Introduction to Multimodal Urban Transportation Systems (MUTS)

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Module No # 11

Lecture No # 52

Urban Transport & Sustainability: Multimodal Level of Service (MMLOS)

Welcome back my dear friends so in the previous lecture we looked at concepts of multimodal level of service. And we looked at multimodal level of service from the point of view of public transportation.

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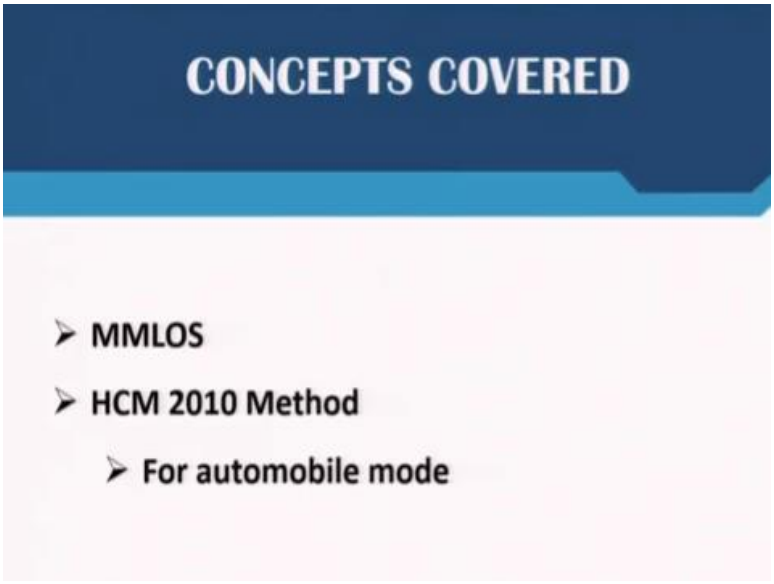

In this lecture what we will go ahead and continue our series in multimodal level of service and look at how you develop it for the automobile mode. Now remember we are developing multimodal level of service but we are still looking at the modes individually. However under the umbrella of multimodal level of service by the end of the next lecture you would see that we would combine all of these levels of service for different modes. We will combine it for one segment and have for that segment there will be multiple levels of service representing each of the modes. So first we look at individual modes. Last class we looked from the point of view of

public transportation. Today we will look at it from the point of view of automobile or your personal vehicle.

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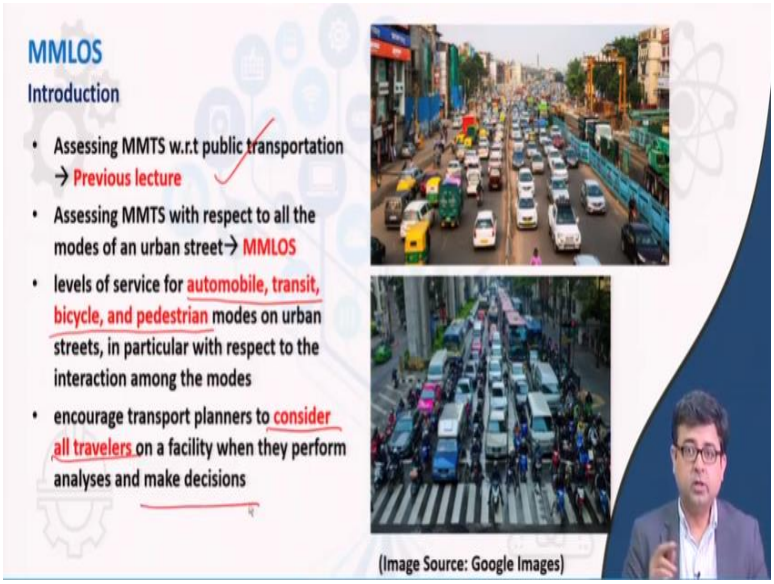

So like I said we already looked at public transportation and now when we are talking about an urban street there are multiple modes that are operating on urban street right. There may be automobile there may be public transportation there may be bicycle or pedestrian. So it is unfair to only develop a level of service for one particular mode on that street. And historically that was we have been keeping on doing is that the entire street is represented by one level of service and that level of service is skewed towards the motorized vehicles. It is not skewed towards the car per se it is skewed towards the motorized vehicle so when we usually use level of service of automobiles it is a motorized vehicle. But now since we are moving into the concept of multimodal transportation we have to develop level of service keeping multiple modes in view. So this is what we are doing now. We are considering all the travellers on a facility when we perform analysis for decision making. For now only looking at, it in the point of view of one mode.

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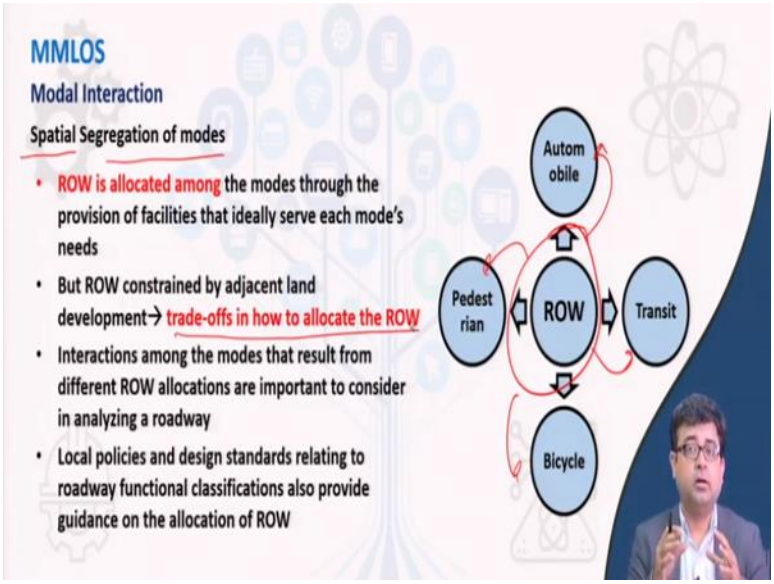

So when we try to do that we can develop a level of service in 2 different ways. We can either develop level of service when there is spatial segregation of modes. For example there is right of way and it is divided for automobiles, pedestrians, bicycles and transit. Maybe a single piece of right of way has dedicated rights of way within itself for different modes. So that is fully segregated when you can develop a level of service and there is this type of segregation between different modes. The tradeoff would be then, how much of space to give? Or how much of right of way to give to each of these modes. Depending upon the space you give, it can have a different carrying capacity and different accessibility. So all of that will then decide the level of service. We can then decide by one of these parameters what right of way that is to be allocated. So that is a how you can develop a level of service when there are multiple modes but they are segregated spatially.

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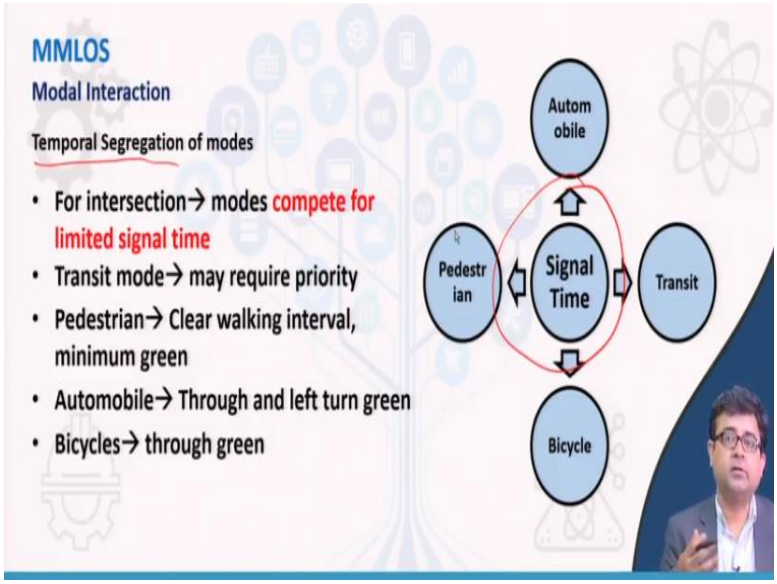

Or you can also develop the level of service when they are temporarily segregated. A temporarily segregated at one point in time means only few modes can access that facility. For example if you at a signalized intersection when you have green for motorized vehicles you will have red for say pedestrians and non-motorized vehicles. So then you are segregating the modes based on time. During this time only these vehicles will move during the other time only those modes will move. So that is called temporal segregation of modes so you can have a level of service based on temporal segregation as well.

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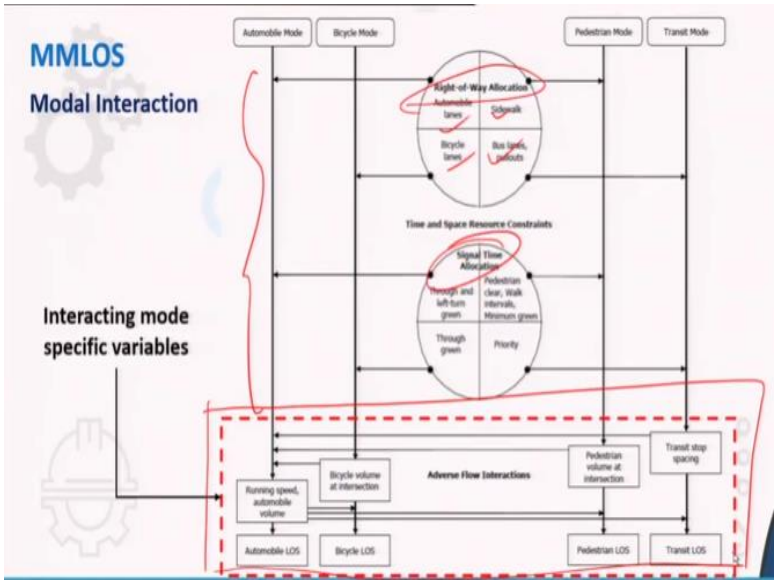

So if you combine these two in this picture, then you can say that usually the along links you can develop level of service based on spatial segregation i.e., when you will have different right of way for different modes. Whereas at certain intersections you can have level of service based on what time multiple modes can move. Whether at a green time only one mode can move or multiple mode can move and then based on how much time they get, the level of service can be determined. So that is what you can do, one or the other. But there are several occasions when there is interaction between all of these modes. Now a typical case would be an un-signalized intersection. You would at a signalized intersection do a temporal segregation. But an un-signalized intersection you are bound to have interaction between various modes because based on personal judgment a cycle may decide to turn left. Whereas there may be a through vehicle coming and then may be an interaction between the two. So may be the cycle has to stop or yield at the vehicle. Thus based on those interactions there may be a level of service that could be developed. Many a times on our streets we see due to the lack of pedestrian facilities they walk on the right of way on the pavement. Then there is interaction between the vehicular movement and the pedestrian movement. We can develop a level of service for that type of situation as well. So there are multiple ways in which you can develop a multimodal level of service and that is the beauty of actual multimodal level of service. Now you can cater for the interaction as well as the spatial or temporal segregation between these modes you can keep in mind those things and then develop a level of service.

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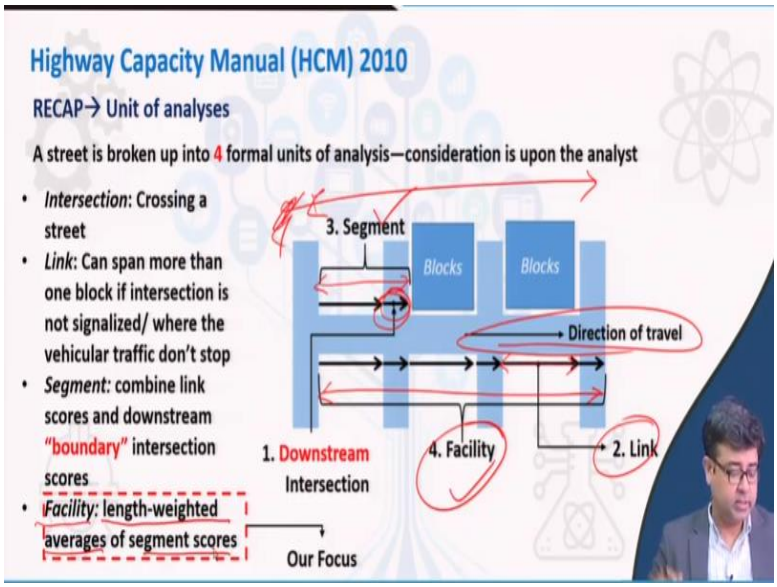

So if you recall we have already gone through this concept of dividing up a facility or a road way segment into various small little chunks. When we have developed the level of service for bicycle or for pedestrians this is how you showed you. So if you quickly look at it and if you think that the direction of travel is this way, then this entire thing would be the facility. I means from here onwards. So this entire thing would be the facility whereas this facility is divided up into various segments and these would be the segments. The segment would include the intersection. That would be segment. Whereas if you do not include the intersection only this distance, that would be a link. If you consider the link plus the intersection that is the segment and if you consider the multiple segments that is the facility. Now what usually multimodal level of service does is it breaks up a facility into different segments but not into different links. So the segment in turn is broken up into a link and an intersection. So what happens is you develop a level of service for the link and the intersection it can be aggregated up to the segment. And then have level of service of each of the segments aggregated up to the level of service of the facility. So that is the entire idea and you do that for all of the modes. Here first we are going to start showing you with the automobile mode and then it will be the same process followed for the bicycle, pedestrian and transit modes. But the variables would be different in each of the different cases. What is the entire concept of developing a multimodal level of service for one facility? Essentially what happens is the facility would be length weighted average of the segments score. So each segment will get a level of service score and then for the entire facility you will weight it by length. One segment length maybe longer while another maybe shorter so you weight by the segment length and the aggregated up for all the segment into developing the level of service for the entire facility.

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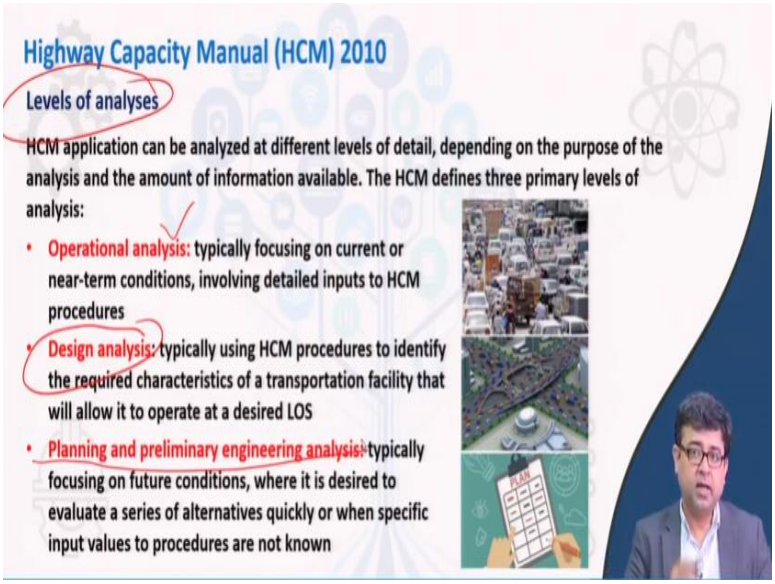

You can also do different levels of analysis for level of service. You can either do an operational analysis of an existing roadway which is open for traffic has been operating for the last 10, 20, 50 years. Or you can develop MMLOS for the design stage as well. When you are actually designing a new road or you are designing a widening of an existing road so you can see how the MMLOS would be when you add a lane for example. Or when you convert a signalized un-signalized section into a signalized intersection what happens to the MMLOS. You can do at the design stage as well. And obviously you can do it at a very planning stage or a preliminary engineering stage however at that point you would not have the data because it is still at a planning stage. You would have to get data from similar facilities elsewhere and then predict that this is what likely to happen when you would design or operate a facility of this magnitude. So you can develop levels of service at different times of operations from planning to design to actual operation stage as well.

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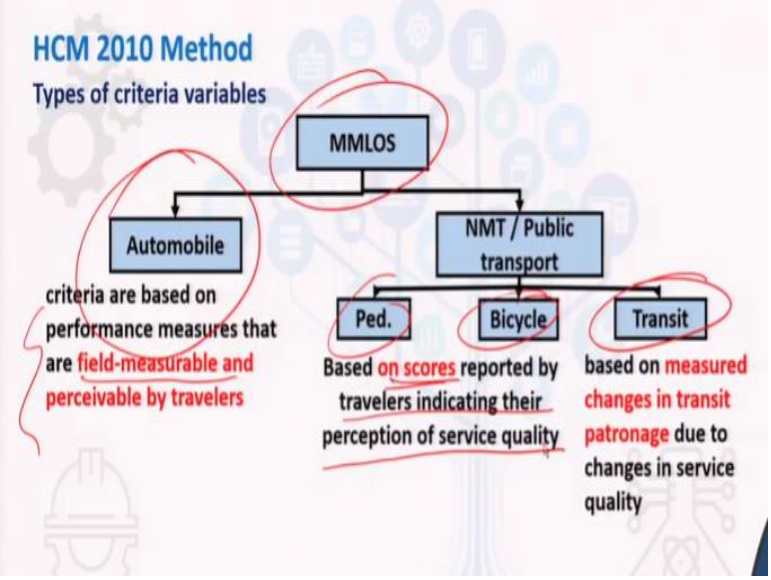

So this is how you can conceptually develop the MMLOS. Although it is looking at the levels of service of all the modes but the automobile modes still stands out because of the measures of the variable that are used in developing the level of service. They still are measures that can be observed in the field so using those kinds of parameters this level of service is developed. Whereas the level of service for pedestrians, bicycle and transit are based on scores that are reported by travelers indicating that perception of service quality. So the levels of service of pedestrian, bicycle and transit or still based on the perception of the users whereas the level of service of an automobile mode is based on actual field measureable parameters. Such as speed, delay and so on and so forth. So this is how you can conceptually think of a how they are different from each other. Although for one street we are going to develop multimodal level of service for each of these modes.

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Here is an example based on the highway capacity manual 2010 which is developed in the US. You would see that a street's automobile level of service have these A to F scale which is common for all of the modes but then what you would have is different definitions for LOS A for different modes. For example an automobile level of service A would be no delay at an intersection whereas for a transit level of service or quality of service A would be more frequent stop and amenities. So a difference can be understood how level of service is calculated for the transit versus the automobile on the same street segment which has signalized intersection and a bus stop in the segment. Now you can develop a level of service differently for different modes. Similarly a bicycle quality of service A would correspond to complete system for all types of user. Based on it may not be only for experienced bicyclist but also for kids, toddlers and for leisure bicyclist. So, a bicycle facility that is good for everybody is at level of service A when you look at it from the point of view of bicyclist. And then finally when you look at it from the point of view of pedestrians, LOS A would be something like a complete system easier to access, easier to cross, improved comfort, etc. So you see that these 3 are perception oriented, and pedestrian being the most perception oriented. Whereas, automobile is more based on field measureable values, like you can measure delay at an intersection. If it is a signalized intersection the delay is essentially the red time for which you have to wait until there is no queue. But if it is an un-signalized intersection, then maybe if you are at a minor street you delay is different as opposed to if you are at a major street. So that is how these levels of service

conceptually look like it is easy to understand if you see these pictures and compare them side by side. Then you know what an LOS A versus what an LOS F is? We just look through the A descriptions you can similarly go through the LOS F descriptions.

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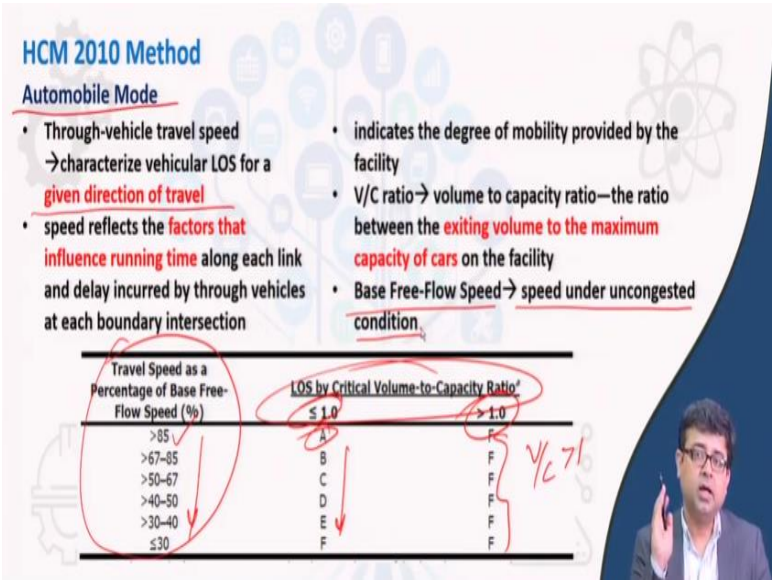

Now when you start looking at the automobile mode we have already given you a brief understanding in the beginning of the class the level of service of an automobile mode are dependent upon speed and especially what speed is it. It is the travel speed as a percentage of base free flow speed. If you know the base free flow speed for that segment and now if you measure the actual travel speed on that segment what percentage is that actual speed of the base free flow speed. If it is greater than 85% and if the V / C ratio is less than 1 then it is level of service A and as the percentage decreases the level of service falls. Of course if V /C ratio is greater than 1 then the entire segment is a level of service F. So that is usually how you measure level of service for automobile modes. What you have to careful about is that, given the direction of travel if it is the divided street segment then you have to develop a level of service for each direction and not develop one level of service for the entire facility. However, it is undivided segment then you can sometimes have only one level of service for the entire facility. Base free flow speed from a recall it is a speed under uncongested conditions right when there is no congestion the speed at which can vehicles can go that is the base free flow speed.

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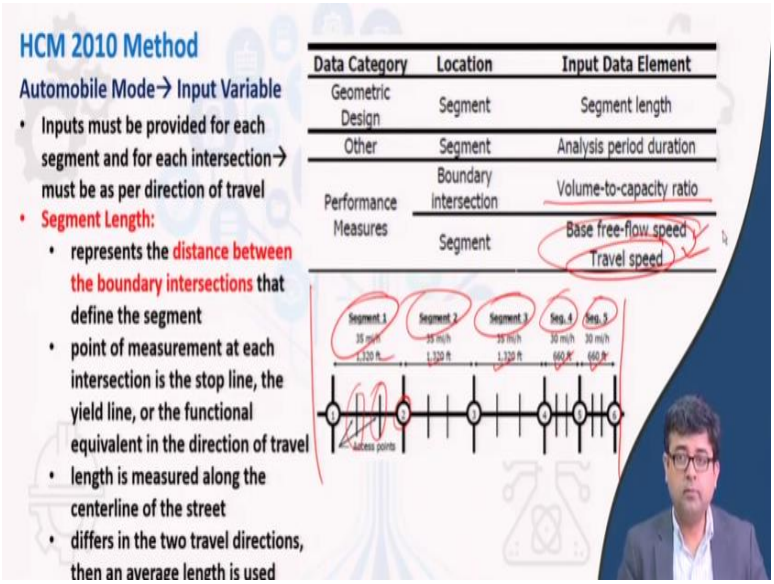

So now if you look at a facility and consider to, develop a level of service for automobile mode for that facility that maybe divided up into segments. And now you have to develop the level of service for each of these segment in order to have an aggregated value of level of service for the entire facility. Why is it important for developing the level of service for each segment? That is because the segments may be varying length. These are similar lengths then you see these are of different lengths. Then there maybe multiple access points within each of these segments which may cause a further delay. So, in addition to delay experience at signalized intersections which is controlled delay you may have delay due to access roads and that may lower the speed. And like we just saw, if this speed lowers when compared to the base free flow speed then the level of service of that segment falls. So you have to break it up into different segments and for each of the segments you have to calculate the volume to capacity ratio and the base free flow speed and the travel speed. If you look at that then you will be able to develop the level of service for the automobile mode for a particular segment.

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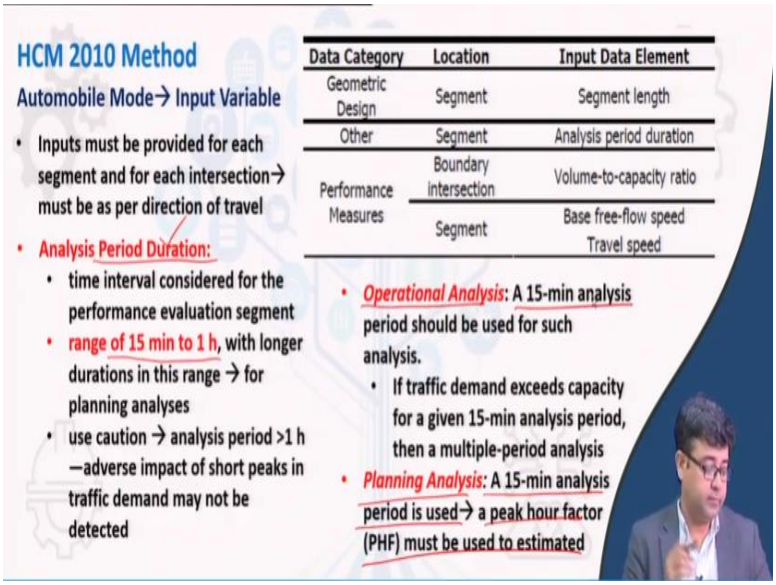

Again few more things to remember when you are developing the level of service for automobiles, is the analysis period. Usually what we do is, we develop the level of service for the peak 15 minute flow. So within the peak hour we look for the peak 15 minute and develop the level of service for that. The reason for that is because we want to have our streets operating at an optimal level of service during the worst condition. Peak periods are usually the worst congested times and the peak 15 minute within the peak hour is the even worse condition. So that is the time if we design our road to not fail, then it will easily carry the traffic during other non-peak hours or normal hours. So that is usually our period of analysis is between 15 minutes to 1 hour for planning analysis. The 15 minute analysis period is used. The peak hour factor is estimated so that we can then aggregate it. We can then develop hourly or daily ranges for level of service. For operational analysis though 15 minute peak hour period should be used.

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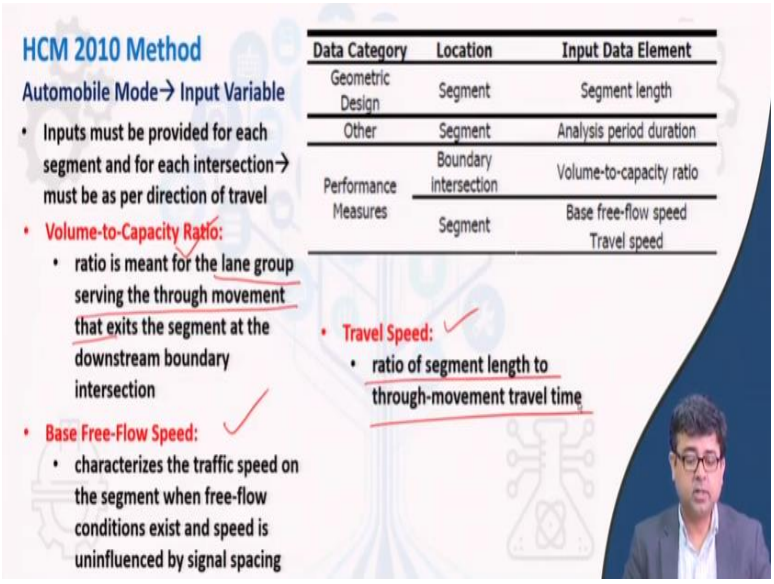

We have already gone through this. You have to develop the volume to capacity ratio. The ratio is meant for the lane group serving the through movement. That is another important thing to realize since there may be multiple lanes in the road. So you have to group those lanes which are allowing through movement. There may be 3 lanes but maybe the outer most lane only allows for left turn. So there may be only 2 lanes that are going through so when you are developing a level of service you have to group these lanes accordingly and it is for that group as a composite you will be developing the level of service. So that is something to keep in mind. If there is only one lane then you just develop it as one lane but whenever you have multiple lanes that is what you have to remember. Travel based free flow speed we have already looked at, it is the ratio of the segment to the through movement travel time. Remember we are weighting it by segment length so we have to take those lengths into consideration.

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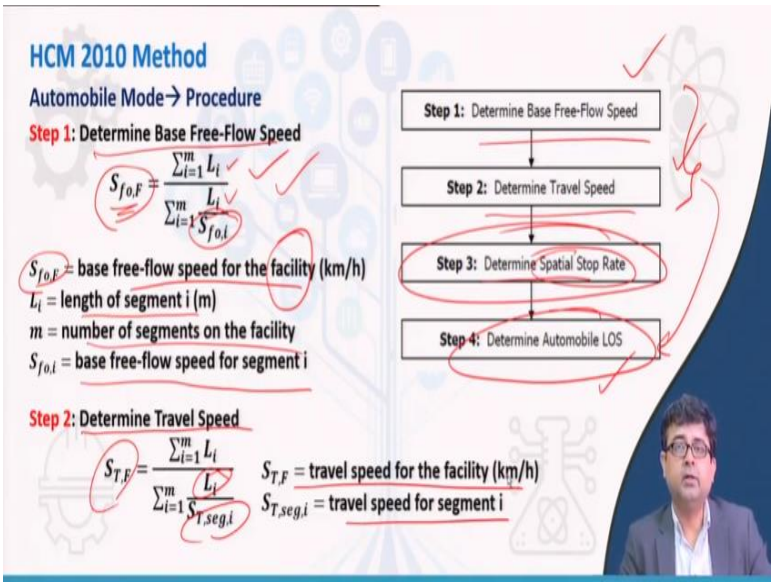

So if you just look at the simple flow of developing this level of service you determine the base free flow speed and then you determine the travel speed. There is an intermediate optional step of determining spatial stop rate. This spatial stop rate is if the through vehicle has to stop because of those access points in between the segment. We showed you the diagram where there may be these access points and maybe the through vehicle has to stop because of these vehicles coming out of these access points. So there maybe if you determine these spatial stop rate that means in space how many times the vehicle has to stop because stopping the vehicle meaning the speed has to go down. If you add that on that will give you an indication of what level of service that street is providing for motorized vehicle but that is an optional step. If you do want to add it you can add it otherwise these two steps are good enough to determine the automobile level of service. This is what we meant when we said that you have to weight as per length so when you determine the base free flow speed. The first what you determine is the base free flow speed for each of the segments you have to have it for each of the segments and then you can aggregate it up to the facility. And then you can weight by length. So each of the segment lengths you have and there maybe 'n' number of segments in the facility. It is the simple weighted average technique of developing the base free flow speeds. Similarly for the travel speed you do the same thing. You have the travel speed for the segments. Weight by the segment lengths in order to develop the travel speed for the entire facility. So when you do that you will be able to develop the level of service for your automobile mode.

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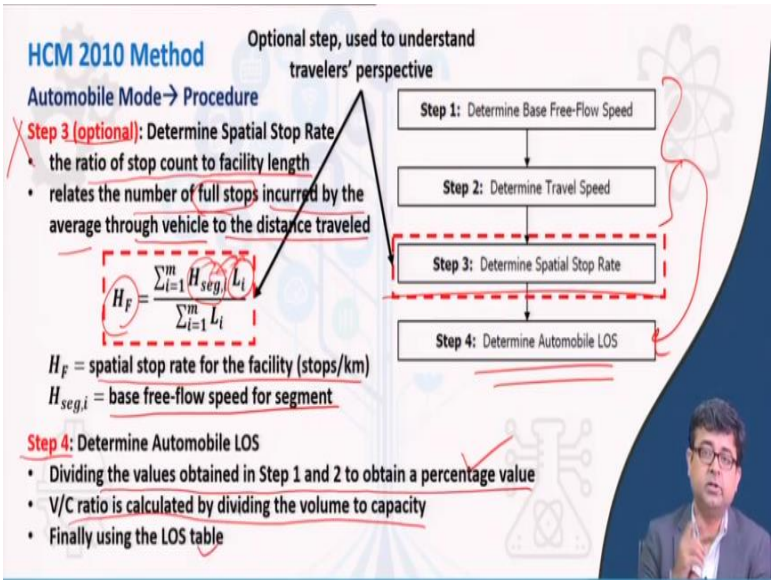

So this is what we were talking about the optional step of determining the spatial stop rate. So the spatial stop rate is nothing but the ratio of the stop count to facility length. How many times the vehicle stops based on the length of the segment so that is what the spatial stop rate is. It relates the number of full stops. It is not just slowing down of the vehicle but fully coming to a halt incurred by the average through vehicle to the total distance travelled in that segment. Again if the segment length is this much and if these are the base free flow speeds of the segment then your spatial stop rate can be determined by multiplying base free flow speed with that length and divided it up with the entire length. So that will give you your spatial stop rate for the facility and you could use that as an additional input in determining the level of service. But what we will show you is that just using these 2 steps you can develop the automobile level of service. So if you decide to skip step 3 what you need to do in the step 4 is you divide the values obtain from the step 1 and step 2 to obtain a percentage value. V / C ratio is to be calculated by dividing the volume to capacity. Capacity of a street is fixed. Volume is something that is just measured on the site. You divide the volume by the capacity you know the V / C ratio. As long as the V / C ratio is less than 1 you use these values of travel speed and base free flow speed to determine the level of service using the table that we have shown you already.

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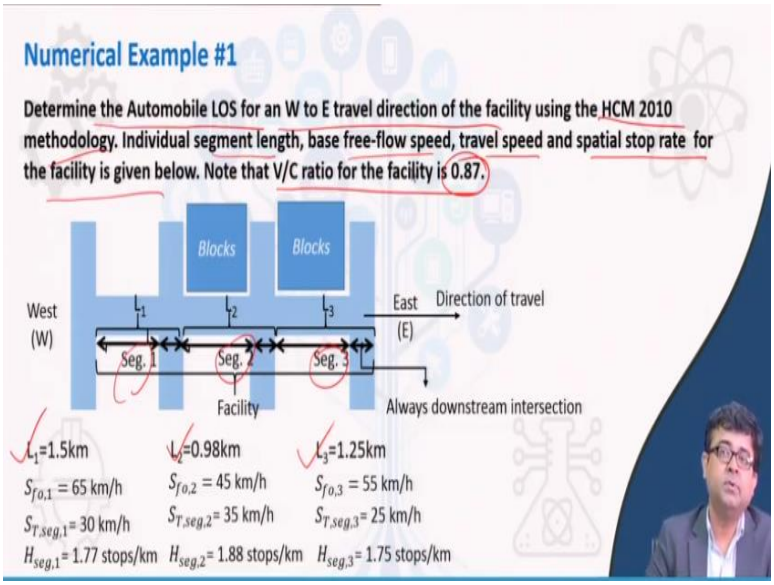

So what we can do is give you an example of how to solve or how to develop a level of service for a street segment for the automobile mode. Say the question asked is to determine the automobile level of service for a west to east travel direction of a facility using these HCM 2010 methodology. Individual segment lengths, base free flow speed, travel speed and spatial stop rate for the facility is given below. So for segment 1, 2 and 3 you have all the input parameters. Now this we have made it easy for you to understand, where we have given you all the parameters but when you are developing it for your street of your city you need to collect these parameters. So you have to actually measure the segment length you have to measure the base free flow speed measure the travel speed and also optionally measure the spatial stop rate maybe. So given this and given the V / C ratio of 0.87 what would be the level of service for the multimodal level of service from the point of view of the automobile for this same section of the road.

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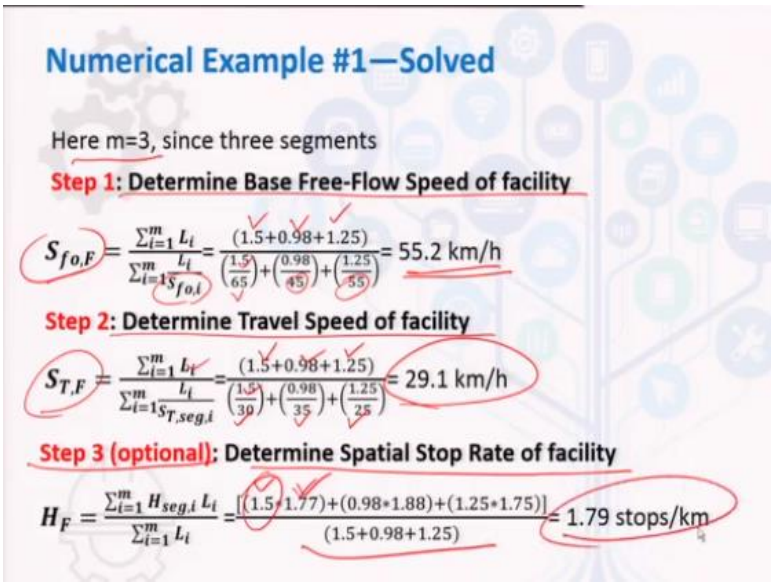

Now as there are only 3 segments, m is equal to 3. What you can do first is to determine the base free flow speed for the facility since you know the base free flow speed for each the segments. You know the segment lengths and you divide the segment lengths by the base free flow speed for each of those segments and you get the free flow speed for the facility. Similarly to determine the travel speed of the facility again you know each of the lengths and the travel speeds in each of the segments. So you see the travel speed varies by segment at one place it is 30 then you have 35 then it is 25 and the segment lengths are also different. So what you get is a travel speed for the entire facility since you have been given the free flow speeds for each of the segments. You can also develop the spatial stop rate. The spatial stop rate is nothing but the length of the segment times the base free flow speed for each of those segments. And you have been given that. Not base free flow speed but directly given the stop rate for that segment. So if you have been directly given the spatial stop rate for that segment all you need to do is you use that spatial stop rate for that segment, multiply it by the segment length, average sum it up. Sum of the products and divide it by the length of the total segment and you get your spatial stop rate.

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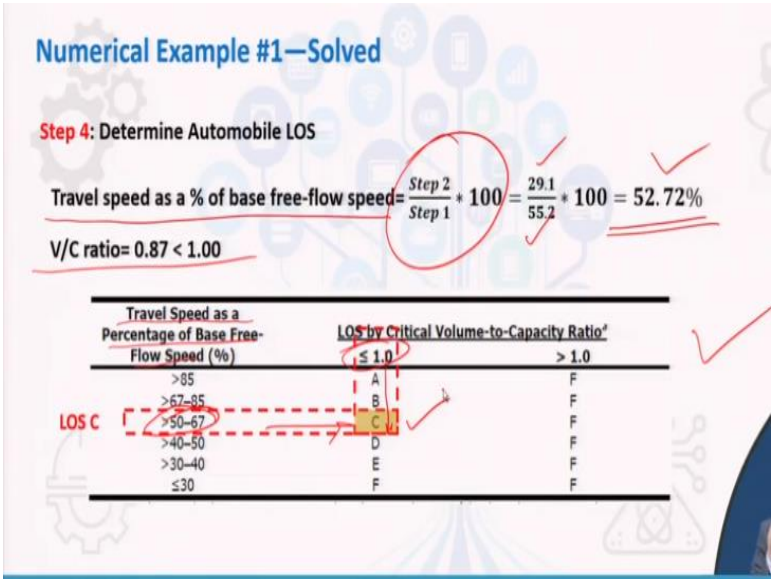

However that is an optional step. To determine the travel speed it has a percentage of base free flow speed all you do is you divide the value of you got in step 2 by step 1. 29.1 is what you got in step 2. 55.2 is what you got in step 1. So you see you get a value of 52.72% and you know that V / C ratio is 0.87 which is less than 1. Now go back to your table, you find out your travel speed as a percentage of this free flow speed. So this is 52% and it would lie somewhere here. And since you have V / C ratio is less than or equal to 1, you go there and you see that this particular facility is providing the level of service 'C', when it comes to an automobile mode. So similarly what we will do in the following lecture is to give you an understanding of how this can be developed for other modes of for the same segment. Then you would see that one particular segment may be providing a very good level of service for one mode but a very poor level of service for the other mode. So that will give you an understanding of why multimodal level of service is very important you cannot have just one value of level of service for a segment or a facility because that segment or facility is not exclusive for the use of only one type of mode since multiple modes are using that segment. Hence you have to have a multimodal level of service for every facility or segment. So I hope you have followed through this lecture for developing the multimodal level of service from the point of view of the automobile mode.

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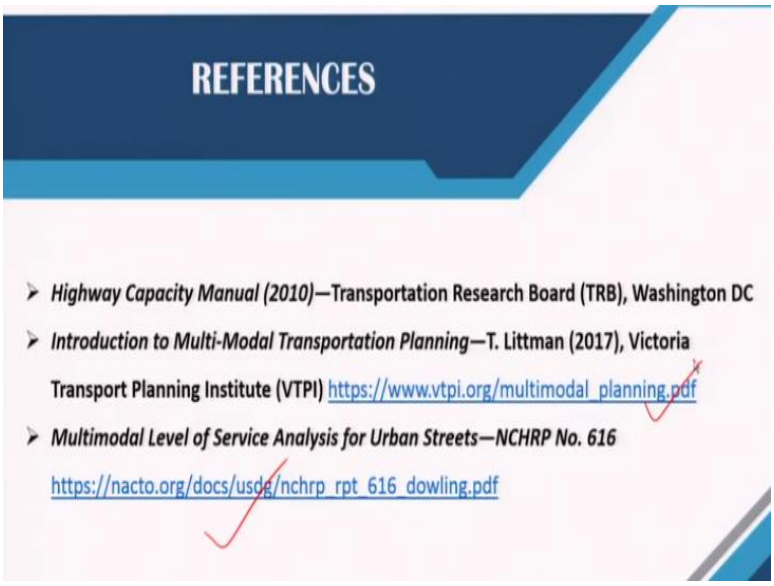

These are the references for this lecture. Materials for multimodal level of service is primarily taken from the NCHRP document which is free for download. And you should definitely look at that and also follow the introduction to multimodal level of service which will give you an understanding of what multimodal level of service is. And obviously HCM 2010. If you have been following, I hope till now you have realized that is the basic for many of the level of service that we have shown you for the individual modes**.**

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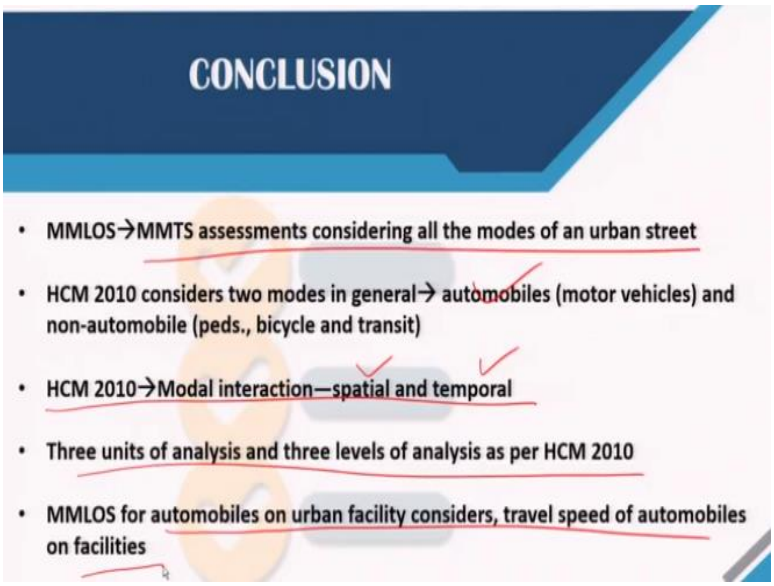

In conclusion what we learnt in this lecture—we looked the multimodal level of service for an urban street from the point of view of the automobile. We have looked at how modal interactions

can be there spatially and temporarily how they can vary and how you can develop a level of service based on that as well. We have also introduced you to this concept of different levels of services that can be developed. It could be developed during the planning phase during the operational phase or also during the design phase. And then we looked at an example of developing a level of service MMLOS. But looking at it from the point of view of automobiles only. Thank you very much for your attention.