Introduction to Multimodal Urban Transportation Systems (MUTS)
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Module No # 02
Lecture No # 10
Public Transportation: Bus Transportation (contd.)

Hello friends. Welcome back to our lecture series on public transportation, specifically on bus transportation. So in the previous lecture, we introduced you to the different types of bus stops, buses, bus stop design, and bus stop location.

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And in this lecture we are going to now utilize all of that knowledge to introduce you to the bus service planning guidelines. So now we will introduce you to how to plan for a bus service with previous knowledge of what are the different types of buses, where the bus stops can be located, what is the spacing, so on and so forth. Finally, once we introduce you to a planning guidelines we will tell you what are the different types of performance indicators that are used to evaluate how well a bus service is operating, the different financial, quality of service, indicators.

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Okay so these are the 4 broad steps in which you can plan for the bus service. In order to plan for a bus service, you have to have a service pattern, you have to have service levels, you have to determine whether you need new routes and you also have to take care of passenger comfort and safety. So broadly the 4 steps in planning for a bus service are these, now we will look into individually what these 4 steps tells you.

So remember these are again guidelines. We will be going through specific examples of each of these but these guidelines have to be taken in and adapted for your local needs. So that is why they are called guidelines, they are not standards, so they are not a law or anything, that states that you will have to abide by, but these are guidelines.

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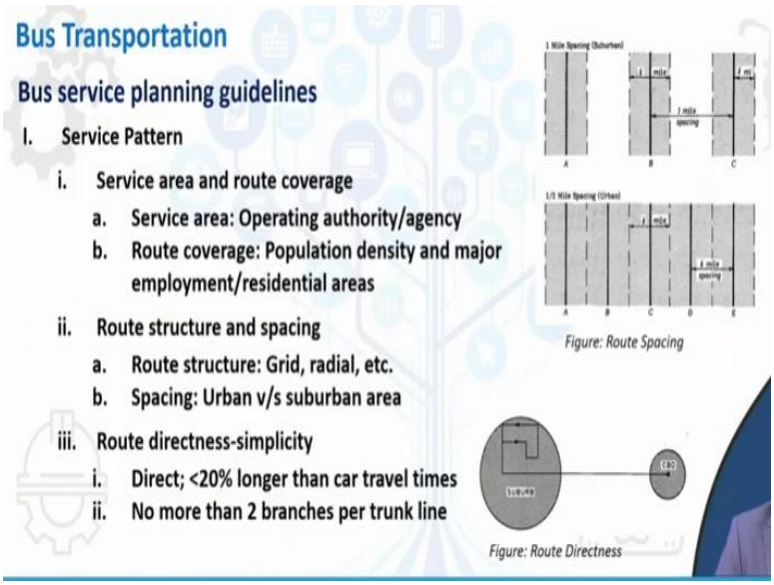

So the first one is service pattern, so what do we mean by service pattern? There are 5 different ways you can understand what we mean to say when we say service pattern. So the first thing is service area and route coverage. So in order to plan for bus service you have to know your service area so that you can coordinate between different operating agencies, authorities, and so on and so forth. Because your service route or service network may cross jurisdictional boundaries, municipal boundaries, and so on and so forth.

So you have to be aware of your service area for which we are introducing the bus service. Next the route coverage meaning -- what is the population density, what are the major employment centers, residential areas, etc. So you have to identify all thatbeforehand, before you start planning for your bus service. Because population density plays a huge role in this access of a bus route. If there is high population density the bus routes are usually successful; if it is low population density they are usually not that successful.

Successful meaning the benefit to cost ratio may not be that high and you have to understand where your major employment centers are, and major residential areas are, so that you can connect them efficiently. So that is the first item under service pattern, which is service area and route coverage. Next you have to understand what is the structure of the route and spacing?

So we have already looked at different route structures, such as ,radial, you may remember from the last class and now you have to understand which network or which route structure to pick,

that will be decided heavily by existing road network in the city but also at the same time by understanding where your population, how your population density is spread out in the city as well as your major employment and residential areas.

Then finally in the second step of route structure and spacing, you have to understand how widely or closely spaced your bus stops should be. So even we have learnt about this in the previous lecture. In the urban areas your spacing should be less because the population density is always higher in the urban areas whereas in the sub urban areas the population density may be lower and your spacing can be large.

The next think to plan for is route directness or simply route directness is measured in a way that any route should be less than 20% longer than a car travel time. Because your bus is direct competition to your private vehicle or car so the route that the bus takes should be no more than 20% greater than the car travel.

Because in the car you can travel point to point whereas in the bus cannot travel point to point so there is a leeway that is given, i.e. 20% higher travel times can be there on the bus but anything more than 20% usually you would see the people shift towards using their own private vehicles or cars. Also simplicity in the sense no more than 2 branches per trunk line so if you have trunk and feeder system do not make it so complex that each of the feeder system have multiple branches again.

So no more than 2 branches per trunk line is advised. You would see that this spacing of the route network are shown in the figure and also the route directness is shown. Route directness usually advises that all the circuitous connection should be closer to the residential areas or the sub urban areas rather than at the CBD, whereas in CBD it should, the route should go to 1 point and everybody should board or de-board from there.

And route spacing also, if it is a sub urban area it can be spaced as high as a mile apart whereas if it is very close to urban area, such as a CBD, usually routes are spaced much closer, less than a half mile apart.

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Next point to remember in this service pattern is route length. It is usually said that it should not exceed 25 mile per round trip or a 2-hour round trip. So when you are planning for any particular route it should be not greater than 2 hour round trip taking into consideration all the speeds and congestion on the route because if it becomes too long, it is difficult to maintain their schedule because of their operating conditions.

Then route duplication, i.e. 1 route per arterial, usually any arterial road should not have too many competing bus routes, then it becomes very difficult operationally. 1 route per arterial is something that is recommended in the guidelines. This can be however changed for different cities but you have to keep this in mind. So the guidelines are telling you that these are the points that you should keep in mind while planning for a bus route.

May be your city is so dense that you do require 2 routes per arterial because there are too many boardings, such as for example here also it is said that when you approach a CBD you may have multiple routes. But the points to be understood or kept in mind is that you have to understand or know about route duplication.

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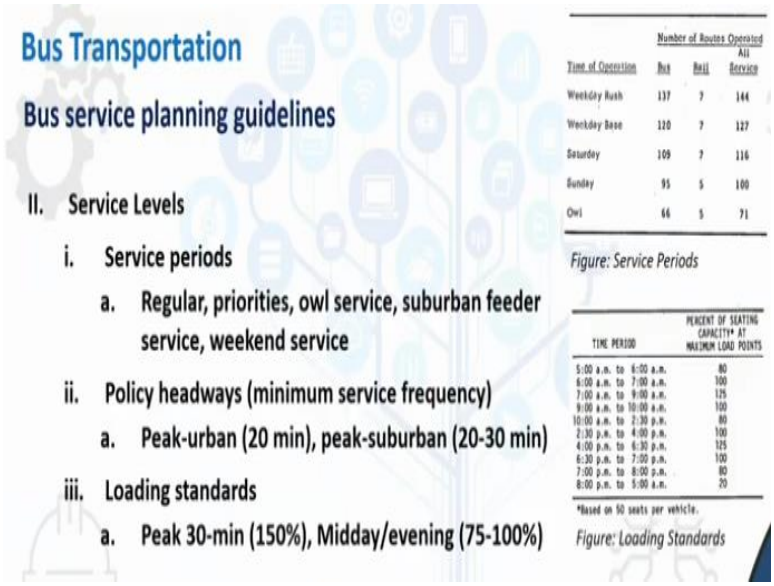

So that was all about service patterns. Now the next thing to remember while planning for a bus service is service levels. So what do we mean by service levels? Again there are 5 different points - first thing is service periods; so you should plan for different types of service periods. There are regular service periods that you plan for; there are night time service period, which are known as owl service period, then there are sub urban periods.

So when you are planning for your route you should not have to a 1 size fit all kind of a situation. You have to plan for different service periods. We have already introduced you to what are policy headways? So that is the minimum frequency, minimum service frequency that one should have, which is usually recommended that for peak urban period no more than 20 minutes between buses, that also seems to be very high.

Anyhow in our case, this is for 1 particular bus line or one particular bus route. Now it may that an arterial or collector may have multiple bus routes and so it may seem that the headway of the bus service is very high, but this is talking about one particular line. Then you have to plan for loading standards, what do we mean by loading standards? How many people are getting on and off of the bus and how many people are able to sit versus stand on the bus?

So you would say that usually it is recommended that in the peak 30 minute they should have 150% boarding's which means there may be lot of people standing in the bus as well. Whereas during midday and evening peak you would say that the loading standards are lower.

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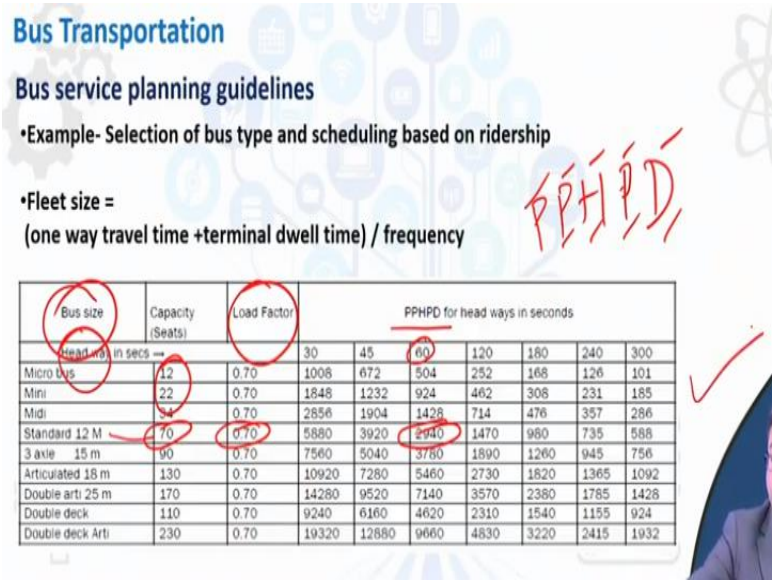

Bus size	Capacity (Seats)	Load Factor	PPHPD for head ways in seconds						
Head ways in secs →			30	45	60	120	180	240	300
Micro bus	12	0.70	1008	672	504	252	168	126	101
Mini	22	0.70	1848	1232	924	462	308	231	185
Midi	34	0.70	2856	1904	1428	714	476	357	286
Standard 12 M	70	0.70	5880	3920	2940	1470	980	735	588
3 axle 15 m	90	0.70	7560	5040	3780	1890	1260	945	756
Articulated 18 m	130	0.70	10920	7280	5460	2730	1820	1365	1092
Double arti 25 m	170	0.70	14280	9520	7140	3570	2380	1785	1428
Double deck	110	0.70	9240	6160	4620	2310	1540	1155	924
Double deck Arti	230	0.70	19320	12880	9660	4830	3220	2415	1932

So this is an example of how you would design for a fleet size depending on loading factor and the bus size. So if you know the bus size, and if you know the headway, and if you know what type of bus, as in what is its capacity, then you could say how many passengers per hour per direction. So PPHPD is passenger per hour per direction. so how many passengers can a standard bus that has 70 seats. with loading factor of 70% and say has a headway of 60 seconds, transport?

So every minute a bus comes then you can have 2940, approximately 3000 passengers per hour per direction. So that is gives you an idea of how you can plan for your bus service.

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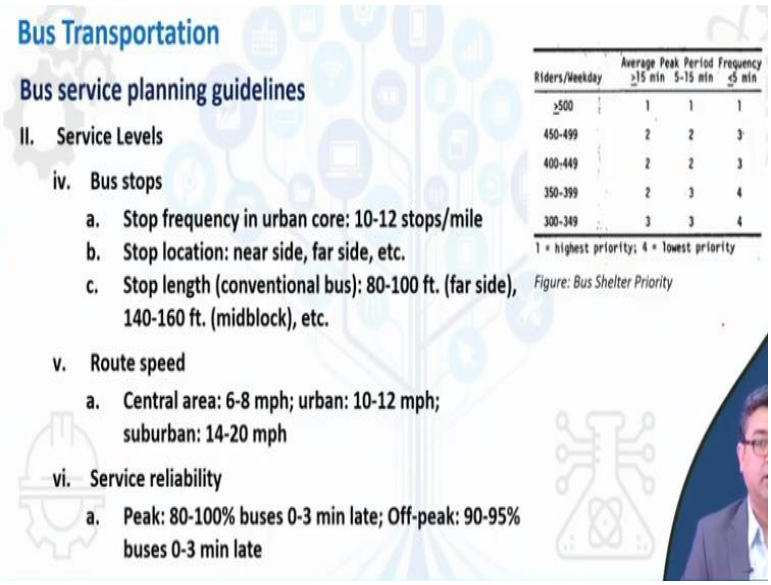

The next thing to remember in service levels is about bus stops. Now we have already introduced you to different types of bus stops, i.e. bus stop frequency or spacing between bus stops. So you have to keep all those in mind when you are planning for your bus service in your particular city. Next thing to remember is route speed. Usually we would see that route speed changes, i.e. increases as you go from CBD to the sub urban areas, and some general patterns are given here.

The last thing to remember is service reliability. Now this is something that many passengers who want to take buses are always weary about, i.e. that the services is not reliable. So you may set some reliability standards and check them from time to time. For example, in during peak period it is said that 80 to 100% of the buses should be no more than 3 minute late. So that gives you have a very good a service reliability.

Whereas during off peak you can say that little bit more number of buses can be late because it is an off peak time. These are again, please remember, these are guidelines which you may change according to your needs of the city.

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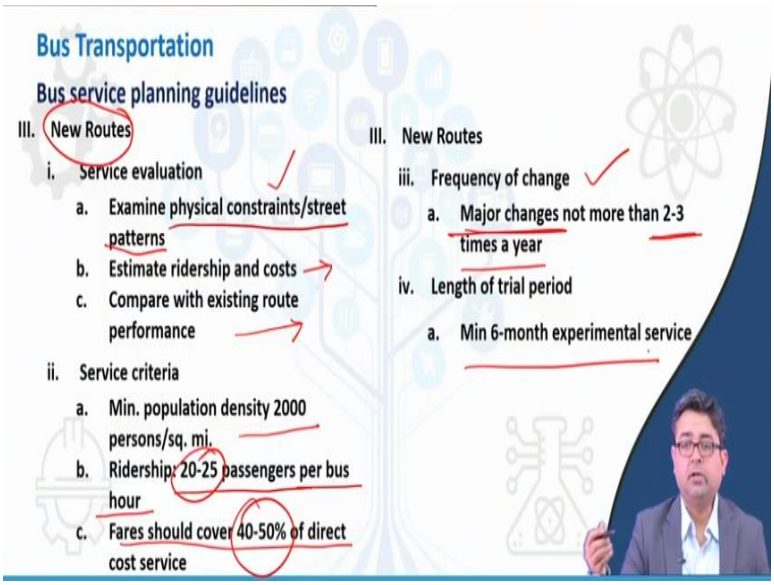

The next thing to remember in service planning is to how to incorporate new routes. So all the time there will be requirements from different types of organization, citizens, politicians that please add a service to this new area, please increase the frequency of buses, etc. So when you are trying to plan for such new routes, how do you plan for them? You first have to evaluate, then have to set some service criteria, and then have to look for a minimum experimental time period during which you will put the service and see how well it is doing okay.

So you have to look at physical constraint / street patterns. When you trying to add a new route we need to see if the street can accommodate your fleet of buses. You have may be, you have large articulated buses and these streets are narrow so the buses cannot turn easily those routes. In that case you have to look for smaller buses. So that is the point made here. You have to then estimate ridership, and cost of course, everybody needs it.

But can the demand support your cost and then you have to compare it against existing performance. Usually what the guidelines says is that you have to have a minimum population density of 2000 people per square mile, and the ridership at least be 20 to 25 passengers per bus hour. Bus hour meaning, the hours that the bus operates on average. Every hour there should be at least 20 to 25 passengers and their direct fair should cover about 50% of your service cost.

So if the fares are not covering 50%, that means the demand is not enough, or the population density is not enough to give you a new routes. However, something to remember is that you

should not very often make changes to bus routes; it is usually said that no more than 2 to 3 times a year major changes should be made. Minor changes are fine, but major changes like adding new routes, the frequency, may not be done much and always have experimental time period during which you are testing out this new service to see if it is working out; if not, it has to be reverted back.

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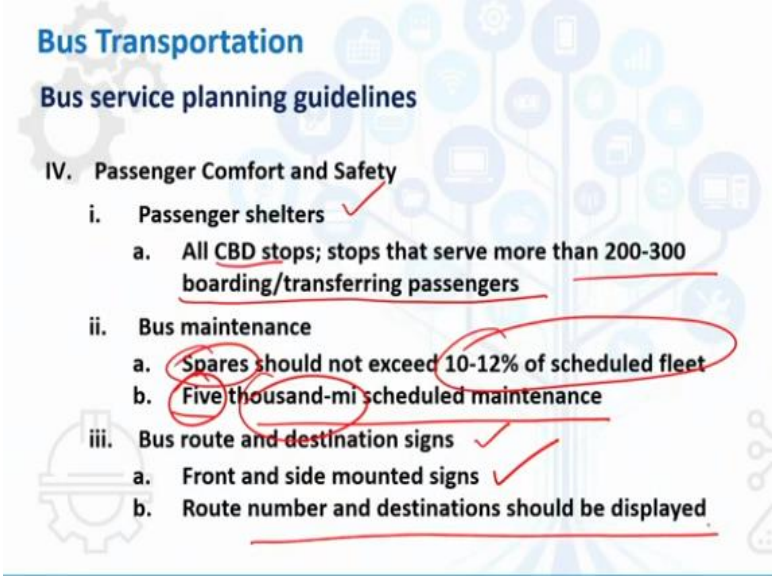

Finally, you have to look at passenger comfort and safety. When it comes to passenger comfort and safety there are several items that one has to plan for. For example, passenger shelters. So do you need a shelter and benches at your bus stops? Usually what is recommended is that if the stops serves more than 200 to 300 boarding or transferring passengers you need passenger shelter, and all CBD stops need passenger shelters.

What is the schedule for bus maintenance? It is said that the spare buses should not exceed 10 to 12% of your scheduled fleet. So you should not have more than 10% of buses that are just spares because you think that maintenance will be required and this will be used. So if you have more than 10 to 12% then you are actually not efficiently managing your bus system. And there should always be, the other guideline is there should be at least 5 1000-mile scheduled maintenance.

So these are schedule maintenance, not maintenance that are generated out of wear and tear, but these are schedule maintenance so there should be at least 5 of them per 1000 miles driven. What about bus route and designation signs? Many a times people standing at the bus stop do not know

what or how many routes are being served bythe bus stop, especially if you new to the area or new to the city, you do not have much information and it is problematic, as the bus network may or may not have a website or something like that, which people can check.

So always have a sign at the bus stop at least showing the route number and the destinations that bus stop is serving.

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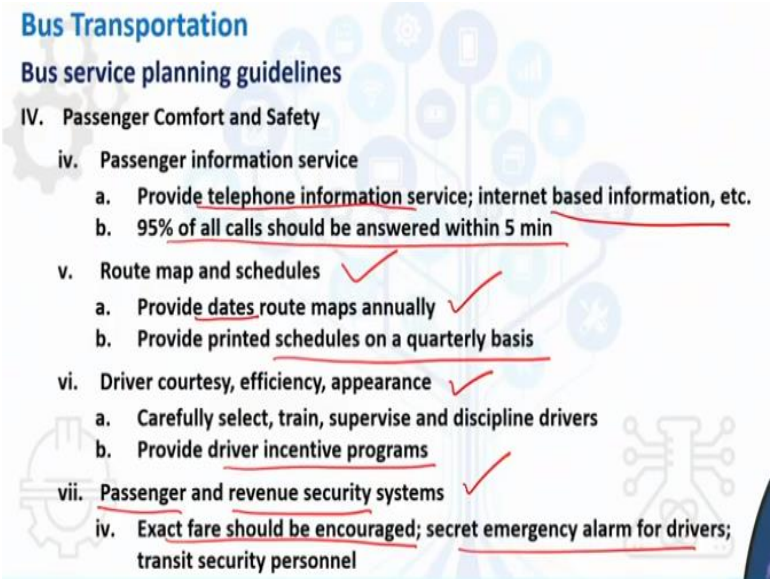

Passenger information service, like I said, at least there should be internet based information and also for people who do not, or are not internet savvy, they should at least have a telephone information system available that can tell you, or a person can tell you when is the next bus, what are the schedule of the bus, and these are standards that you can have differently for different agencies. This is an example that says that 95% of all the telephone calls should be answered within 5 minutes.

So, if you have standards like that then you can always compare against it and see whether your bus service is doing well or not. Always have route maps and schedules and always date them because if you are changing or adding schedules or changing rules are adding new lines, people can be misguided by something that you have printed earlier or something you have on the net, which is older.

So always have a date on your route maps and try to have at least one a year printed; schedule should be always printed with more frequency because you may have schedule changes more frequently. Driver courtesy is something that has to be trained; good training has to be given to drivers as well as incentive programs have to be developed. Because if the drivers do not have enough incentive it becomes very difficult to run a bus service, say for example during the weekend, or during the night time.

So they have to have some incentive programs and lastly there has to be good security systems on the buses for both passengers as well as revenue collection because you know the buses may collect a lot of money that is prone to theft sometime. So exact fare should be encouraged and this is why many bus systems are now moving towards fare cards rather than dealing with cash because people do not have exact change that makes boarding alighting very difficult.

There are other safety features such as emergency alarms and security personnel at the bus stops or transit stations.

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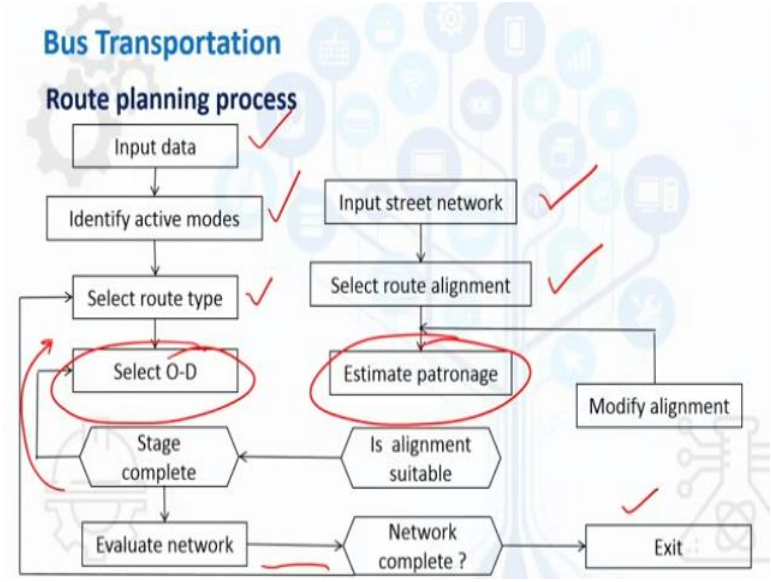

So those are broadly the 4 steps that you have to remember or take into account while you are planning for your bus service in your city. This kind of flow chart while gives you the same information. So you input all the data that you have planned about bus stops, types of buses, and everything, to identify what other modes are running on the route, you select a route type, you

know your existing street network, you know your route alignment; on which streets your bus would run.

Based on that you would estimate how many people would ride your buses. You know your origins and destinations, and if your alignment is suitable, then you evaluate your network and that is it. If your alignment is not suitable then again you go back and select new routes and redesign the network. This is kind of a snap shot of how do you do the route planning process.

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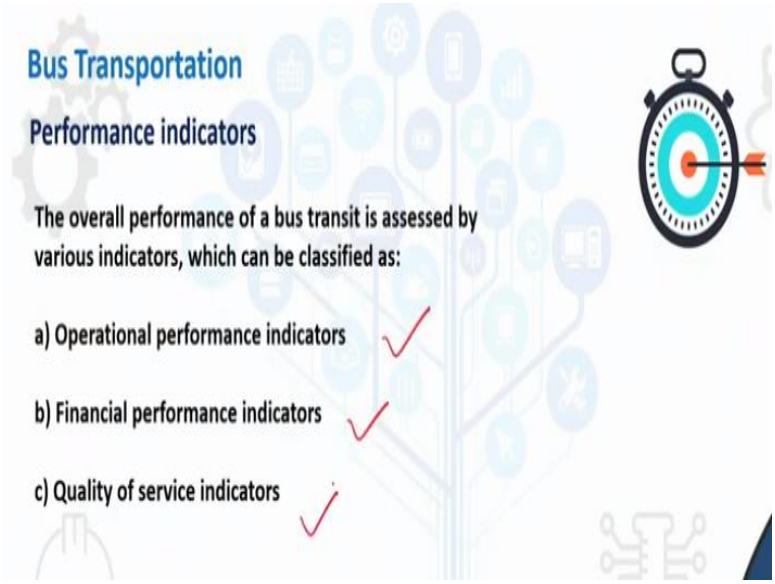

Finally, once you have a route in place you have to have certain performance indicators that you can measure to know how well the route is doing. So there are usually 3 different types of performance indicators that we look at -- one is operational, another is financial, and one is quality of service.

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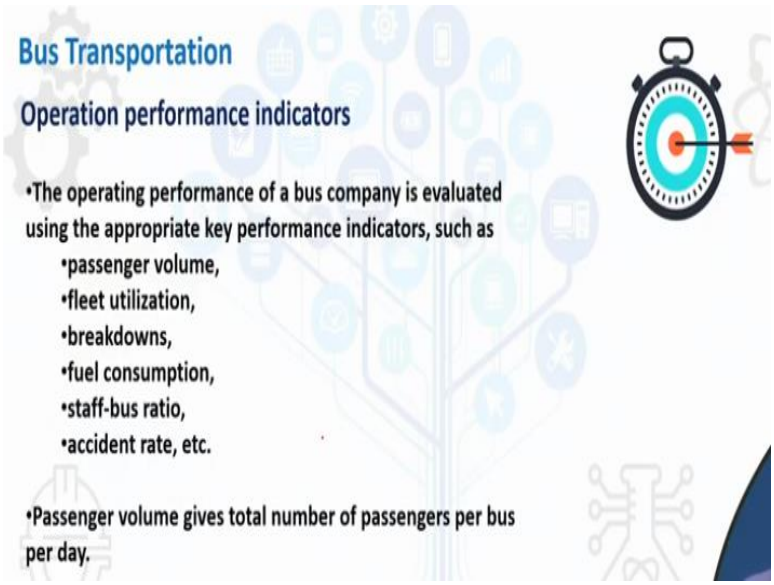

Operational performance indicator involves passenger volume, fleet utilization, break downs, fuel consumption, staff to bus ratio, and accident rate also. So these are all very self-explanatory and are explained in these slides. So passenger volume you have to, or you want to know, how many total number of passenger per bus per day your system is carrying. If they are doing well that means and your collecting enough revenues, then you are doing pretty well as a service.

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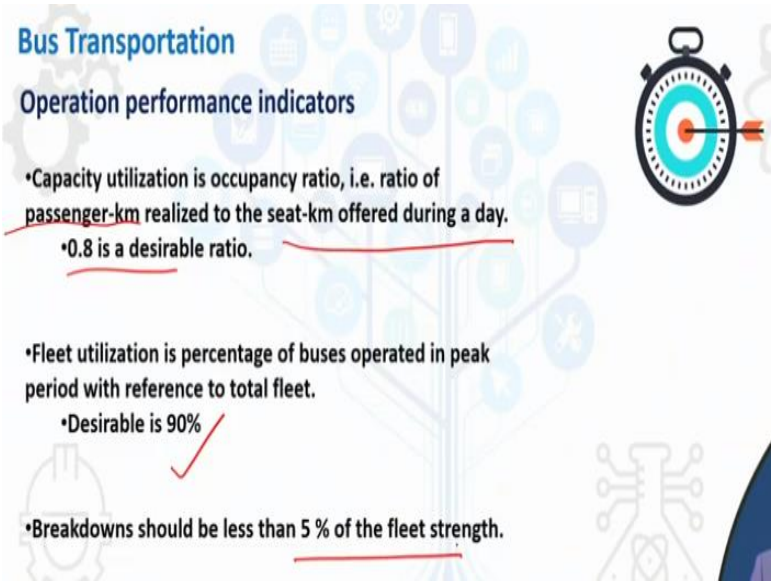

Capacity utilization is occupancy ratio, that is the ratio of passenger kilometers realized to the seat kilometers offered. So you may have lot of seats available that means your fleet may be large but there are not many passengers that are using those seats to travel longer distances or

travel distances. So remember passenger kilometer does not only mean passengers, it means how long a passenger travels; \passenger – kilometer, okay.

0.8 is the ratio that is desirable. These are again guidelines, desired guidelines which you can set for your own bus system. Fleet utilization is percentage of buses operated in peak period with reference to the total fleet. The peak period usually you say that 90% of buses should be at least utilized otherwise the fleet is too less. Breakdowns should be less than 5% of the fleet strength; many buses should not be breaking down.

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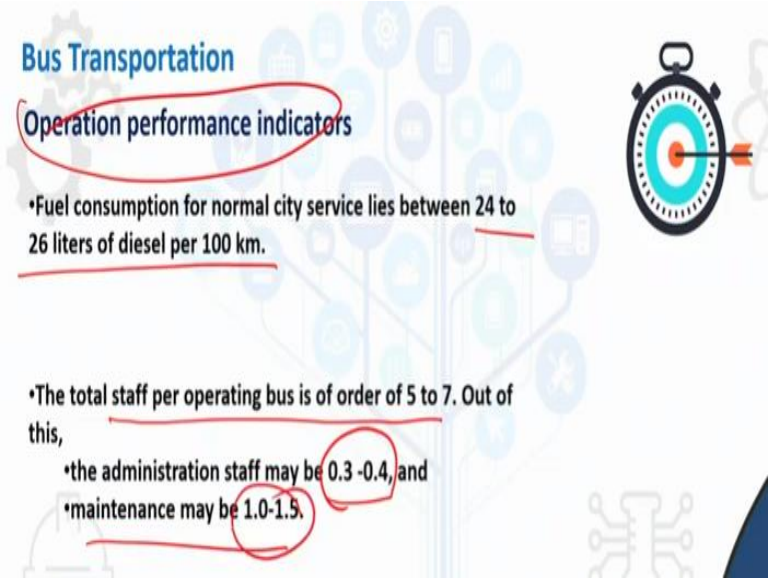

These are all the operation performance indicators, fuel consumption -- for normal city this lies between 24 to 26 liters of diesel per 100 kilometers. Again you can set your own consumption limits but this is based on data from several cities that are collected. Total staff per operating bus is a very important ratio because you have lot of people involved in operating a bus system.

So this is usually said that the administrative staff should be only around 0.3 to 0.4 per operating bus that means for almost 2 buses you can have 1 administrative staff whereas maintenance staff you have to have a bit more okay 1 to 1 and half.

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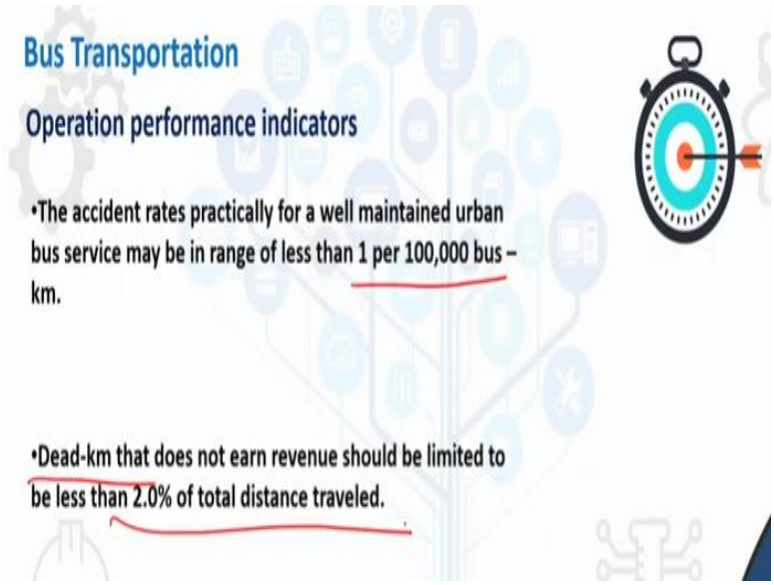

The accident rates are usually very less for buses; usually 1 accident per 1,00,000 bus kilometers. So that is why bus is one of the safest mode to travel. And also the dead kilometer should be very less, less than 2% of the total distance travelled. Remember the dead kilometers meaning the kilometers that the bus runs when there are no passengers on the bus.

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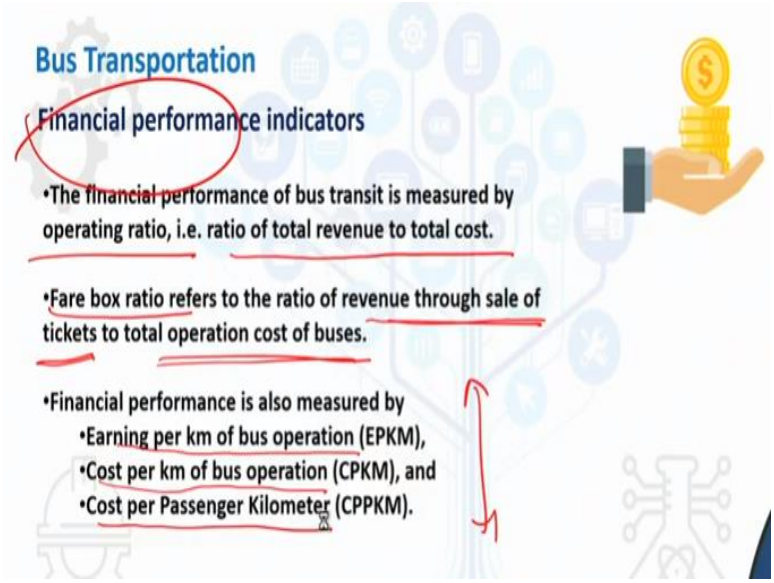

Financial -- moving on to financial performance indicators, you would see that the first performance indicator is operating ratio, which is the ratio of total revenue to total cost. That is easy to understand how much you have collected as fair revenue versus how much cost is incurred to run the service. The next is fair box ratio, it is the ratio of revenue through sale of tickets to total operating cost of buses.

So sometimes you get revenues through non-sale of tickets as well, for example you may get revenues through advertising on the bus. You will see lot of advertisements pasted on the bus so you may get revenue through that whereas fair box ratio tells you how much revenue you get through sale of tickets to the total operating cost of buses. Similarly, there are other financial performance indicators which are easy to measure, i.e. earnings per kilometer of bus operation, cost per kilometer of bus operation, and cost per passenger kilometer. So these are again different indicators that are used to understand how well your bus service is performing.

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Lastly, quality of service performance indicators -- this takes into consideration, these performance indicators takes into consideration what the public thinks about your bus service. So there are different quality of services that are measure -- well people are asked, or the public is asked what do they think about passenger waiting time, what do they think about walking distance to the bus stop, journey time, if they need to interchange between routes, and the affordability and reliability.

So these are different indicators that tell you how well people perceive that the bus service is doing.

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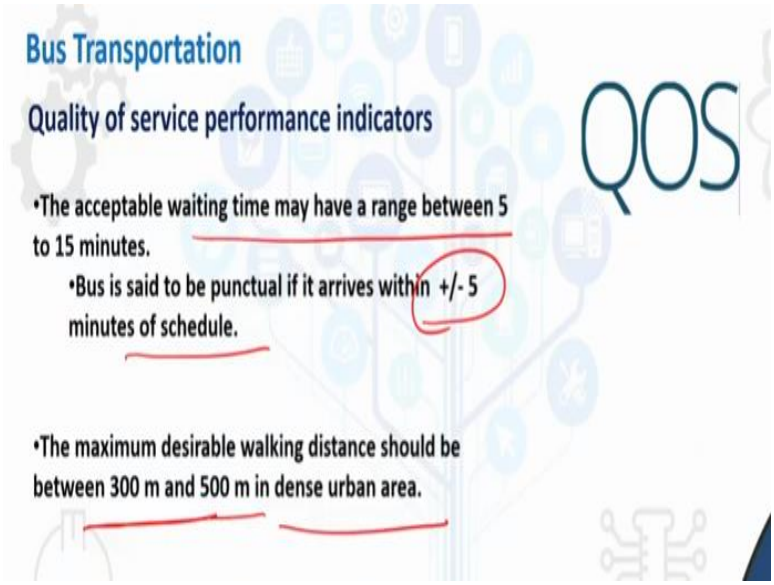

So the acceptable waiting time for example has a range between 5 to 15 minutes. A bus is said to be punctual if it arrives within plus or minus 5 minutes of the schedule. So this is what people perceive right if the bus is more than 5 minutes is delayed people perceive that the quality of service is not good. Maximum walking desirable distance is no more than 300 to 500 meters in dense urban areas. So we have seen that already that this can be helped by bus stops spacing.

So if the bus stops are spaced very close to each other in the urban areas, in the dense urban areas, then people would have to walk very less and they would then rate the quality of the system very high.

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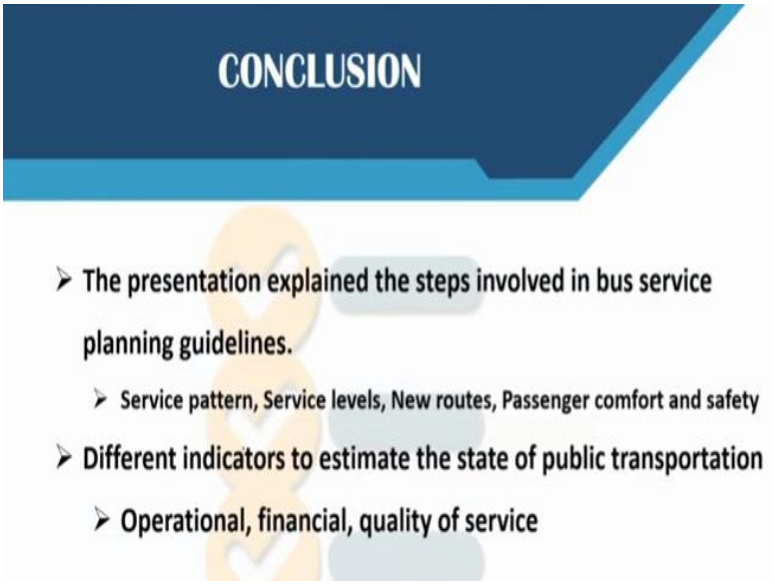

So that concludes this lecture. In this lecture, we have shown you the different steps that are involved in bus service planning guidelines. They are essentially service patterns or service levels, new routes, and passenger comfort and safety, and we have also introduced you to different performance indicators that allow you to test how well your service is doing. There are operational, financial, and quality of service performance indicators.

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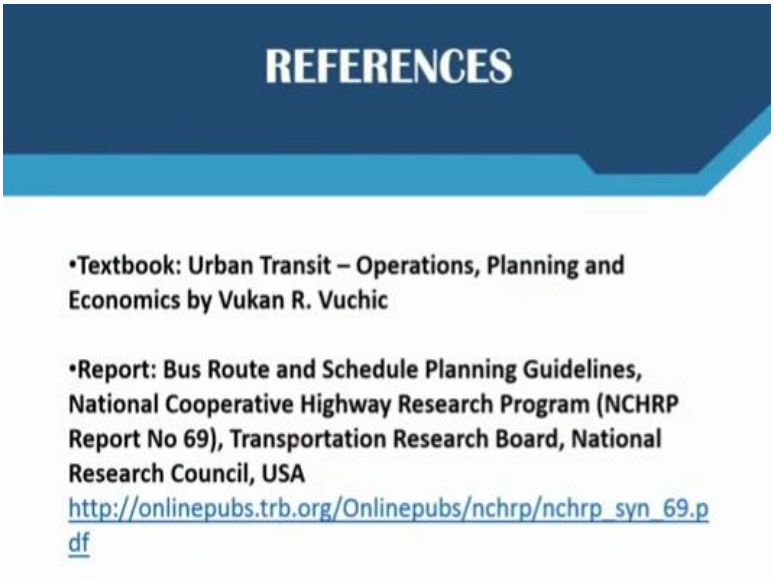

These are some references, along with the textbook. Some material is taken from a research report which is available freely online and can be downloaded. Thank you very much for your time.