Introduction to Multimodal Urban Transportation Systems (MUTS)
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Module No # 04
Lecture No # 16
Public Transportation: Advanced operation concepts of public transportation

Welcome back friends, in this week of the public transportation lecture series we will introduce you to the various critical concepts or operational concepts that are used in public transportation. You have so far learnt about how to measure the performance of public transportation systems, we have looked at IPT, rail and bus. Now let us look at some of the operational concepts in public transportation systems.

Some of these may be a little bit advanced, so I request all of you to kindly pay a little bit more attention to these lectures.

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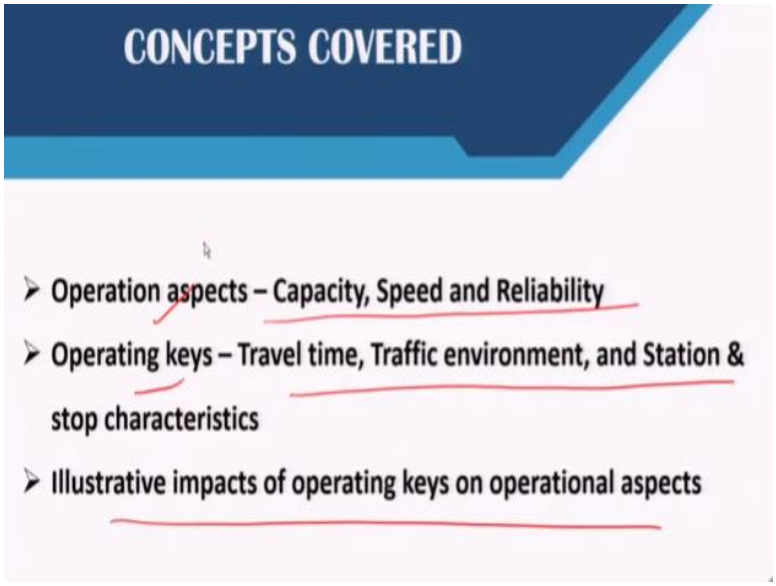
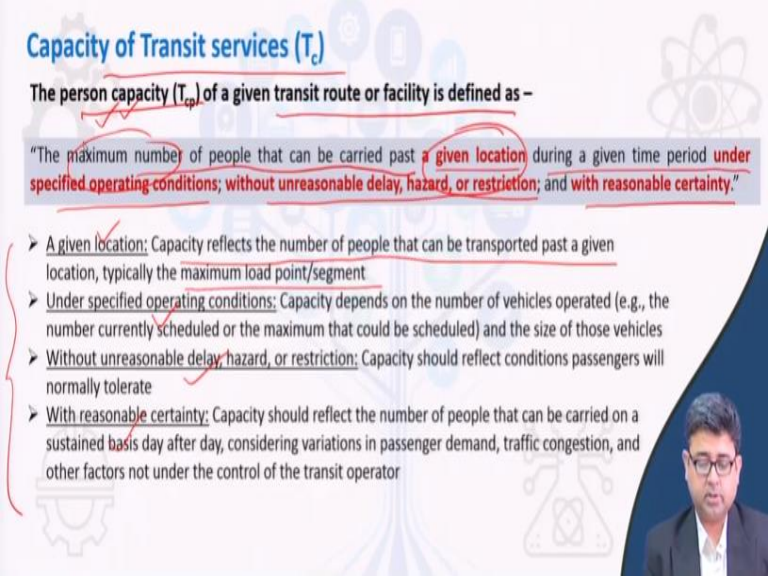


What we are essentially going to talk about are the operational concepts of capacity, speed, and reliability and how to measure them, how these affect travel time, travel environment and station stop characteristics. How all of these aspects are inter connected and how they affect each other and I will give you some illustrative impacts of operating keys on the operational aspects that will tell you how each of them are related to each other. **(Refer Slide Time: 01:33)**



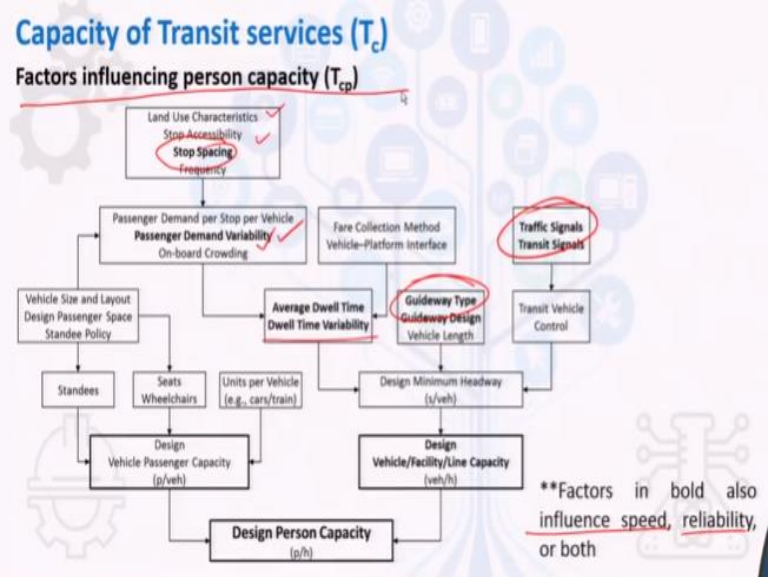
So, when we talk about capacity of transit services, the first capacity that we want to know is the person capacity (T_{cp}). So, person capacity is something that we are always wanting to know of any public transportation system, or of any transit route, or a facility. It is defined as a maximum number of people that can be carried past a given location during a given time-period, under specific operating conditions, without any unreasonable delay, hazard, or restriction and with reasonable certainty.

So, it is essentially that a maximum number of people that can be transported or carried using your public transportation system under certain provisions. These provisions must be met so it is carried past a given location. If you want to know the capacity of your line you have to pick a location. At a given location, the capacity reflects the number of people that can be transported past a given point, which is typically the maximum load point of the segment.

So, if you just pick a segment and say that 'n' number of people have crossed this segment on your public transportation system, that gives you the person capacity. It is under specified operating conditions, so these operating conditions should be normal, should not be any unusual day where there is unusual capacity or unusual stress on the public transportation systems, without unreasonable delay, hazard, or restrictions.

The conditions where the public transportation operations should be normal as well as there should not be any excessive delay, rather than just the normal delay that you see on day to day operations. Meaning that there should not be a huge accident or anything that is causing larger delays to the system and with the reasonable certainty saying that this is the capacity that can be carried day after day.

This is certainty, i.e. when we are saying that this is the person capacity that can be carried day after day it is not just a day in which this much maximum number of persons can be carried. So, all of these put together gives you an understanding of person capacity of a public transportation system. **(Refer Slide Time: 04:01)**



So when we look at the different factors that influences person capacity, there are a whole host of factors starting from land use characteristics, stop accessibility, but more importantly if we look at the ones that are in bold, because those are factors that will not only affect a person capacity but it also influences speed and reliability of the systems. So, may be these are the ones that you should focus on, for example “stop spacing”.

So, if the stops are too closely spaced with each other that means there may be possibility of a greater number of people accessing the system and enhance the per person capacity of the public transportation system. Whereas, if the stops are spaced too far from each other then people will

not be willing to walk up to the stop or take an auto rickshaw to the stop. They may be just willing to use a private vehicle and not use public transportation at all.

So stop spacing plays an important role. Next is passenger demand variability - do all type of passengers want to use it? or is it just the office going public? or is it just the captive passengers who wants to use it? This will tell you what dwell time is. How long a bus sits at a bus stop to collect passengers is dwell time, so the larger the dwell time more the number of people that it can serve. However, larger dwell time may also mean that it may be missing out on other passengers in other stops.

So, there must be optimization to that. Next is guideway type - if it is an exclusive guideway that public transportation system is working on, its capacity increases. If there are too many traffic signals, then the capacity decreases, so on and so forth. So, there you will see that it is a complex method to calculate or to estimate the person capacity of a transit route. But if you were to do so, as many public transportation systems have done it, you will have to take into consideration such different factors.

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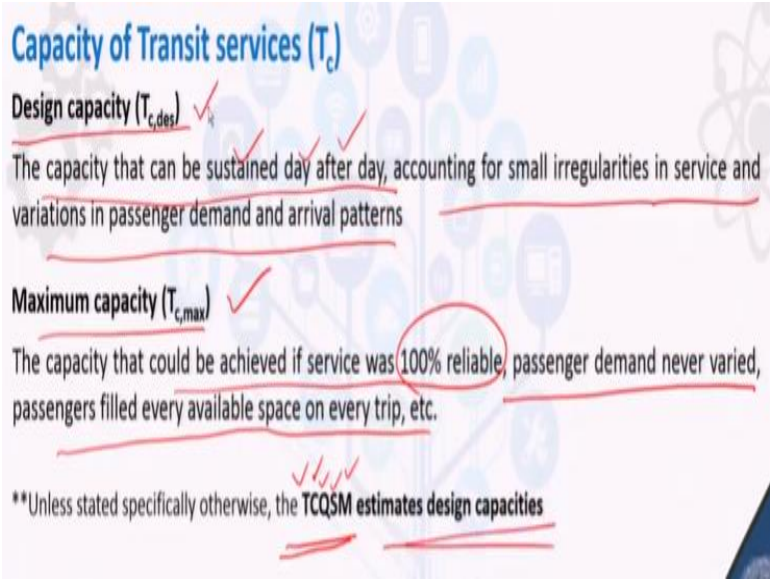

Then there is what is called the design capacity, that is the capacity that can be sustained day after day accounting for small irregularities in service and variations in passenger demand and

arrival patterns. That is the demand capacity. So somebody asks you how much is your system designed to carry? How many passengers is your public transportation system designed to carry?

So, if you want to know the design capacity then you must again bring that reliability into the factor that can be sustained day after day. May be on one day you can carry a lot of people, but the next day you carry very few people so that will not be your design capacity. Design capacity is somewhere in between them, the number of people most probably that you can carry day over day. So, you never look at the highs, you never look at the lows, but look at how much you can carry day after day.

Maximum capacity on the other hand is the capacity that could be achieved if service was 100% reliable, passenger demand never varied, passengers filled every available space on every trip etc., So this is the very theoretical concept of maximum capacity which in theory you can design and understand just to get an understanding of how many people your system will carry, but to reach that number, it is very difficult.

These all concepts are taken from a manual called transit capacity and quality service manual developed in the United States. All these estimate design capacities, rather than maximum capacity or per person capacity.

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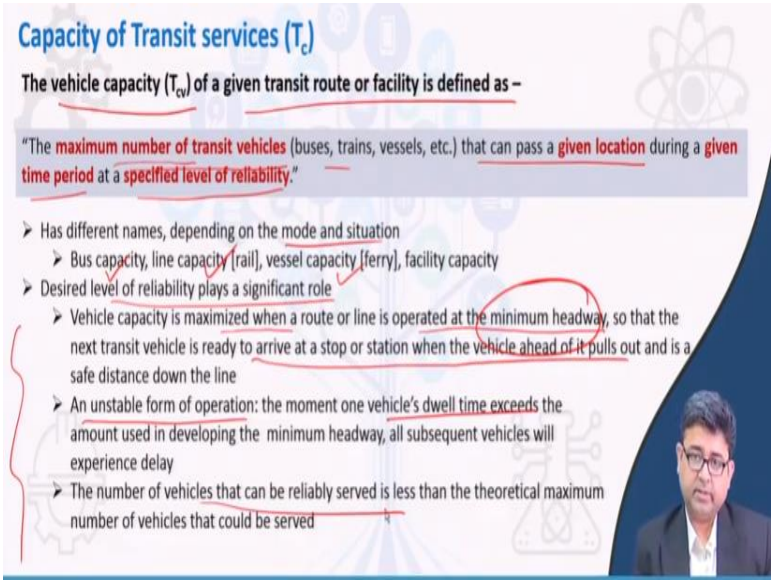

Then comes the vehicle capacity, so now if you know that how many people can be carried as person capacity, you also may be wanting to know what is the vehicle capacity of a given transit route or a facility. Now how is it defined? It is defined as the maximum number of transit vehicles - buses, trains, vessels etc., that can pass a given location during a given time-period at a specified level of reliability.

Again, there are different reliability levels, different types of time periods, all that conditions put together, then maximum number of transit vehicles that can pass the given locations. Now we are talking about vehicles, so from the operator point of view they must know that what is the vehicle capacity of the system. If the operators know how much the person capacity is, then they can easily calculate the vehicle capacity as well.

So, they must match the person capacity to the vehicle capacity. This vehicle capacity can be given different names based on the different modes. So, for bus it can called bus capacity if you are talking about bus transportation, line capacity for rail or vessel capacity if it is ferry etc., And the desired levels of reliability play a significant role. Vehicle capacity is maximized when a route or line is operated at the minimum headway.

Headway means the time between the arrival of two vehicles. For example, the time that the next bus arrives at the same point that is the headway between the 2 consecutive busses. So, if that headway is minimum, that is when the vehicle capacity can be maximized. So that the next transit vehicles are ready to arrive at a stop or station when the vehicle is out of that bus stop. However, we know that to maintain the proper headway is difficult under operating conditions because of traffic congestion and dwell times.

So, we always want to minimize headway so that we can keep the vehicle capacities at maximum. There is always unstable form of operation, say if we talked about the dwell time exceeds the amount of time, then the number of vehicles that should be served will be less than what that can be served. So, when the reliability decreases, the vehicle capacity also decreases.

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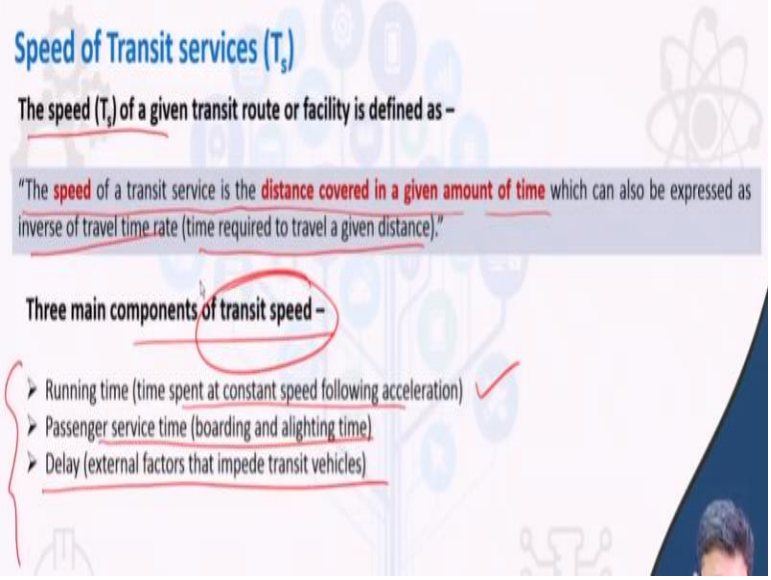

The next concept to understand is the speed of a given transit route, because people always make a tradeoff between whether to use their private vehicle or whether to use public transportation. One of the factors that they always take into consideration is the travel time or the speed by which they will be able to reach their destination or what if the speed with which the vehicle, i.e. public transportation vehicle will, move along in the traffic stream.

So, you must understand the speed of a public transportation system or a vehicle. The speed of a transit service is the distance covered in a given amount of time which can be also expressed as an inverse of the travel time rate or time required to travel a given distance. So, there are 3 main components of a transit speed, i.e. running time, which is when the vehicle is running at a constant speed following the acceleration, the passenger service time (boarding and alighting time) - that is also when the vehicle is not moving but it is loading and unloading passengers. So that is also the time that must be considered when you are calculating the transit speed. That is why we always want to minimize the dwell time at the stations. So we have to load and unload very quickly that is why you see that there is one door from which you allow people to board and other door where you allow people to disembark, so that is the case that speeds up or reduces the dwell time.

And lastly delay. External factors that impede transit vehicles because of either congestion, or if you do not have your exclusive right of way, or when delayed by other kinds of things, such as

signals and so on and so forth. So, all of these components, play a crucial role in determining the transit speed.

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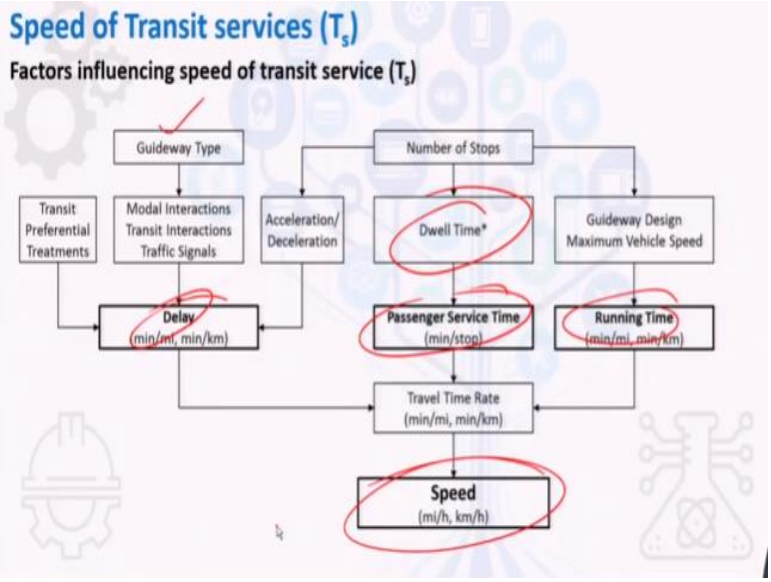

Again, we have already discussed the dwell time, delay running time, passengers service time. So, if you have your own right of way on a guideway you can maintain a good speed of your transit, whereas, if you are operating on shared right of way for example the buses or trams then your transit speed will be affected by those other modes as well.

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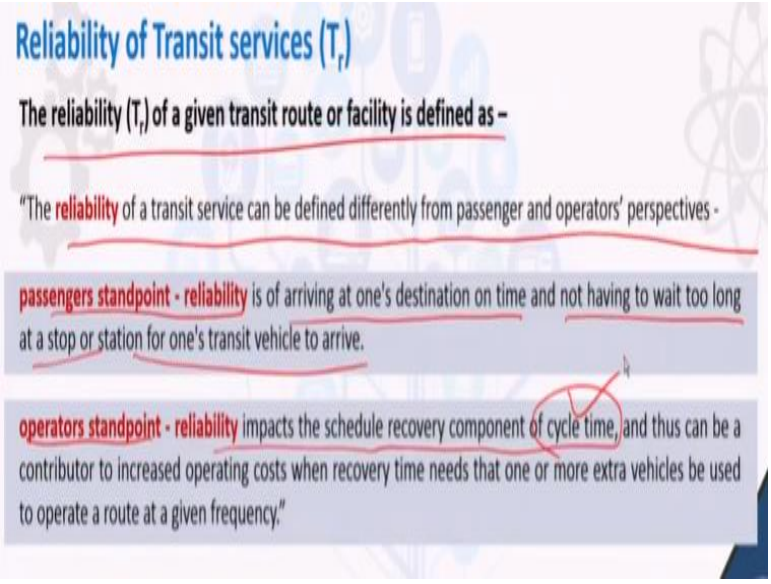

We have talked about reliability a whole lot. The reliability of transit service can be defined differently from the passengers and operator's perspective. We have been always talking about

reliability in terms of passengers, what is the passenger's standpoint. Reliability is arriving at one destination on time and not having to wait too long at a stop or station for one transit vehicle to arrive.

So, reliability is that – every day if I come here at 9 AM I will get the bus number 246 for example. So that is reliable transit service from the point of view of a passenger or a user. From the point of view of a passenger any service should be reliable - the bus should come at the same time every day and it should take almost a similar time for me to reach my destination day after day. So, one day it takes 45 minutes the other day it takes me 25 minutes that is not reliability, then there is something seriously wrong in the operational condition of the buses.

So, it must take me similar amount of time every day well someday it takes me 31 minutes whereas someday it takes me 29 minutes that is fine. So, on an average I say that travel time on the public transportation is 30 minutes and that is reliable. So that is what from a user's point of view reliability means. Whereas from the operator's standpoint, reliability impacts the schedule recovery component of a cycle time.

So, what the operator is looking at is that a bus that has left one depot has to get back to that depot at a certain time. So there is a cycle time for the bus and if it maintains that cycle time and stops at all of the bus stops at the schedule time that is what is called reliability from the point of view of the operator. Otherwise what happens is the operator cannot run all the scheduled number of buses on that route then he/she will incur a lot of revenue losses for the day.

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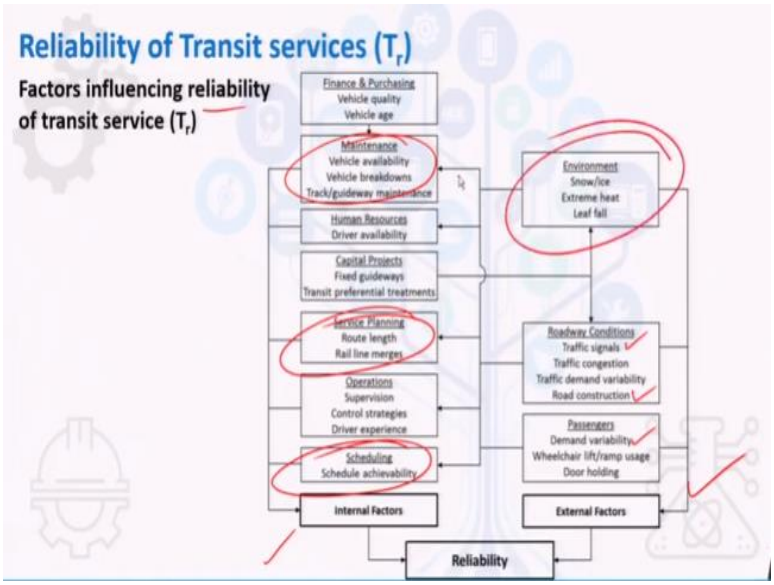

Again, if you want to look at the different types of factors that affect reliability - they can be internal and external factors. We have already looked at some of the external factors which could be traffic signals, passenger variability, ongoing road construction etc. Internal factors include if the vehicles are not maintained well, service planning is not very well, routes are too long, or the routes are not well designed, scheduling is not achieved, etc.

So, all of these are internal to the bus route scheduling, whereas for external factors environment may come into play as well.

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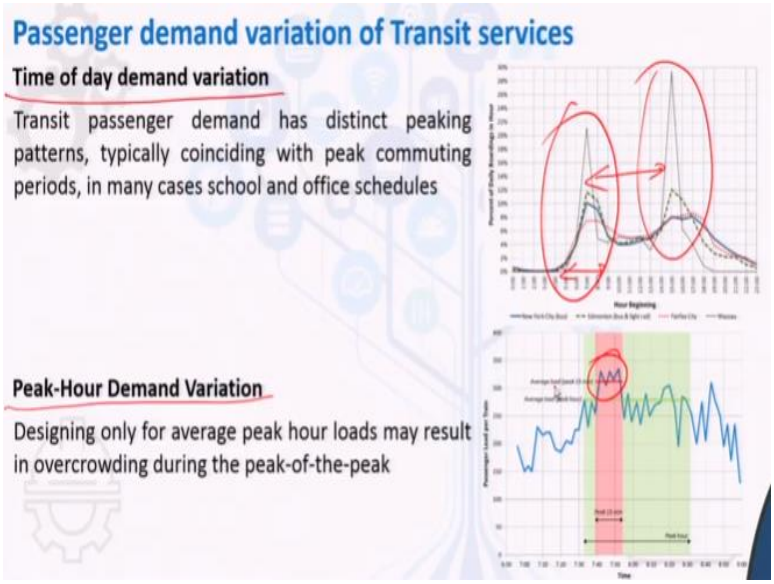

Then after knowing all these operator's operational characteristic such as passenger capacity vehicle capacity, transit speed reliability, we must know the characteristics of operation of public transit systems. There is always time of the day demand variation - during the peak hours, the demands are higher. So, you run public transport at a much lesser headway during those times.

Whereas during off-peak times you keep the headways longer, so that it also allows your operational cost to be stabilized, or to be maintained. There may be peak hour demand variation as well. There may be within the 4 hours of peak period, there may be certain "15 minute" there may be 1 or 2 "15 minute" peak period etc. So even within the peak time there are peak periods. For example, a peak time can be from 8 AM to 10 AM but the peak period within the peak hours may be 8.45 to 9.15 or something like that. So, we have to pay extra attention to detail when it comes to these operational factors in order to maximize revenue and minimize operating cost.

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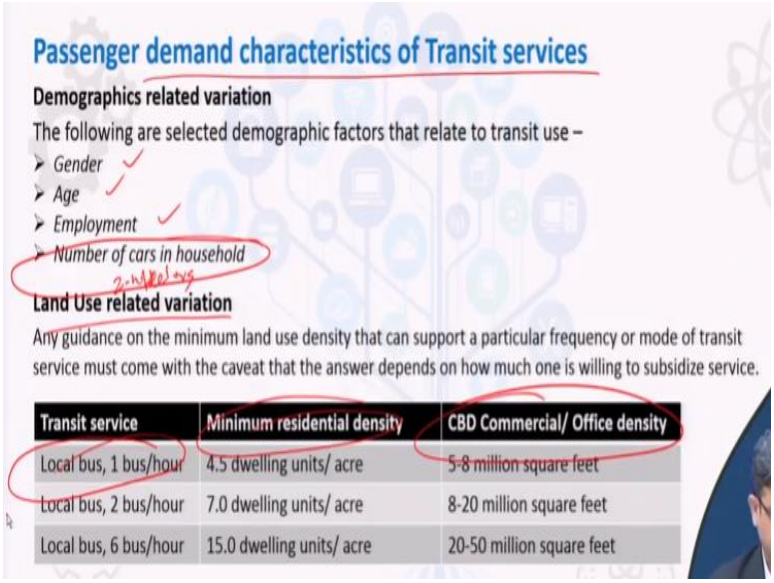

So, how does passenger demand characteristics vary when it comes to transit services? They vary by gender, age, employment, and one of the important factors is number of cars in household, number of cars or private vehicles in our case 2 wheelers as well. So, the minute you own a vehicle your tendency to use bus goes down.

So, the other is landuse, which also play an important role. It has been seen that if it is a CBD area and dense landuse area there you may need for higher bus frequency or the headway

between the buses need to be lower, whereas for the residential density or sub urban residential densities which are more spread out, there you can do by less number of buses per hour for example. So when you are operating your bus service or any public transportation service in your system, you have to take care of all of these things, you have to keep in mind all of these things and just not design a bus service based on some other cities characteristics or some best practices from somewhere else.

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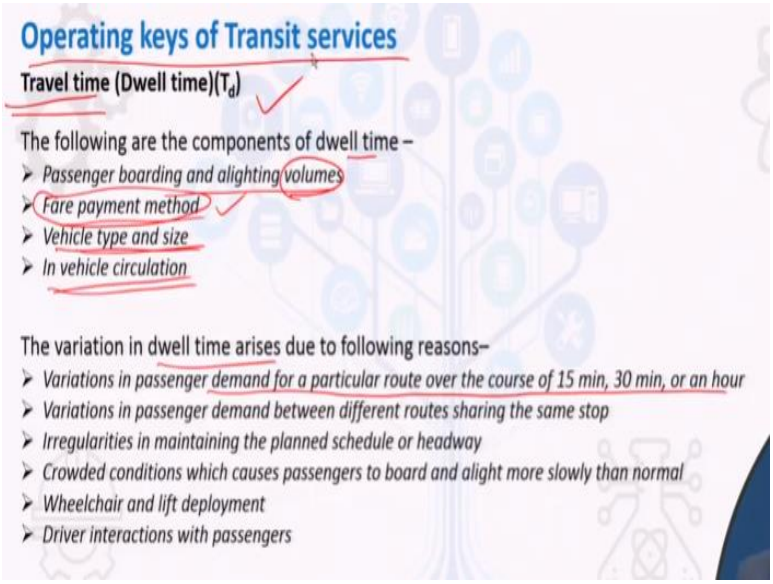

Let us investigate some of these operating keys of transit service, dwell time; dwell time is an important factor as we have already mentioned. There are 4 different components to the dwell time, i.e. passenger boarding and alighting volumes, fare payment method, vehicle size and type, and in-vehicle circulation.

All these impacts the dwell time at a station. For example, variation in passenger demand for a particular route over the course of 15, 20, 30 minutes that may cause the dwell times to rise. So, if you just understand dwell time which is the time that a bus or public transport a unit spends at a station or stop to board and alight passengers. So if the volumes of those boarding and alighting are high then the vehicle has to spend a longer amount of time sitting at that stop or idling at that station, it is not the word, idling may not be the right thing to use, but it is stationary. So, let us say it is stationary at the location.

Fare payment methods – if you insist that everybody pays as they are boarding then there will be a queue that is formed and everybody pays the conductor or an automatic fare machine or whoever it is at boarding time and so that may also increase the dwell time. However, if you have prepaid tickets that passenger already have with them, they just have to tap and go, so that reduces the dwell time, queues will be less and that is how fare payment method effect dwell time.

Vehicle type and size – For smaller vehicles, with a greater number of people using those vehicles, dwell time goes up. larger vehicles such as buses with two doors or sometime articulated buses with multiple doors allows you to reduce your dwell time. Vehicle circulation – if there are multiple vehicles on that route that are working, also helps reduce the dwell time as people know that there will be a next bus coming in 2 minutes' time. So, they would not want to keep the first bus waiting for a longer period. So, all these factors help in the or impacts the dwell time which in turn impacts the capacity of the public transportation system.

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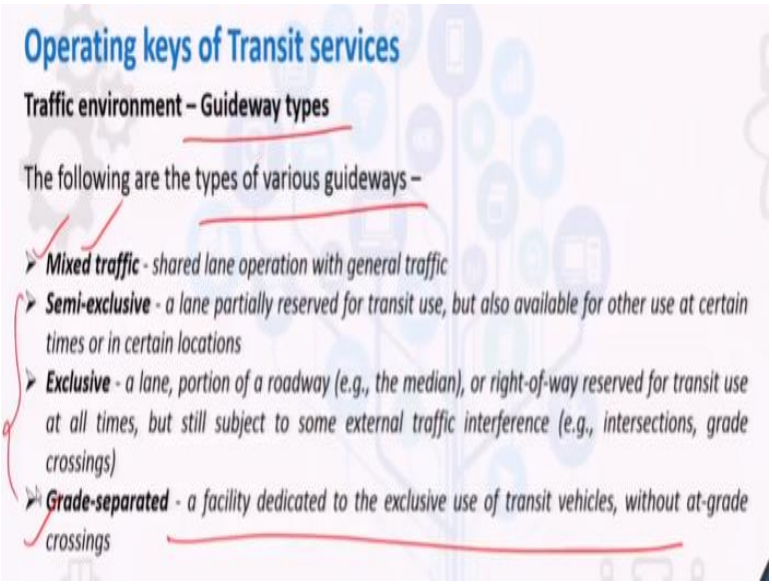

Different types of guideways also have an impact on transit services. If your transit is operating under mixed traffic conditions versus grade separated conditions, the impact will be different. This is something which although is expensive to build but it gives you lot of reliable services and a capacity that is much higher than if you are operating under mixed traffic conditions. The other conditions are somewhere in between these two extremes.

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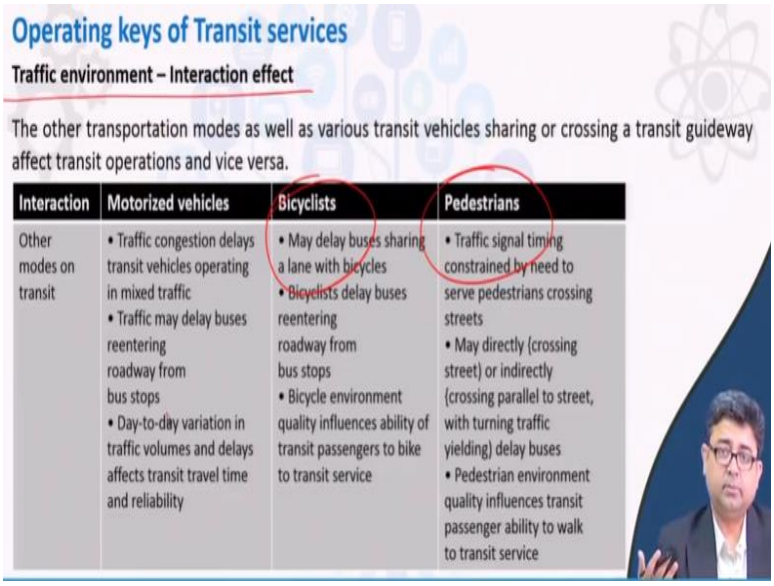

Also, the traffic environment and interaction impact, i.e. in mixed traffic you are interacting with different type of bicyclists, pedestrians, non-motorists' vehicle as well as motorized vehicles. Whereas if you are in a transit guideway or even just something that is separating your right of way from others, it may be still at-grade but it is just separating your right of way from the other traffic, then it helps you not only maintain speed but also helps to achieve higher capacities, so on and so forth.

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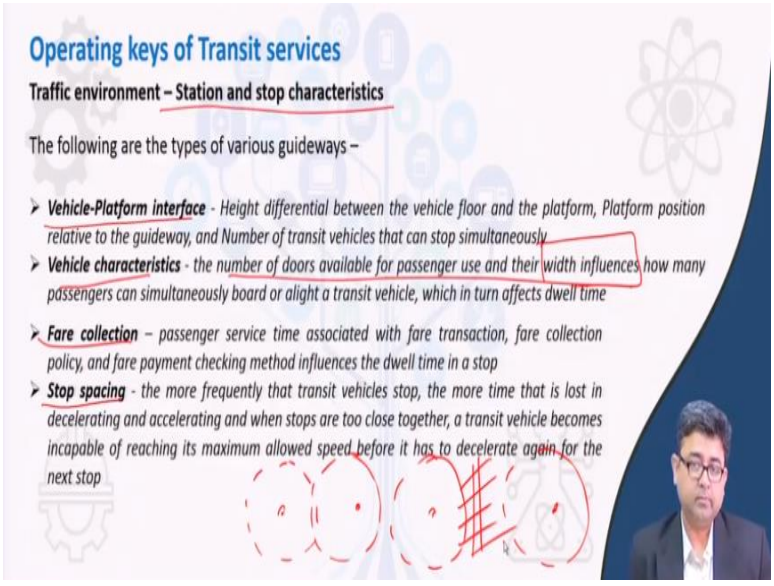

The next type of an environment that impact transit services are the stations or the stop characteristics. Sometimes you do not have a station, meaning where at least you have a

platform, stops means that if you have sign saying that this is the bus stop. So, these types also impact your transit services.

Vehicle platform interface -- if there is a station and there is difference between the height of the vehicle that you want to alight and board or disembark and your station surface, then that creates a problem. For different types of vehicle characteristics, or the number of doors available, we have already talked about number of doors, their widths also influences the capacity, the dwell time. Fare collection and stops spacing also have an impact on the dwell time. Like I said if the 2 stops are too close to each other, the number of people that may be accessing your public transportation system may be very good versus if the 2 stops are too far from each other then you may be losing out on all the people that are living in these kind of an area, and they may not use your public transportation system at all. So, stop spacing is also something that is very crucial to transit capacity as well as speed.

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So that bring us to the end of this lecture series.

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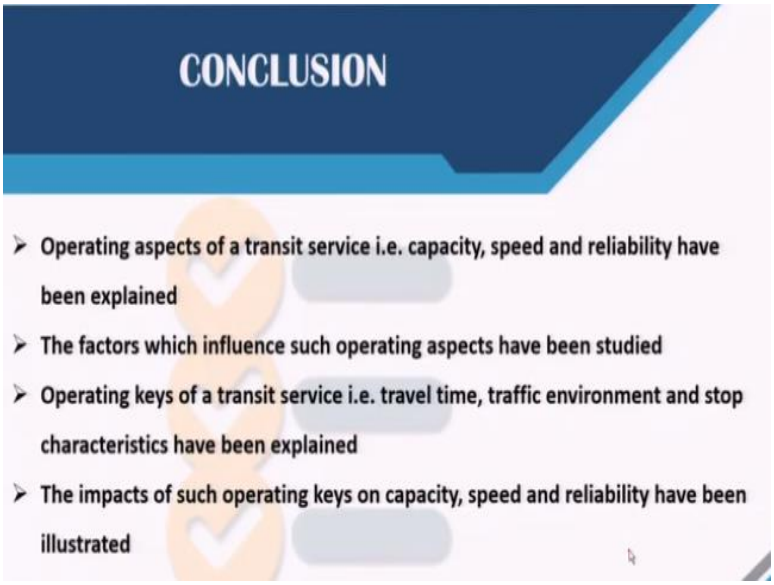

In this lecture what we have told you quickly about the basic aspects or a little more than the basic aspects on operational characteristics of transit; looking at transit capacities, speed, and reliability. Reliability is something that you must keep in mind, both from the user point of view as well as from the operator point of view. When you are talking about capacity, you must look at per person capacity, vehicle capacity as well as station capacity.

So all of these elements that you are now aware of, you have to consider the different factors that impact these aspects of transit service. One of the most important factors is the dwell time and we have given you an understanding of how dwell time impacts these capacities. So hopefully you are now well equipped to move forward into further understanding of how our transit operations happen. Thank you for your attention.