OK. Any questions about this?

We'll actually get to the main two streams on changes to the existing service in the second next slide right now. So the first slide is dealing with basically the continuous monitoring of the system that Transit Authority or transit agency staff regularly do. It's basically, the input into this kind of process involves ridership counts, regular ridership counts, customer communication, customer complaint records, some observations from staff in terms of the performance of these routes and for possible adjustments that could be done and then from operations report.

Then there will be a comparison of ridership to load standards. What we basically discussed last week in terms of level of service measures related to maximum load will actually be tested for all the routes. And then depending on the situation, if there is available vehicles and budgets, then the staff actually making their recommendations of changing the service, if there is availability of vehicle and budget, there will be improvement in the service and increase in the service level. And then it will be reviewed for recommendation, staff approval, and implementation, and this is a closed loop that is usually done on a regular basis.

Then there is another process related to the existing service that deals with yearly review of the routes in terms of route efficiency review. And basically, you kind of consider a route from a cost and benefit perspective. And on the left, you can see new riding counts or yearly riding counts that's actually are collected from the study year. And then that goes complemented with the record of complaints and customer satisfaction reports and service regularity. And it will be combined with the financial performance and basically the measure of costs that are

spent to each route.

And then it comes to this joint here with reviewing the structure of the route. Some of these routes may be routes with branches which actually makes the analysis a little bit more difficult, especially design of branching and alignment of branching, making sure that the frequency and the load profiles and maximum loads are actually satisfying the standards before and after the joints.

Because as you may have already thought about, some of-- so, for example, say Green Line here in Boston, in the part that is-- for example, where you have higher demand in the central area, one of the effective techniques in design of routes is to join some of these routes into one service to avoid additional transfers and to produce connectivity to the central area without need of a transfer here.

However what it actually causes is that the demand that you're collecting from lower density suburbs are basically based on given frequencies here. And you set these frequency based on these demands. But when it comes to the merge points, the frequency will be the combined frequency and the demand, kind of crowded situation will be the combined situation. So you need to make sure that all these standards and all the guidelines are holding for all these branches at the same time. OK.

And then after that, let me try to clarify this a little bit. For example, considering the-- similar to the example that we made last week related to two suburbs that are actually using the transit service. So let's say suburb one, suburb two, and this is downtown area. If the existing service is a direct line between suburb one to destination and passengers from suburb two basically walk to this stop to get to destination, then assume that the new proposal of service is basically adding one detour here to serve this.

Try to clarify this a little bit. For example, considering similar to the example that we made last week related to two suburbs that are actually using the transit service in the-- so let's say suburb one, suburb two, and this is downtown area. If the existing service is a direct line between suburb one to destination and passengers from suburb two basically walk to this stop to get to destination, then assume that the new proposal of service is basically adding one detour here to serve this suburb two on the way to destination, then what needs to be done is that we need to make sure that the total generalized cost that is computed for all the passengers from suburb one and suburb two to destination would be reduced after the

introduction of this detour.

And then how do we compute the total generalized cost that is experienced by the passengers? There are some equivalent values that are usually used. For example, for every vehicle travel time, you assume, one in vehicle travel minute. And then for every minute of waiting time, you assume 1.5 or so. For every minute of walking time that is required, you consider two minutes of in-vehicle time. That's the case for, for example, when you want to measure the cost of walking from this area to the stop. And then the cost of each transfer is considered to be 10 minutes, equivalent to 10 minutes. Is there any questions about this?

AUDIENCE: So from the local suburb [INAUDIBLE] so in case there would be [INAUDIBLE] However, it may just be the fact that [INAUDIBLE].

NEEMA NASSIR: Right. If the service can attract latent demand-- so the question was that this condition does not account for latent demand, and it kind of assumes that the demand is constant between the two scenarios. So my impression is that whenever there is latent demand, that could actually be considered an advantage. So you can safely assume with the existing level of demand if this change or if this new service can reduce the total system cost? But I do not know how they exactly implement this when it comes to demand prediction. OK.

So any other questions about this? You may ask where does these numbers come from? I mean, these coefficients, how do we get these coefficients? They may make sense. At least, to me, actually, they're kind of consistent with the way I perceive the cost of travel in different components of trips, in vehicle time, waiting time. Go ahead.

AUDIENCE: Why is the transfer worth more than 10?

NEEMA NASSIR: That's 10 minutes considered for one required transfer. So for example, that's the case where you have direct access between origin and destination versus where you need to make at least one transfer to get to destination.

So the way these coefficients are quantified or understood is that if you look at the choices people make in terms of paths that they choose, given their available path alternatives, and you can basically calibrate these coefficients based on the assumption that passengers try to maximize their utility or minimize their generalized cost.

There is techniques involving the theory of utility maximization that is usually used in practice to look at the actual observed path choices the passengers are making and quantify these

coefficients.

AUDIENCE: So what if you maximize-- I mean, for that to result in benefit for customers overall, you would have to increase, for example, like headways or frequencies from part of the trip, but then go back to previous frequency levels?

NEEMA NASSIR: You mean, in the merging?

AUDIENCE: Here, as part of the transfers. It's only way to maximize the benefit for customers.

NEEMA NASSIR: Right. So the scenario that I tried to explain here was removing this route and adding this layout for the route and replacing it with this alternative. So you can keep the same frequency before and after and the waiting time could be kind of the same. Or you can alternatively add additional routes and improve the frequency for other parts of the system but make sure that you're serving the demand on the distant suburb.

AUDIENCE: How do you compensate the path right here?

NEEMA NASSIR: This one, right? This part?

AUDIENCE: Yeah, because they're traveling a longer route.

NEEMA NASSIR: Yeah. They basically-- the in-vehicle time for these people will be increased. So this is the measure like the-- after you implement this change, if you want to and analyze the scenario, the in-vehicle time for traveling from-- it's usually IVT for S1 to D for after will be greater than IVT for S1 to D, right?

So in-vehicle time will be increased. However, what's going to change for passengers who are traveling from S2 to D, the walking distance is going to decrease, which has a coefficient of two. The in-vehicle time may increase somehow because they are boarding now at this point, but depending on what frequencies you're designing, you can compute the waiting time and put that into consideration and into computations.

So how are we doing on time? OK.

So Toronto financial standards and comparisons-- basically, service change proposals are evaluated according to customers gained or lost per dollar spent or saved. Again, the benefit that is imagined for transit is in terms of the number of customers, the number of passengers that are added and are using and benefiting from the service. And the cost side is basically the

net cost, like the operating cost minus the revenue. And Toronto applies this for new service proposals and possible reduction to the service and to fare changes.

Again, the financial unit actually that goes into these computations is the net cost, operating cost minus the revenue. And the threshold that is used by Toronto is 0.23 as the standard threshold, that's 0.23 passengers per dollar spent. So for each dollar that you're spending on the operation minus the revenue, you need to guarantee at least point 0.23 passengers are basically getting served.

AUDIENCE: That's operating dollars and passengers. It's not a capital expense. It's operating.

NEEMA NASSIR: It's operating. Yeah, I think it's operating cost minus the revenue, probably, right.

AUDIENCE: Yeah, OK.

NEEMA NASSIR: Right. And then services that are operating below this level, we actually get kind of reviewed in the annual yearly review process.

Again, in terms of service change process, major service changes are evaluated twice per year. They're basically ranked in the comparative analysis and based on their performance and based on productivity of the existing service. There is a board in the Transit Agency that makes these decisions. Usually, they invite people from metropolitan transportation planning agencies too or higher level governmental agencies. So these boards basically review the recommendations from the staff and make decisions based on their merits.

The guiding principles for TransLink for Vancouver in service optimization program, is to maintain basic service for transit-dependent customers, like what we discussed about the existing service and how passengers may actually be dependent. And we need to be careful when we want to remove some of the existing service and maintain service that are strategic for network connectivity. Sometimes it becomes a little tricky when we look at the routes individually and do not consider their role and their functionality in the performance at the network level.

So the guiding principles of TransLink kind of enforce this concentration. And then minimize service reductions in area with no transit alternatives, supporting growing market where productivity is improving, reinvest in service to generate higher revenue ridership, and reinvest in service that supports long-term goals and objectives of TransLink.

So let's open a discussion now for a few minutes in terms of possible critiques and possible caveats of the existing practice for short-range planning. Let's start-- does anyone have any comments or any thoughts about the existing caveats or critiques yet?

AUDIENCE: Slide 36.

NEEMA NASSIR: Yeah, it is actually.

AUDIENCE: Where it says the TTC value is, the financial impact of service changes. Any service change proposal is evaluated according to customers gained or lost per dollar spent or saved. Does not mean that they could eliminate any stops, for example, and not lose any customers? They'd just make those customers walk further and make service less convenient for them, that that would be a sound decision according to these criteria?

NEEMA NASSIR: So yeah. So do you mean, if you're making some changes that reduces the actual number of customers--

AUDIENCE: Say they make a change and they don't lose customers but service is worse for customers. The customers have no other options, so they continue using the service, even though it's slightly worse.

NEEMA NASSIR: So yeah, that's a good point. That's a good point. So probably the important caveats is that many of these guidelines and standards are not from the passenger's perspective. So passenger's perspective performance measures and passenger's perspective perceptions of the quality of service is something that probably should be incorporated in some of these measures.

AUDIENCE: Isn't it some of the checks and balances in place because it's relatively easy in services neutral users of these services lean on it and some people have to walk further. So that in itself would lead to a reduction in the number of people who take the route. So for example, from suburb S1, the number of people who [INAUDIBLE] So analysis at route level, because then it might actually go in favor of the agency.

NEEMA NASSIR: So exactly. So analysis at the network level should be something that probably better captured by these guidelines. And one of the other things that is not actually included here is the actual objective of transit agency, which is improvement and increase of the ridership, which is not explicitly tied to any of the existing guidelines. That's something that could be identified

thinking of it as an optimization problem as an optimal or objective function to be optimized over the solution of space, which is the guidelines, existing guidelines and standards in the service.

So what this guideline that we discussed here is just the bound on what is acceptable and what's not acceptable. But the fact that is this going to be beneficial to the system or not? That's something that requires better analysis of the plan basically. So any others? OK.

AUDIENCE:

Comment on just one thing. Is this less for the short term service planning and the problem with short-term planning often a lot of the demand and [INAUDIBLE] will be contemplate. Whenever you do major additions, extensions, or you have a major budget crisis and it's a cut off service, that would not be considered entirely a short-term thing but more of a bigger impact. So the study would be required with demand more.

NEEMA NASSIR:

Correct. Exactly. OK so in the last slide there is a list of possible caveats that are mentioned here. Couple of those we already discussed. Focus of the existing practice is on poorly-performing routes, whereas it does not necessarily have to be a poorly-performing route that has the potential to be improved to improve the performance of the system.

There is data limitation both on type and quality. We observed that in many of the measurements and in many of the decision making, there is lots of uncertainty that is related to quality of data and limitations of data. So hopefully, with the new generations of passively-collected data that are nowadays introduced, there will be improvement in the existing practice to take advantage of that data and improve the planning process.

Again, measures not always closely tied to objectives. That's something that is relevant to what Adishak mentioned in terms of some of these measures are basically just constraints and lower bound and they're not necessarily tied to the objective, which is improvement of mobility and improvement, increase of ridership.

And then focus on individual routes may actually not be ideal because kind of it ignores the network level functionality of routes. So any questions about this? Any additional comments in terms of-- right. OK. Yeah, please.

AUDIENCE:

So the idea of utility is not always something that someone actually calculates for when they're considering these simulations or calculations or changes. It's kind of theoretical. If we do this then it will affect us but there isn't necessarily a quantitative way.

NEEMA NASSIR: Right. The utility itself is a random and unknown quantity, right? There's a random component to it. But the marginal rate of substitutions of these coefficients related to different components, that's something that can be quantified. For example, what is the disutility of waiting time as compared to the disutility of in-vehicle time. So that's a way kind of have a sense of the generalized cost.

AUDIENCE: Couldn't you also use a dollar proxy to say that the economy is stimulated in x, y, and z? Is that another way of looking at it?

NEEMA NASSIR: I think the-- yeah, I'm not sure about--

AUDIENCE: It's typically used for capital investments. All these people that are looking for short-term funds, things like environmental impacts and economic welfare at a large scale are equally the methods. You are considering a minor extension or increase in service with the same alignment.

So you're probably not going to do a fully [INAUDIBLE] gradual marginal change. But in a bigger context then, yes, you would have, a four-step model and you would look at CO2 and look at many other things. And one example of that would be the recent example of London Crossrail, where a lot of the business case for Crossrail had to do with deliberation and things like this, not necessarily the time that people were saving.

AUDIENCE: When we say poorly-performing routes, are we talking only in terms of timing, for example, or are we also talking about poorly-performing in terms of financial return of the route?

NEEMA NASSIR: Right. Right.

AUDIENCE: I'm afraid that for example, if people talk about financially, certain routes might get closed for low demand, and then you have the equity problem that we talked about over there.

NEEMA NASSIR: Right. Yeah. So I believe when you're evaluating the quality of these routes, we can use all the existing criteria that we mentioned. For example, the criteria that is related to access, the criteria that is related to span of the service, access over time and space, and then measures that are dealing with the productivity of the route and the financial aspects. So my guess is that this is probably kind of when we're evaluating the routes, we are taking into account the equity issue and the access issue and all those sorts of guidelines that we discussed last week into consideration.