Introduction to Multimodal Urban Transportation Systems (MUTS)
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Module No # 11
Lecture No # 53
Urban Transport & Sustainability: Multimodal Level of Service (MMLOS) (Contd.)

Welcome back friends so in the previous lecture we gave you an example of how to calculate the MMLOS from the point of view of automobile mode. In this lecture we will continue this series.

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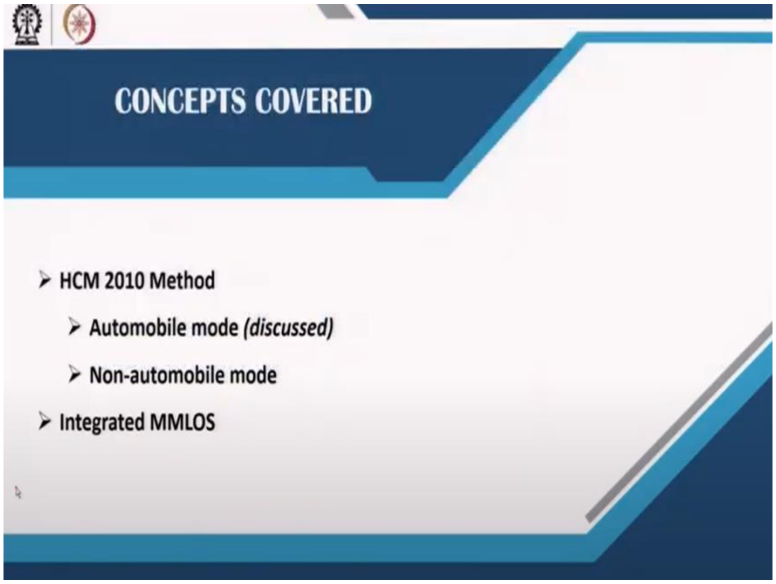

And now we will introduce you to developing MMLOS concept for the non-automobile mode right. And then also finally we will look at how you develop an integrated MMLOS considering all of the modes together.

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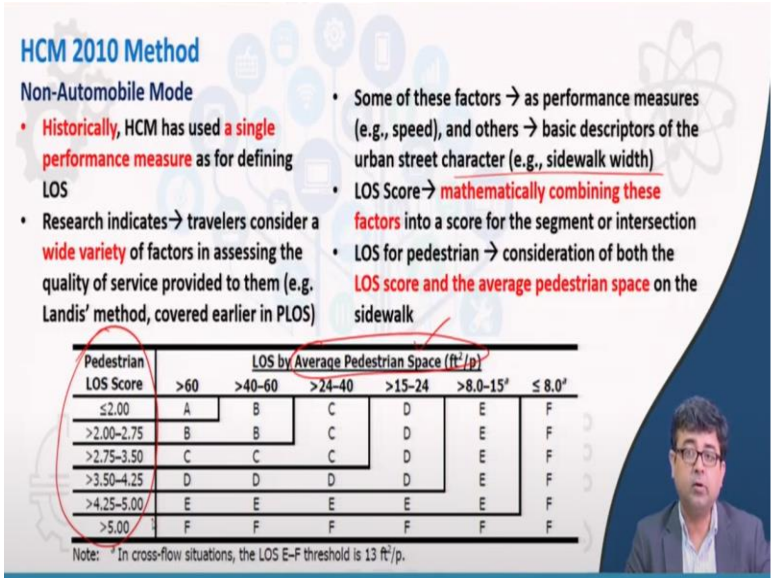

We have already look at the level of service on automobile mode and we have seen what the factors on which the level of service on automobile mode is based on are. And if we look at the non-automobile mode and start looking at first non-automobile mode which is the pedestrian mode. We will see that and you have already gone through the level of service of pedestrian but you already know is that the pedestrian level of service depends upon the average pedestrian space and a pedestrian level of service score. So the score is developed by getting the perception of different pedestrian on different facilities of a street. For example what do the pedestrians perceive about the sidewalk width? What do they perceive about the shade, comfort etc.? All of those things aggregated up to develop a service score. And you actually look at how much average pedestrian space is available for them to walk on. So the interaction between those 2 will give you different levels of service. So that is essentially how you develop a level of service for pedestrian even when we are looking at the point of MMLOS for pedestrians.

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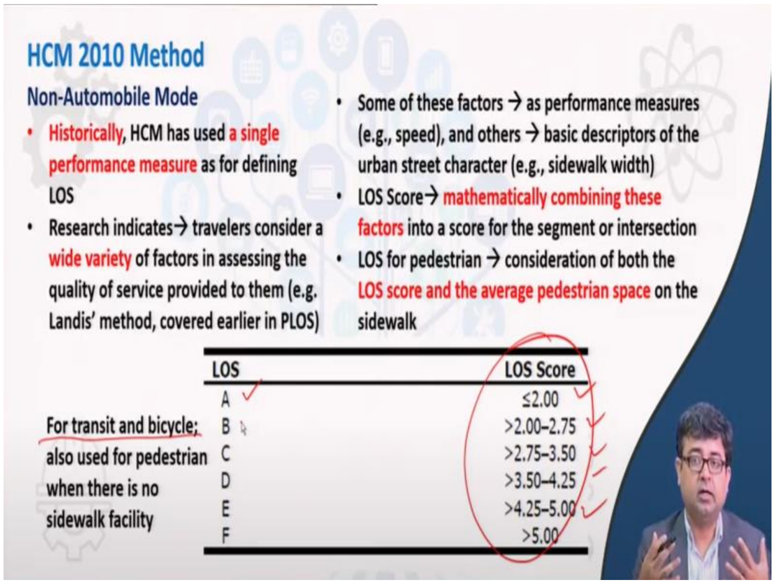

If you want to develop a MMLOS from the point of view of transit or bicycle it is still at a very nascent stage. And all the research has been able to develop so far is a level of service for either transit or bicycle using only the level of service score. However the score is developed separately for transit and separately for bicycle but the range remains the same and the LOS A versus B versus C ranges remains the same. But obviously the variables that are asked as the input would be different for transit versus bicycles.

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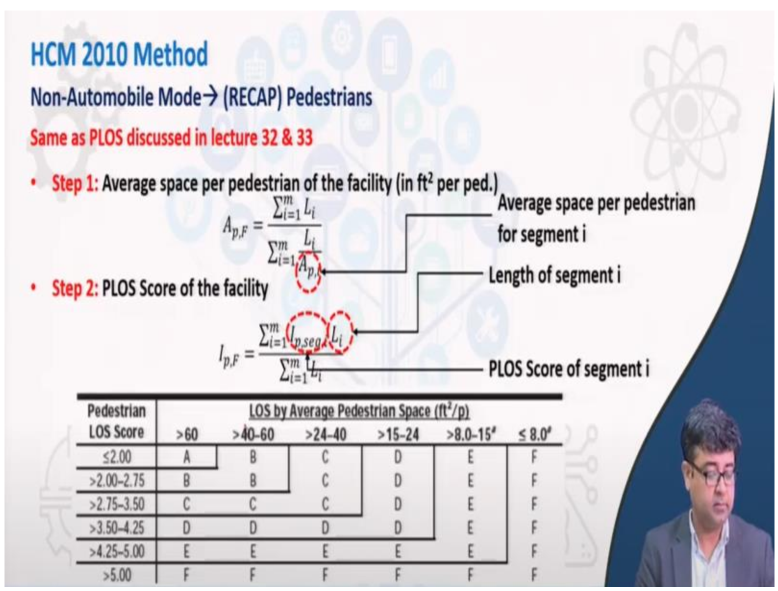

You would again see that the level of service for pedestrian is done in a similar manner. We have shown you for the level of service for the automobile mode. Again the entire facility is broken down into different segments. And the segment level of service is individually developed. And then weighted average of all the segment of level of service score is aggregated up to develop the level of service score for the entire facility. Similar model is followed here as well.

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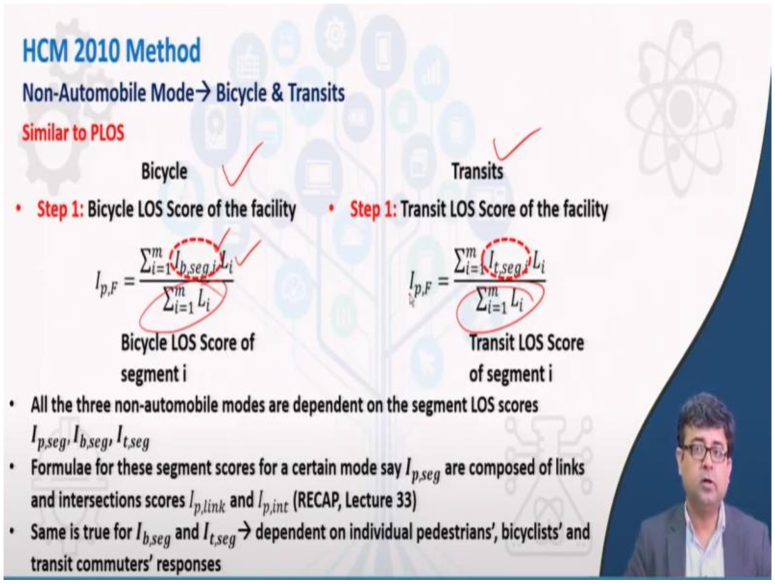

Even for the bicycle and transit level of service you will see that the individual level of service scores for each of the lengths are calculated and then weighted average for the entire length of the facilities is developed. So that is how these things have been started in their implementation because these are very new concept. So as more and more data get available and sophisticated techniques are developed I am sure these will evolve into more robust methods of developing levels of service. But for now what latest we have is this weighted average level of service scores for each of these 4 different modes when we look at multimodal level of service concept.

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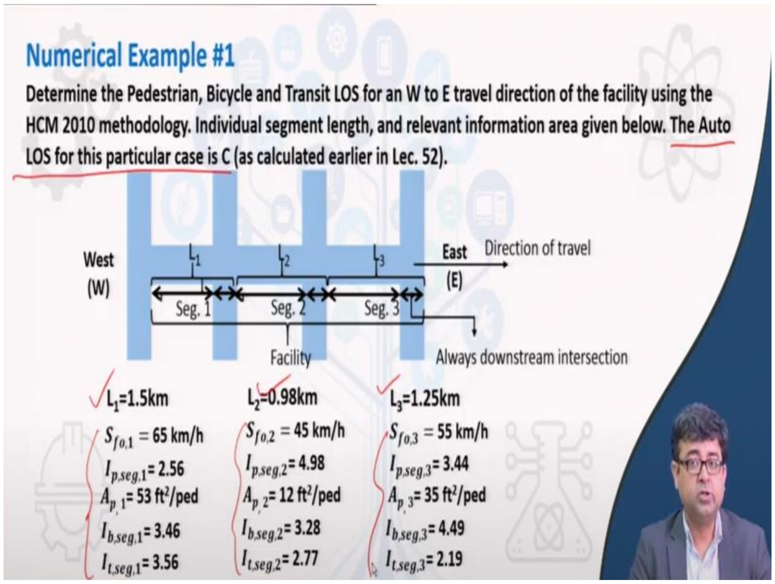

If you take the same kind of street segment for which we have already, calculated the auto level of service in the previous lecture to be C. Now for the same 3 segments you have different levels of service course for your pedestrians, bicyclists and transits. How do you develop that and then compare the levels of service offered for each of those mode on the same segment. This is the big advantage that has to be driven home, that each of the segments may offer different levels of service to different type of modes. So it may be good for walking but it may not be very good for the motorized vehicles. Whereas sometimes it; may be very nice for the bicyclist but not so good for the pedestrians. So same piece of road stretch you can analyze it from different perspectives. This is what MMLOS 2010 technique allows us to do. All these parameters for these 3 segments was given to you.

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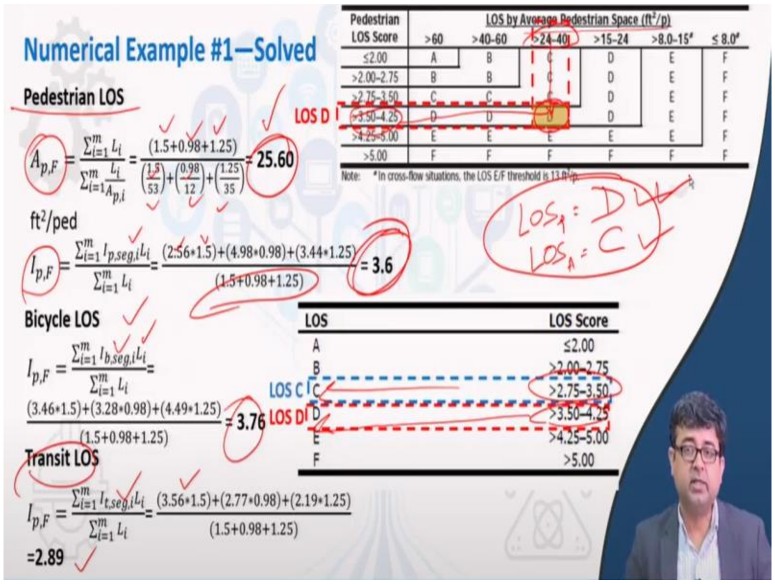

So if you start looking at pedestrian level of service the space pedestrian first you want to understand what the average pedestrian space is. Each of the space values are given and each of the length segments are given. If you use the formula and get the score and then if you develop the level of service score for each of the segments weight by length of the segment divided by the sum of the entire segments you would get a value of 3.6. So if you go back to the table and you see that your average area per pedestrian is 25 so which falls between 24 and 40. And then your pedestrian level of score is 3.6 which, falls between 3.4 and 4.25. This points to level of service ‘D’. Now you can already start to think that this gives a poorer level of service for pedestrian when compare to the level of service for motorized for automobiles. For example it will give the level of service ‘C’ as we saw in the previous lecture. So already you can see the variation in the levels of service offered by the same stretch of road to different modes are different. Similarly if you do it for bicycles, remember for bicycle it is only the level of service score that is used as of now to develop to determine the level of service. So if you know the scores for each of the length segment you just do a weighted average you get 3.76. So that falls in this range. And so even for bicycles it is a level of service D. And for transit if you do it in similar manner you get a 2.98 which gives you a level of service C. So for transit and for automobiles this stretch provides the level of service C whereas for bicycles and pedestrian it provides a level of service D. So you can conceptually figure out that this stretch of road is more favorable towards motorized vehicles. Because public transportation mostly is motorized some form is non-motorized. If you have cycle rickshaws so on and so forth but mostly it is motorized and automobiles are mostly motorized. So this way in which the street is designed maybe it favors this motorized road and hence it offers a better level of service. Whereas if you are non-motorized mode user or if you a pedestrian it offers a poor level of service which is of D. So this is an easy way of comparing the various levels of service that a segment has to offer.

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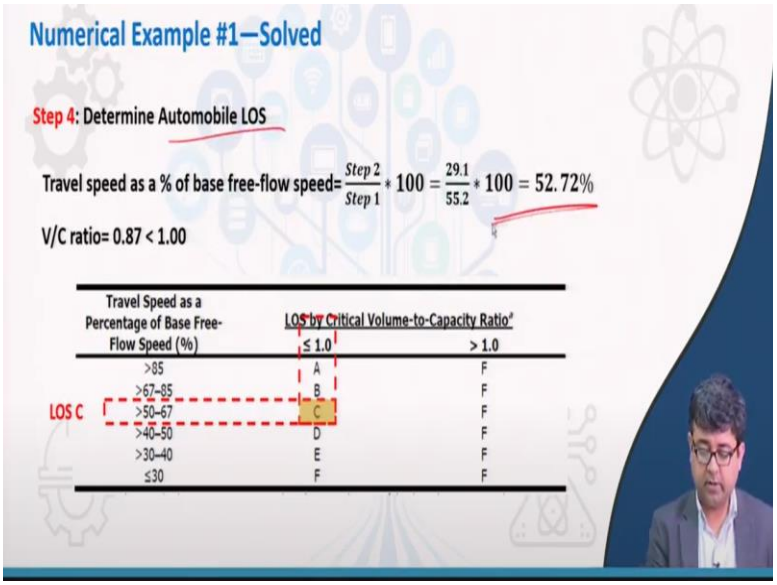

So we have gone through all of that we already know that the level of service for automobiles for this road stretch has already calculated in the previous lecture.

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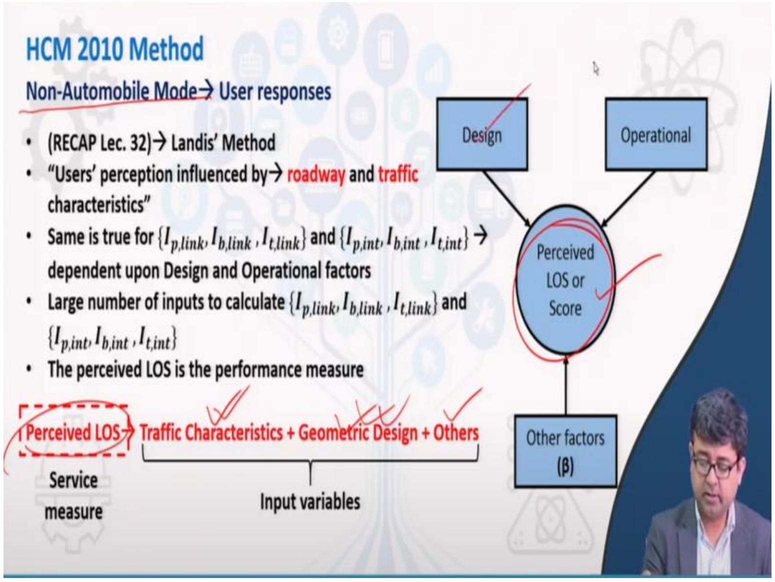

So now we can compare all of that. Essentially what happening now is you are measuring all these level of service score. We have to develop the perceived level of service score. For simplicity sake we have given you these scores but we actually have to develop these scores. So what these scores consist of usually are perceived levels of service or perceived quality of service that various traffic characteristic geometric design other feature of that road offered to the users. When I am walking on the street I would perceive the street in a different fashion, traffic wise, geometric wise and other factors wise versus another person maybe perceive it differently. So, when we essentially ask enough pedestrian on that street about their perception of different traffic factors, geometric design factors and may be comfort factors which are grouped under other. And then you develop a statistical technique to come up with the score, which is what is called a pedestrian LOS score. So these are other element that you are using when you are developing a pedestrian level of service. You are not only using the average space for pedestrian but you are also using the level of service score. So these score are coming from either design factors traffic operation, traffic characteristics factors or other factors which may include for example shown here.

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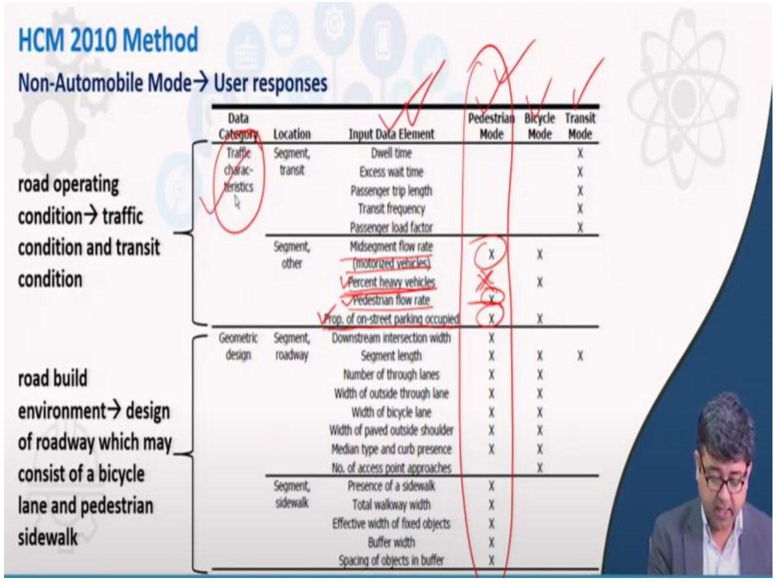

So these are all say comprehensive factors or input parameters that have been used for developing pedestrian levels of service scores for each of these modes. So when you look at developing a level of service score for pedestrian mode you are taking the mid segment flow rate of motorized vehicle into consideration. You are taking the percent of heavy vehicles into consideration. You are taking the pedestrian flow rate into consideration. You are taking the proportion of on street parking occupied into consideration. So these are very important to know what does the pedestrian level of service score depend upon right. So the pedestrian level of service score or bicycle level of service score will not only depend upon the pedestrian mode or the bicycle mode but there comes the interaction. But now even though you are walking but you are affected by the percent of the heavy vehicle for example that are plying on the road next to your walking. But you are affected by the proportion of on street parking that is occupied. So if there is on street parking available and what percentage of it is occupied affects the perception of the person who is walking along the road. And that perception when it gets affected, it affects the level of service score. So these are a comprehensive list of all the data elements that are used for developing this level of service score. So you should be aware of this and take these as base input parameters at least for your own facility. You should know that these are all parameters that are used in the HCM 2010 method which is based by mainly in the United States. But it does not mean that it may not reflect the characteristic of your own town or your own city. It may or may not but at least this is good starting point. So you start with these and see if you get intuitive results of levels of service scores. If you do not get you get other parameters to include in the development of a level of the service score. So this is a good starting point.

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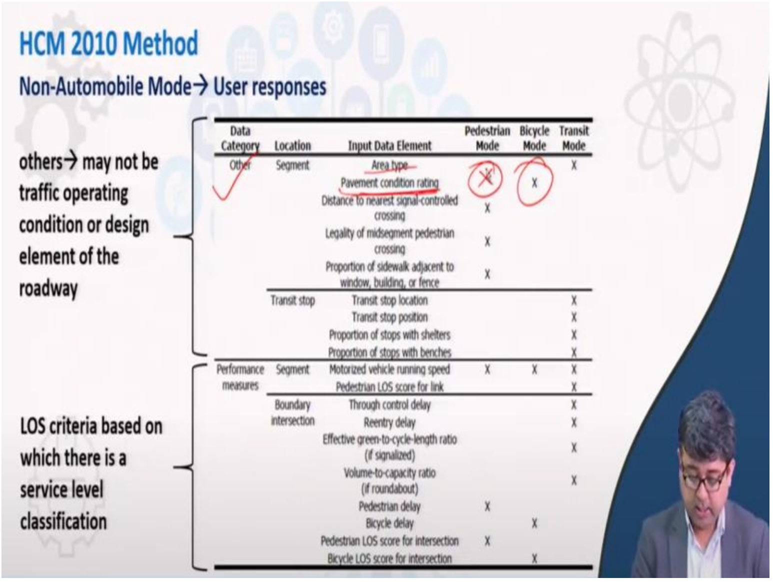

There are different traffic characteristic and geometric design parameters that are given here. As well as different other parameters. For example in the other parameter section you can have the area type which is residential or pavement condition rating. It is important for the bicycle mode. But may not be important for the pedestrian mode. Pedestrian usually should not be walking on the pavement, he or she should be walking on the facility dedicated for pedestrians. But in our case in India maybe this actually becomes a factor which should be considered in developing the pedestrian level of service score. So that is what I mean when I say that these input parameters should be a starting point for you to start understanding how to develop a score. Some of these change based on pavement condition that is up to you to look at your local condition and tweak them in an intelligent fashion.

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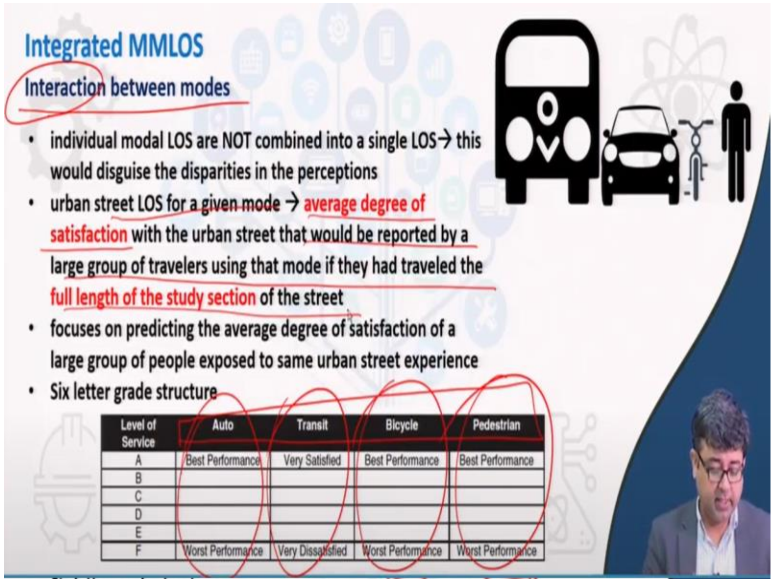

So now when, we start looking at the interaction between modes. This is the last step in understanding how to develop multimodal level of service. When you have actual interaction between the modes and then you develop a level of service score. So we just show you how this interaction may happen. When you are walking you are not only affected by other people who are walking but you may be affected by the vehicles on the road. You may be affected by the parking on the road. So those are not pedestrian factors but those are factors from other modes such as the automobile mode. Similarly for bicyclist you may be affected by the volume of heavy vehicles that is on the road and that is not a bicycle factor. But that is a factor from the automobile mode. So automobile mode may have an effect on the level of service scores of the other mode. So that is essentially the interaction that we are going to show. Also transit mode will have an effect on a pedestrian level of service and bicycle level of service and by vice versa. So there will be a lot of interaction and when you see those interactions at end of these slides you will understand that how complex this concept of multimodal of service could be, when you actually develop or when you try to develop one score for example. We have not yet venture into developing one multimodal level of service score, we are still at the level of having multimodal level of service score develop for each of the modes but for one facilities. That is where we currently have not developed a combined level of service and showed it for the entire facility. We are showing it for individual modes. But if you start understanding the interaction that is when you will be completely getting the depth of the problem that we are handling. The urban street level of service for a given mode is the average degree of satisfaction with the urban street that is reported by a large group of travelers using that mode if they had travelled the full length of the study section of that street. These are some of the some of the nitty-grity that you have to keep in mind when you are doing this survey. You should be not asking a person who is may be a leisure traveler. May be he or she is out of city traveler who has come here for leisure. And then if you ask him or her how good this facility is then it would not be a correct representation of the people who walk on that street every day. So when you do all these you have to keep in mind how to sample. How to develop a sample size? What sampling? Whom should you include in the sampling? Do we use random sampling? But the random sampling should include people who walk there more often than not. So you have to be very careful when you when you develop your samples for these level of service.

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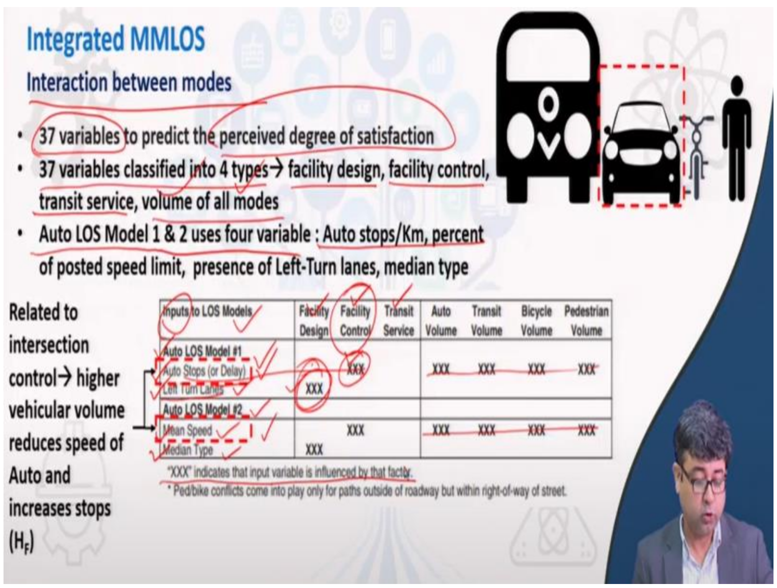

So now if you start looking at the interaction between modes there are 37 different variables to predict the perceive level of service or degree of satisfaction. These satisfaction variables are divided into 4 types one is the facility design. So how what are the parameters that affect the design of that facility control whether it is it has signalized intersection, un-signalized intersections, access points, remember the diagram we showed of the entire facility. Transit service whether that piece of that stretch of road or that facility actually has bus routes, metro routes. Does it have multiple routes? So all the factors are going into account and the volume of all of the modes. Obviously how much volume of transit, automobiles, bicycles and pedestrian are there. All of these 37 variables are grouped under these 4 factors. And then we see that these individual parameters how they interact among each other to develop level of service for each of these modes. For example the auto level of service model 1 and 2 uses only 4 variables. So you can develop an automobile level of service using 1 of the 2 model that are shown here. Model 1 is developed based on delays or the presence of left turn lane whereas the level of service model 2 develops it for using mean speed and the median time. So you can choose one or the other in order to develop the automobile level of service and use only 4 variables which have been shown here. These are the 4 variables that are shown here. These four variables differ for different types of facility design. These variables differs by facility control and obviously all the volumes of the different modes will have a bearing on that variable. So this is what this entire table allow you to tell you what the input for the level of service models are for each of the mode. And how do that input variables vary by the type of category that we have classified them into. Does the delay depend upon facility design or facility control? Obviously depend on control because if it is an un-signalized intersection the delay will be different versus the signalized intersection. So depends upon the facility control of that piece of road for example. Whereas the presence or absence of the left turn lane is not a control feature but it is design feature. So that is what this allows you to tell. XXX indicates the input variable that is influenced by that factor. So if you see automobile mode you have only 4 variables by which you can develop a level of service.

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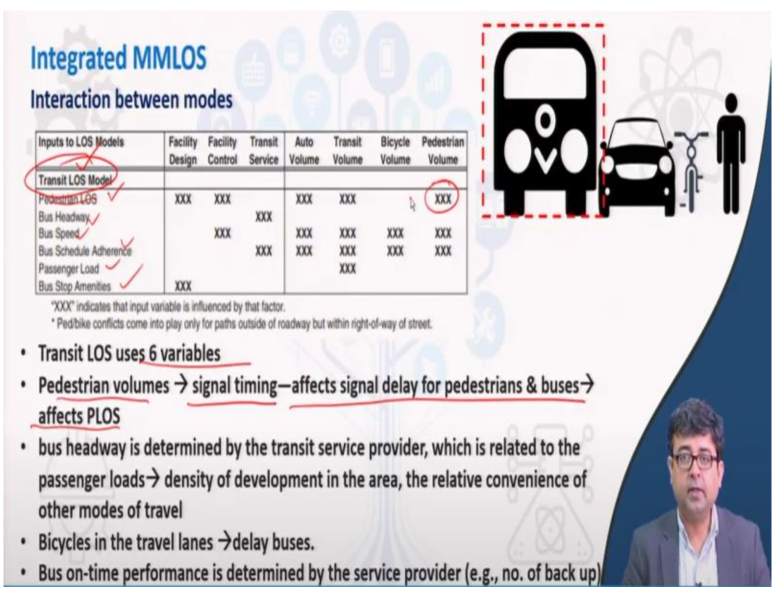
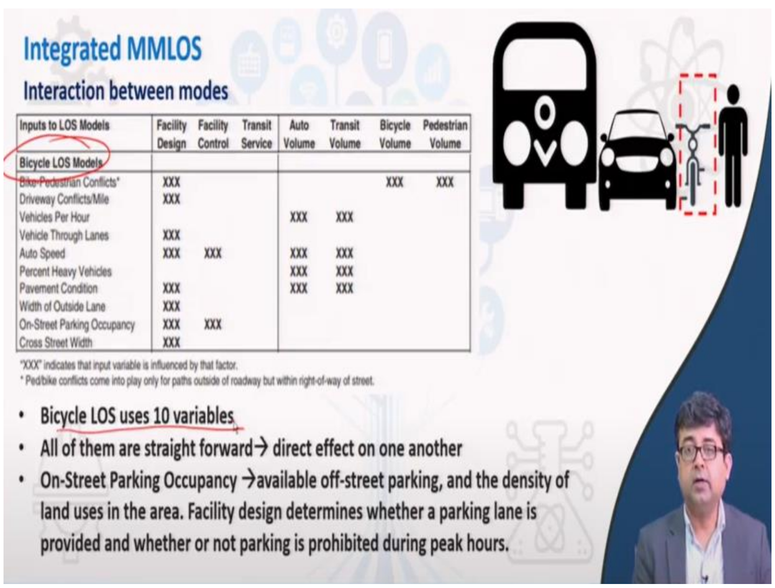


Whereas if you start looking at the other levels of service for example the transit level of service that uses six variable. And these 6 variables are grouped are effected by various thing in this table. For example the pedestrian one of the variable that has an impact on the transit level of service score is the pedestrian level of service. So this is the interaction. So maybe higher the pedestrian level of service or the better is the transit level of service score as well. So this is an interesting interaction that you can immediately see how 1 mode is affecting the other mode right. This is what we mean when we say the interaction between different modes and there interaction actually affects the level of service of different modes. So you can easily follow through all of these. When we talk about pedestrian volumes it affects signal timing which affects the delay for pedestrian and buses. And hence affect pedestrian level of service. If you have higher number of pedestrian volume, at signalized intersection then there may be greater green time for the pedestrian to move. That may impact a green time for the transit and the transit level of service may be affected. So those are all the various interesting interaction these different parameters have with for different levels of service of different modes. **(Refer Slide Time: 23:17)**



Now when we start looking at the bicycle mode you will see that becomes even more complex where bicycle level of service now uses are 10 different variables in order to develop a level of service score. So you will see how we are gradually getting more and more complex. Whereas automobile mode you could just use 2 variables per model to develop a level of service. Whereas a transit needs to be 6 variables now to be collected. From the field bicycle level of service now has to collect 10 variables in order for them to develop a level of service score.

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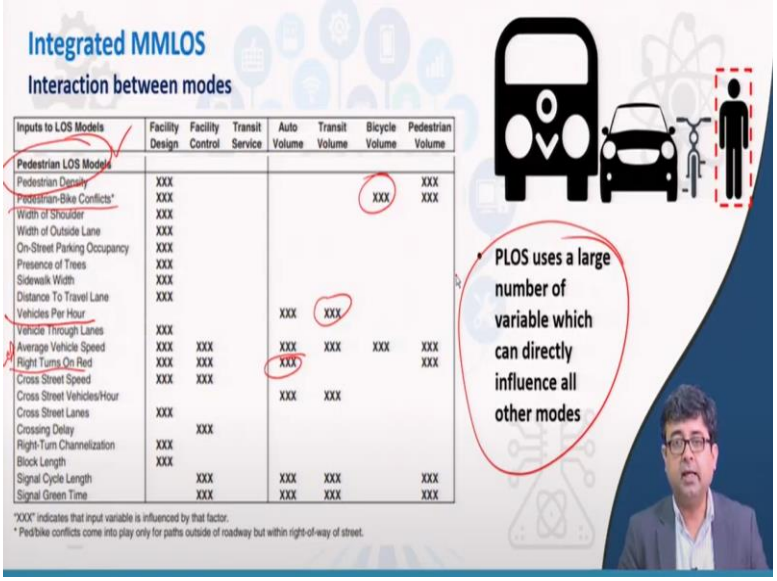

And then when you get into pedestrian level of service score this is the something that gets really complex because now you are dealing with human being who are walking and their perceptions and their perceptions may vary by age, gender, occupation I mean multiple things. So now it becomes very difficult to just capture the level of service score using few variables now you have to have a whole lot of variables to actually capture the level of service. And then when we talk about interactions, there are vehicles per hour. It also has a bearing of the pedestrian level of service. Pedestrian-bicycle conflicts has an impact that is directly related to bicycle volume that has an impact on pedestrian level of service. For transit also vehicles per hour has an impact. If you permit free lefts at red lights then that has an impact on pedestrian level of services because pedestrian may be crossing the road then you have free left and then maybe a conflict point may arise. So you see when you are developing a pedestrian level of service you have a whole lot of variable that can influence it and then it becomes very complex to develop the level of service

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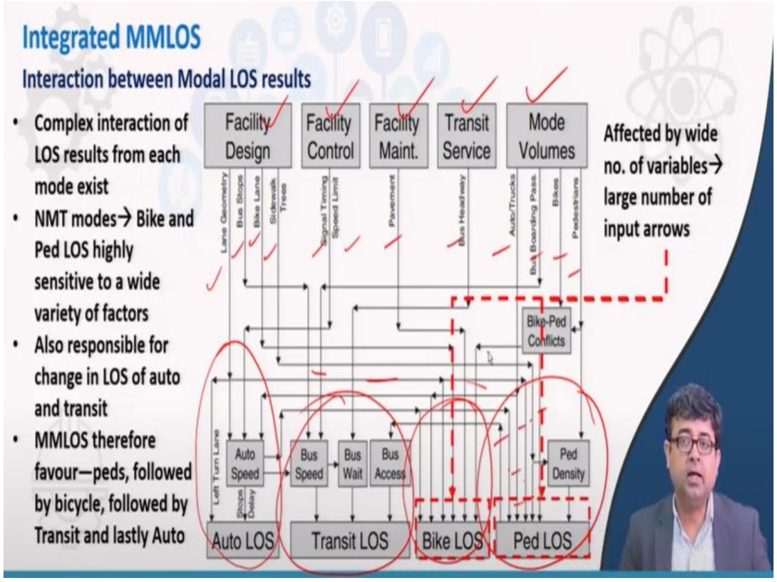

Now put all of these together to actually see how the interaction between the modes occur. You have your groupings on the top and you have all of these different variable shown as arrows here. You start to observe that the number of arrows that feed into the automobile level of service is much fewer when compared to the transit level of service which is again fewer when compared to the bicycle level of service. And finally the pedestrian level of service has so many arrows that are coming in from different directions which makes it even more complex to develop a pedestrian level of service when you actually looking at the interaction. If you had to just consider, for example, developing a pedestrian level of service for an off street trail, it is a trail that goes that goes through a forest area and you want to develop a pedestrian level of service for that trail. Now that is an easier task to do because there is no other mode that can go through the trail. So there is no interaction with other modes you only have pedestrian to pedestrian interaction and the level of service for developing level of service score for such a facility would be easier. Then on the other extreme if you want to develop a level of service score for an express way. And on express way no other modes are allowed other than vehicular modes. It is restricted for non-motorized transport and obviously it is not restricted for buses public transit. But just for the nature of the design of the express ways no public transit runs on it. So when you are trying to develop a level of service score, for automobiles for expressive way it is much simpler than when you want to develop a level of service score for an automobile mode for an urban street maybe urban collector or urban arterial. So why it is difficult you can see it now in this picture that because there is interaction with other modes. Now this interaction with other modes makes things very complex. But we have given you very simplistic methodology by which you can do it. The HCM 2010 methodology where you can calculate the level of service scores for each of the segments. And you know how to develop the level of service scores because we have shown you what input parameters can you use. And those input parameters you can then take to develop a survey questionnaire for your city or your town and get the perceived value from the responses of the citizen that are using those facilities. And then develop a level of service score for each of the segment, you can then average it up using the lengths. Based on the lengths you can develop the level of service for the entire facility. I hope that this has been very helpful to you. This is a concept that is clearly in the path of evolution and still lot of research is happening. This is a new avenue that transportation researchers are engaging in. And also policy maker are getting more and more interested in because many cities are now choked and congested. And they want solutions to ease this congestion and they can develop solution only when they know how where the problem is. Where the problem is with pedestrian mode? Is the problem with the automobile modes? Is the problem with the transit mode? Unless they know that they cannot offer a pointed solution. So this is something that is going to help everybody and everybody is going to need this in the near future.

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Again the references are given here the highway capacity manual is the reference that we have been following for a long time. And so has been the NCHRP report please read through them carefully.

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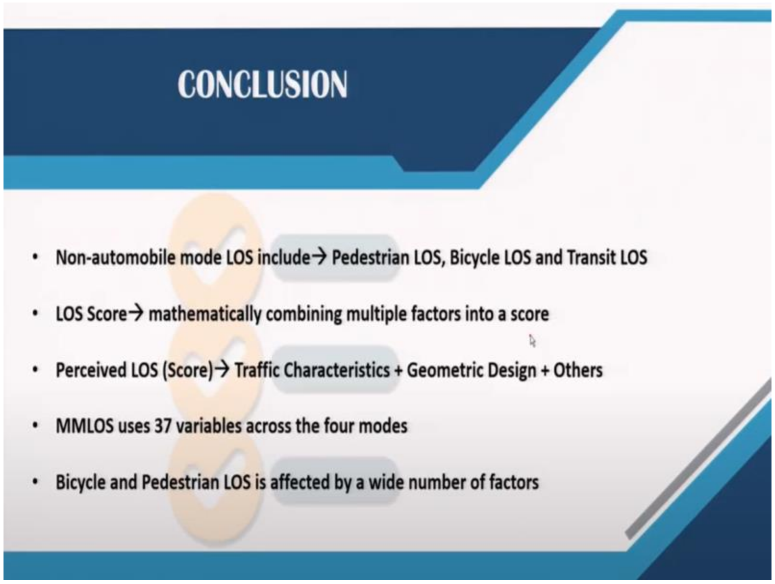

So in conclusion what we have looked at today is the non-automobile mode LOS including pedestrian, bicycle and transit. We have shown you the input factors for developing the LOS score. Remember the LOS score is then divided up into different ranges which then in turn tells you the level of service for that facility. So, all the 37 different variables across four modes was shown to you and then we showed you interaction that the variables have when the level of service is developed. Thank you very much for your attention.