Traffic Engineering
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Lecture 23
Analysis of Urban Street Segments (As per HCM, 2016) - II

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Welcome to Module D, Lecture 8. In this lecture, we shall continue our discussion about analysis of urban street segments as per Highway Capacity Manual 2016.

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In Lecture 7, I introduced to you about urban road segments, how we define urban road segments, the type of control various systems of operations, both coordinated and non-

coordinated, types of analysis planning level, design level and also operational level analysis, the LOS criteria and operational level analysis framework for LOS.
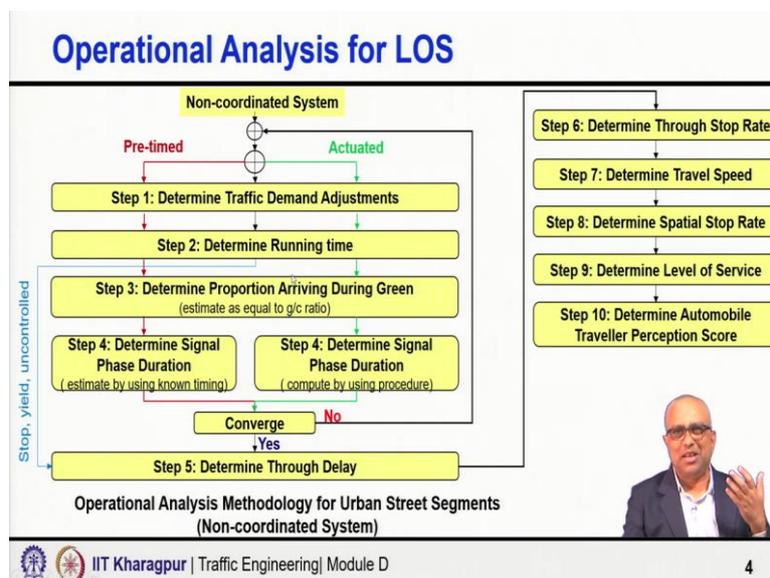
I just mentioned to you about two flowcharts showing the steps, but I did not go into detail discussion. So, today we shall discuss about each step as indicated in that flowchart for operational analysis.

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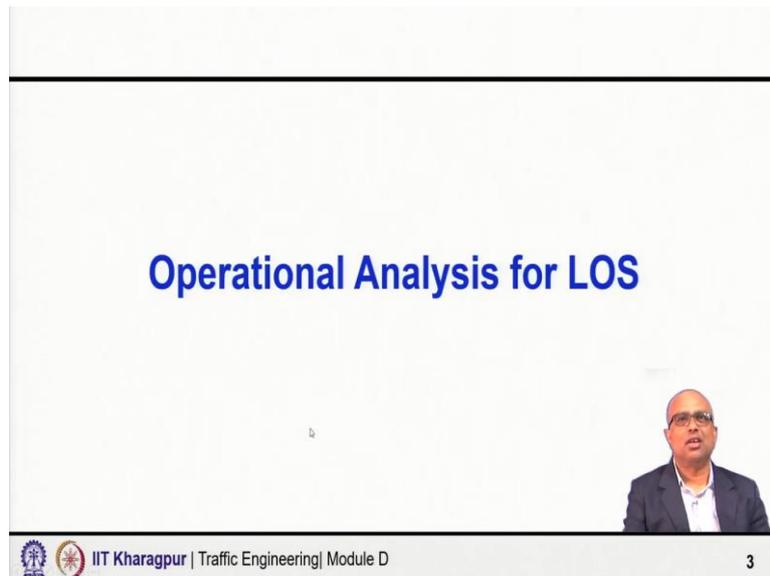
So, this is the flowchart for non-coordinated system, a similar flowchart was shown to you for coordinated system and the only difference was this connection were for non-coordinated system, the stop, yield and uncontrolled intersections may also be included and maybe analyzed. But when it is coordinated system, then obviously, the stop, yield and uncontrolled intersections cannot remain present.

So, I have just picked up one of the flowcharts to remind you about the steps, otherwise, all 10 steps are similar. So, with this background, let us now try to understand a little bit more about each step. Obviously, if you look at Highway Capacity Manual, every step is discussed in great details and it is really not possible to discuss everything at this stage or within the scope of this course, because of the time constraints.

So, I shall give you more of a broader understanding of why we execute a step and what we actually try to do it. The other difficulties that since it is interrupted flow facility, the intersections time and again we will refer to intersection, some terminologies, some procedural aspects and these I will omit anything related to intersection, grossly I will omit because the next module deals in details about the intersection, signalized intersections and we have 3 weeks for discussion about various issues aspects about intersection operation.

So, anything which is a little bit linked with this overall 10 step methodology, I will connect but then I will skip I will not discuss them at this stage. We will discuss about those when we discuss about signalized intersections and in Module E. So, with this background, let us go to each and every step, these are the generalized steps.

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So, step one relates to determining traffic demand adjustment, what all traffic demands, we need to fairly estimating traffic demands, what all adjustments we need to carry out. Now all these adjustments are extremely undertaking, why we undertake to ensure that the volumes evaluated accurately represent segment traffic conditions, because there are several entries,

multiple exits made to be possible apart from that mature corridor, through corridor entry exit one in the beginning one in the end there could be other entry exit in between.

And the overall traffic what we are saying they need to be that traffic need to be representative of that section. So, to ensure that the traffic what we consider is representative of the sections, we need to carry out several adjustments. Multiple adjustments are carried out once for limiting entry to segment because of capacity constraints. That is, one due to capacity constraint, we need to limit the entry to segments.

Second, balancing volumes entering and exiting the segments. The overall volume which are enter, which is entering and overall volume which is exiting, they should match. Third, mapping entry to exit flow paths by using origin destination matrix this I will again discuss further, then the fourth one is related to spillback occurrence from a turn bay or from one segment into another segment. Now, again all this required to be discussed little bit more.

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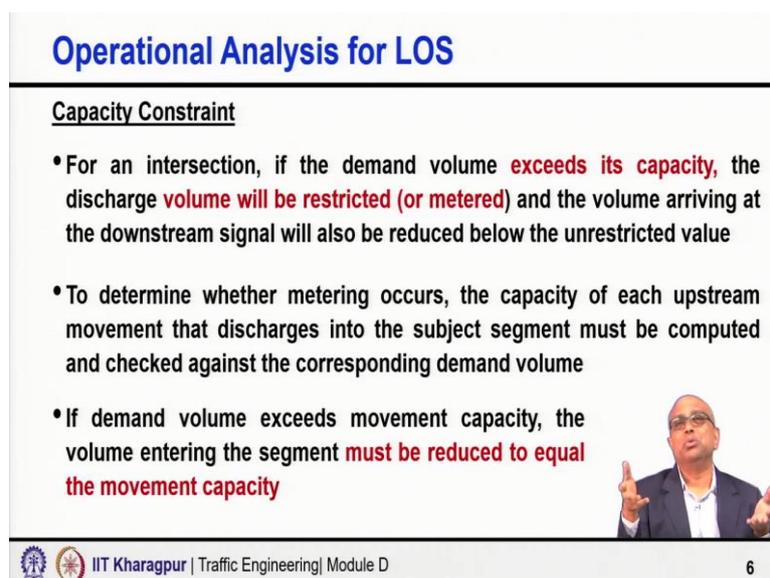
Operational Analysis for LOS

Capacity Constraint

- For an intersection, if the demand volume exceeds its capacity, the discharge volume will be restricted (or metered) and the volume arriving at the downstream signal will also be reduced below the unrestricted value

- To determine whether metering occurs, the capacity of each upstream movement that discharges into the subject segment must be computed and checked against the corresponding demand volume

- If demand volume exceeds movement capacity, the volume entering the segment must be reduced to equal the movement capacity

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First, taking the capacity constraint. Why we need to do some kind of adjustments related to this capacity constraint? For an intersection when the demand is more than its capacity for any approach, any approach. For any approach, if the demand exceeds capacity, then what is the discharge volume, that discharge volume will be restricted, discharge volume will not be equal to the demand because demand might be more, but intersection has got its own capacity.

So, every approach even not only every approach every moment also will have some capacity, but again the details will be known later, but generally at this stage let us consider that every approach will have a capacity. So, if the demand is more than the capacity, then

the discharge volume what is actually getting discharged from that intersection will be restricted or metered, we can call it also will be metered.

And therefore, the volume which is actually reaching to that downstream intersection and assuming that that is a signalized intersection that also will be reduced, not the actual demand is reaching to the downstream intersection, because the flow is actually metered at the upstream intersection.

So, to understand if the metering is actually happening or the restriction is actually getting imposed, what we need the capacity of each upstream movement that discharges into the subject segment, because the subject segment upstream signal might be discharging as a through movement as a left turning as the right turning.

So, to determine whether metering occurs, the capacity of each upstream movement that discharges into the segment, we are talking about that must be computed and checked against the corresponding demand volume. So, we must calculate each movement what is actually the capacity and what is the actual demand. And if the demand volume exceeds the capacity that shows that it is actually getting mitted.

And therefore, the volume which is entering the segment must be reduced to equal the movement capacity. We cannot take the demand but we should actually reduce the volume which is entering into segment equal to movement capacity, we cannot simply take the demand which is coming to that intersection.

The second is volume patterns, the combination or the combined volume of through movements which are entering a segment maybe as we say that if you consider upstream signal, the left turning is happening the right turning is happening and the through movement happening. So, the combined volume from through movement entering the segment must be equal to the combined volume exceeding the segment and that balance must be maintained must be ensured for each direction.

The accuracy of the performance evaluation may be adversely affected if the volumes are not balanced because then you are entering volume or exiting volume during the analysis period in the whole segment is not balanced is not equal. To balance the volume, volume of each movement entering the segment is assumed to be correct, entering volume must be assumed as correct and if the existing volume is different, then the existing volume must be adjusted accordingly in a proportional manner.

So, the question is for the segment if you find the given data it is actually balanced then there is no need for any correction. But if the entry volume and the exit volumes for the segment, total entry volume and total exit volumes are not matching, then how to do the balance then we are assuming that the entry volume is correct and accordingly the exit volume we will apply corrections to match the entry volume and that corrections may be applied in proportional manner.

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Third, origin destination distribution. The volume of traffic that is arriving at a downstream intersection represents the combined volume from each upstream point of entry. That means, if suppose downstream intersection, some is the through movement, some value x, y, z some value. Now, that through movement, we will assume is actually coming from, a share is coming from each of the through movement. If the exact 2d is known, fine, but exact 2d many times you may not be able to capture it.

So, what we assume here that in proportion. So, my exit through movement is this one then whatever are the entry points, if this is my through movement, I know what are the entry movements. So, traffic entering from different points in proportion I will assume that the entry is happening. So, that is what I say the volume of traffic that arrives at a downstream intersection represent the combined volume from each upstream point of entry, sentence does not end there, weighted by its percentage contribution to the downstream movements.

So, what is the percentage contribution for the downstream movement, in that percentage we will try to get the contribution. The distribution of this contribution percentage expressed in percentage between each upstream and downstream pair is represented as an origin destination distribution metrics. So, downstream intersection, if it is through movement then we must know from all the entry point how much percentage is actually coming to make this total volume.

Similarly, the left turning, whatever entry volume has happened from different movements from different points and different directions in proportion it has to be. So, that is what how

we get the origin destination matrix. I shall try to take an example problem in the next week when I plan to solve one problem while discussing about the planning level analysis. Let us see how much we can do.

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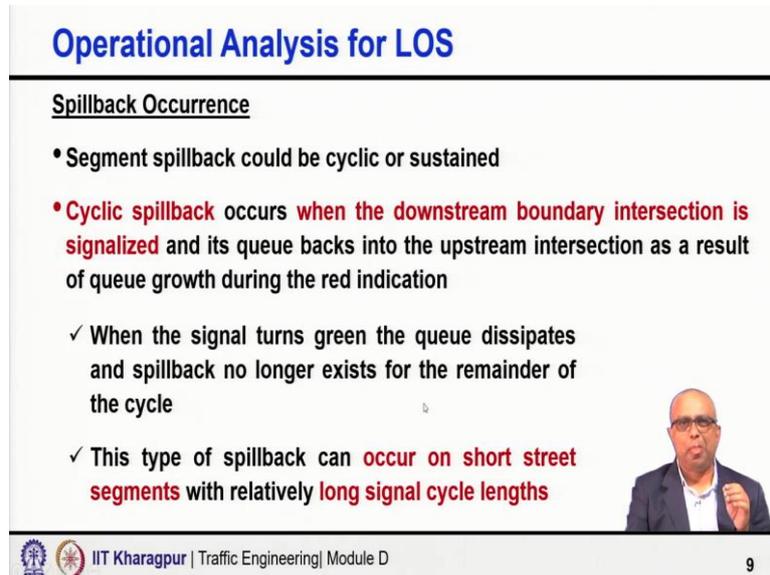
Next point is the spillback occurrence. So, we need to apply adjustment for this spillback occurrence. What is the spillback? Segment spillback could be cyclic or sustained, both types of spillback are possible. Both types of spillback are possible. What is cyclic spillback and when it occurs?

Cyclic spillback occurs when the downstream, we are talking about the downstream intersection. And obviously, it is signalized that is why spillback is happening, otherwise also it will happen but here we are considering the two sides signalized because of certain things as I am saying now. And its queue backs into the upstream intersection as a result of queue growth during red indication.

So, it is a signalized intersection in the downstream boundary and because the traffic is accumulating when the downstream intersection is red, so the queue is getting formed and the queue backs into the upstream intersection as a result of this queue growth. So, why we are seeing cyclic spillback?

Because when signal turns green the queue dissipates and eventually spillback no longer exist for the remainder of the cycle. So, the signal turns green vehicles at discharge and therefore, this spillback no longer exist eventually in the whole cycle. So, during this green time, all vehicles are actually cleared in the sense that there is no spillback.

This type of spillback may happen on short street segments, because then the queue accommodate, capacity to accommodate queue vehicle will be less with relatively long signal cycle length. Stretch is short and the signal cycle length is longer relatively. So, the queue spillback may occur, but that is cyclic spillback because when the signal turns green, the queue dissipates and spillback no longer exist for the remainder of the cycle.

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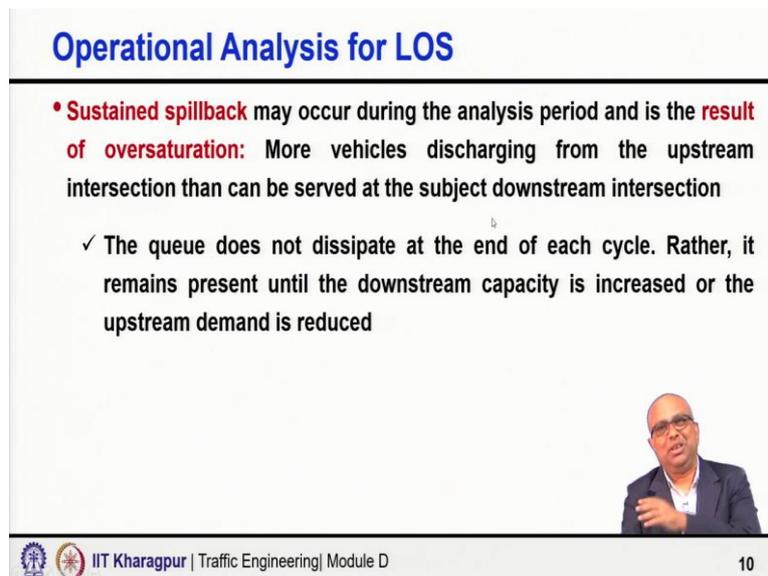
Now, as I said the other type of spillback is sustained spillback. Sustained spillback may occur during this analysis period and is the result of oversaturation. In the previous case, there is no oversaturation because vehicles are getting accumulated and the spillback is happening during the red, but when the green comes, everything is cleared no more spillback. So, every cycle whatever spillback is happening during red is getting cleared during green.

But in this case, sustained spillback during the period and is the result of oversaturation. So, what is happening, more vehicles discharging from upstream intersection, upstream intersection more vehicles are getting discharged from upstream intersection as compared to what can be handled by the subject downstream intersection. So, what will happen in this case?

The queue does not dissipate at the end of its cycle rather it remains present for the entire period until the downstream capacities either increased for some way or other, you do some physical changes and increase the capacity of the downstream intersection or the upstream demand is reduced. So maybe peak hour it happened, but the peak hour is over and the demand is reduced eventually.

So slowly over a period of time the queue spill over will dissipate but during this analysis period, every cycle end of every cycle the queue is, the queue spillback is dissipating, that is not happening. It is getting accumulated because there is overall oversaturation as I say more vehicles discharging from the upstream intersection, then what can be served at the subject downstream intersection.

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Now going to step two. so, I discussed what, why and what all adjustments we need to do as part of step one, for the traffic demand adjustment. Now going to step two that is determine running time, what is the running time for the vehicles considering the segment under consideration. Now this includes how to calculate the running time.

We need to calculate the free flow speed because everything starts from there, not only free flow speed it is actually start from the base free flow speed unless we do a direct field measurement, then vehicle proximity adjustment factor. I shall explain what it is and additional running time due to mid segment delays. Let us discuss one by one. First, you are familiar with the free flow speed.

So, start with the free flow speed. So, free flow speed is the average running speed of through vehicles because everything our focus is the through vehicle. The whole methodology and everywhere we are interested about through vehicle, at least in this part of analysis. Traveling along the segment under low volume conditions, which is suitable for measuring the free flow and without delay due to traffic control devices.

That is what the free flow. Now, it reflects the effect of street environment on drivers pictures, what I mean by speed environment, maybe the speed limit, access point in city, type of median, curb, and also the length of the segment. Length of the segment also matters for these urban segments depending on how much is the length, if the segment length is relatively short and the signals are closely spaced, and between upstream and downstream signal the length is relatively short, then there will be an impact also on the free flow speed. So, free flow speed captures all these effects.

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Now, if we can measure the free flow speed from the field, it is fine. We may not be able to measure most cases. So actually, thing starts not from the free flow speed, but may start from the base free flow speed. You have seen earlier when we discussed about multi lane highway segments, freeway segments, we always started with base free flow speed, so BFFS. The bass free flow speed can be measured again or estimated.

Now, assumed to be the free flow speed on longer segments with no effect of signal spacing. So, if we consider that there is no effect of signal spacing, then this BFFS and free flow speed FFS maybe assumed same. We can estimate as I said, if we have to estimate in this absence of any field measurements due to whatever reason, then this is the equation given in highway capacity manual, which can be used to estimate the base free flow speed.

S_{fo} is the bass free flow speed. What are the other components? We are saying S_{calib} that is the base free flow speed calibration factor, this value may be taken as default as 0 because it

goes here plus minus and the average value. So, if it is not known you can take it as 0 miles per hour then S_0 is the speed flows constant, it is a function of the posted speed limit.

So, depending on the posted speed limit, you can get the value of S_o, which is the speed constant. So, that is the starting point. So, you can consider when we are estimating S_{fo}, So, is our basic quantity. And it is again given in highway capacity manual exhibit 1811. Once you know the posted speed limit, then you can get the speed constant an equation is also available, I have not written all these equations here.

And then interestingly what I want you to understand what are the other adjustments we are doing because, so many formulas and so many values, you cannot remember that is not the objective, but basic aim here is to give you an understanding, what are the factors that are influencing. So, the adjustment for cross section, access point and on street parking.

So, here are all these adjustment factor what value you should take under what condition all these are given in exhibit 1811 of Highway Capacity Manual 2016. So, you can actually estimate this base free flow speed.

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Then, as I said, that, when I was talking about BFFS that with no effect of signal spacing. So, now, the effect of signal spacing need to be considered. So, evidence such as that shorter segment length particularly when in this case, we defined by signalized boundary intersections, we have two signalized intersection at the two end of the segment, upstream and downstream end.

When shorter the segment length tends to influence the driver's choice of free flow speed. So, when the segment is shorter, the free flow speed is influenced. So, here this equation is given, you can use this equation to calculate signal spacing adjustment factor. Obviously, this has to be less than or equal to one, because it can go only on the lower side, once you use this factor and whatever BFFS you have estimated that can go only on a lower side when you consider this Signal Spacing Effect or it may be same.

So, this factor always is less than equal to 1 and S_{fo} is the base free flow speed and then Ls is the distance between adjacent signalized intersection. So maximum of LS and 400 feet we will take. So, practically we are saying beyond 400 feet the balance, you know it remains constant. So, that way you can, then once you have calculated f_L you can multiply this free flow, base free flow speed S_{fo} with that multiplied by f_L so get you can get the adjusted speed.

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Now, next adjustment we no need to do is for the vehicle, as I said that how the running speed. So, this is the free flow speed part, then the vehicle proximity adjustment factor. What is that? The vehicle proximity adjustment factor is actually taking care of some other component. The proximity adjustment factor at just free flow running time, whatever is the free flow speed and the corresponding running time we are now adjusting that to account for the effect of traffic density.

If the volume is there, obviously volume increases, so density also will increase under the stable flow condition. Even otherwise as the demand is increasing, the density will increase. So now we are taking care of the density or taking care of this free flow running time,

modifying that to take care of the effect of traffic intensity, because so far, we have not considered the volume effect.

So, the adjustment results in an increase in the running time and obviously, corresponding reduction in speed, with an increase in volume. So, that equation is there and you can see logically the proximity adjustment factor then it is basically to take into consideration the effect of traffic density. So, what you take?

You take the mid segment demand flow rate and also the number of through lane and the free flow speed, these are the functions, these are the factors which influence the calculation of the proximity adjustment factor and all are absolutely logical and you can understand those very clearly.

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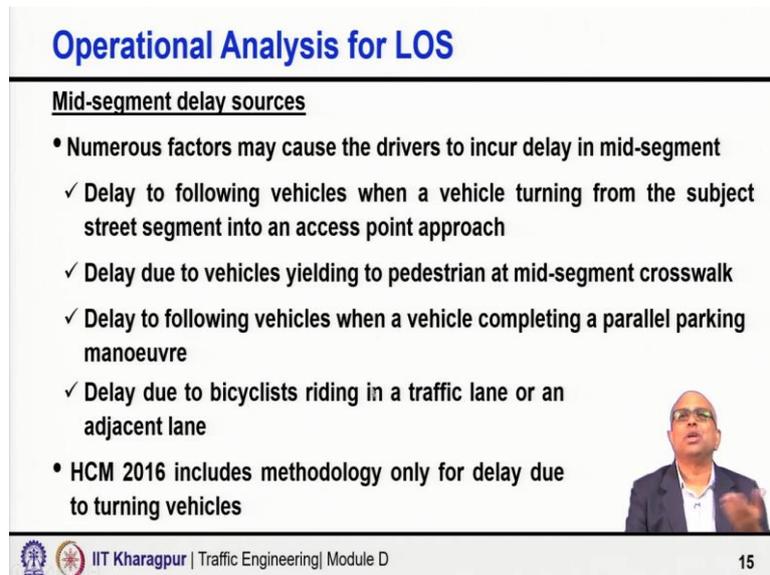
Now, there are other mid-segment delay sources. So, numerous factors that may cause drivers to incur delay at the mid-segment for example, the delay may be for the following vehicles when a vehicle is turning from the subject segment into an access point approach it may be left turn it may be left turn the effects may be different with US norms, if a vehicle is taking left hand that mean in Indian condition it is the right turn, then the vehicle may stop actually.

So, till it is able to do the maneuver and if it is taking right turn as per US convention and left hand as per Indian convention then the speed will get reduced and then the vehicle will take left turn. So, the vehicles which are following that vehicle which is trying to take time either left or right that may get, you know speed get influenced and delay may occur.

Delay may also occur when the vehicle is trying to yield to any mid-block pedestrian crossing where the pedestrian is trying to cross or maybe for following vehicles may, following vehicles may get impacted when a vehicle is completing a parallel parking maneuver. So, obviously the speed will get reduced, try to place the vehicle.

So, the following vehicle is getting impacted. Or maybe the in the same traffic lane, or in adjacent lane bicycles are going. So, depend on what type of operations we are doing, how much segregation we are able to do. So, all this. So, now, among all these the Highway Capacity Manual 2016 provides a table tells you the methods how you can take care of this effect of turning vehicles the first point, delay due to turning vehicle.
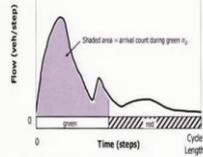
Others they do not provide any basis how you can calculate or do not provide readily available table, but if you can quantify this such any of these effects or all the effects in a given context you can consider them.

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Then going to step 3, determine the proportion of vehicle arriving during green. Now, this step applies to the downstream bounded intersections when the operation of a signalized urban intersection is evaluated. Because otherwise the green if it is not signalized operation, the green and other things will not come into picture.

So, if the upstream intersection is not signalized, upstream intersection is not signalized or signalized, but not coordinated with the downstream boundary intersection then the proportion of arriving vehicle arriving during the green is equal to the effective green to

cycling threshold, that is quite logical. So, vehicles are arriving during randomly, so what proportion is arising green it is basically effective green to cycle ratio.

But otherwise, how we can calculate. Otherwise, we can calculate using this equation as shown here. Suppose this is the proportion vehicles our largest share of vehicles in a coordinated format in a coordinated system, larger share of vehicles are available in the green and then the remaining vehicle are available.

So, what is we can calculate the proportion is n q, vehicle arrival count during green, which is this shaded area that many vehicles are arriving during green divided by q d is the average flow rate for downstream lane group. So, what is the average flow rate? Multiplied by the cycle time. So, that is the proportion that is arriving.

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Step 4, determine signal phase duration. Now, as I said that this is applicable only when the downstream boundary intersection is signalized and what is facing, how we determine the face all these are going to be discussed under module E. So, I will skip the discussion here.

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Similarly, the next step is determination of the through delay, through vehicle how much delay are incurring. The delay incurred by through vehicle as the exit segment is used for travel time calculation, how much time or how much, what is the time the vehicles are taking to travel the segment. So, therefore, through vehicle, this travel time is through the vehicle delay is therefore, very important.

Now, what is it through vehicle? Already you have discussed this but again I want to mention that it is a vehicle that enters and exit the segment as a through vehicle. So, once it enters into the segment from the upstream it is actually going straight, not going here and there. So, through vehicle is the sum of through vehicle delay is actually includes two types of delay, one is called control delay, another is the effect of geometric delay.

So, through delay is the sum of two delay sources, one is control delay, you can generally say it is delay due to the traffic control at the boundary intersection. Now, how exactly it can be defined, what exactly it means, how we can calculate again we are going to discuss in module E because this relates to traffic signal operation.

And geometric delays, the delay due to the negotiation of intersection geometry, for example, maybe the curvature effect. So, this control delay plus geometric delay for the through vehicle added together we can get the through delay.

Step 6, determine through stop rate. So, through vehicle stop rate. What does it mean, stop rate? Average number of full stop per vehicle. So, not all vehicles will stop. So, we need to calculate what is the average number of full stop per vehicles that enter and exit segment as through vehicle because everything is through through through. So, everywhere the through vehicle we are talking.

Now, when you have a signalized intersection, when you have a signalized intersection then what we mean by a full stop, and when it can occur. So, when a vehicle slows to 0 or a crawl speed, if it is in the queue, then also it may be considered almost stopping, as the signal changes from green to red. Remember that it is only for that reason, the signal is changing from green to red.

So, we will consider a vehicle as full stop when the vehicle slows to 0 or crawling speeding in queue as the signal changes from green to red. So, this is very important, changes from green to red only because of that. And in an unsignalized intersection full stop may happen when a vehicle slows to 0 or again to a crawl speed if in queue due to the presence of a control device, you have a stop control intersection, not signalize, so it is mandatory for you to stop. So, what we do, how we take the values?

The through stop rate may be assumed as one stop per vehicle for a stop control approach, obviously stop control. So, every vehicle has to stop legally. Then look for a gap and then do maneuverer. You can take zero stop vehicle for an uncontrolled approach, no mandatory required for stopping and then what is remaining is basically signalized intersection that need

to be estimated. How it can be estimated? HCM 2000 gives you the details and I am not going into that discussion at this stage.

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Step 7, determine travel speed. Overall travel speed of through vehicle for the segment. So how you calculate? A simple formula very logical formula. Once you know the segment length, you know the segment running time considering all the steps earlier and also you know the through delay, so through delay and segment running time you add together that gives you the total time.

So, basically linked by time. The delay used in the above equation is that incurred by the through lane group at the downstream boundary intersection. Here, we are talking about the lane group, I am not going to discuss very specifically about this, but again, please be careful you are talking about through lane group. So, you will know what it is lane group, movement group, when we discuss about module E.

Now, step 8, determined special stop rate. Special stop rate, we said number of stopped vehicle, how many stops determined through stop rate. So, average number of full stop per vehicle. But here what we are saying, special stop rate. That means spatial stop rate is expressed in terms of how many units of stops per mile special. Why we are taking it? That is what is written here.

This is an equitable means of comparing the performance of alternative street segments with different lengths. You may have many sets many segments, how you can compare different segments which have got different lengths. So, I am comparing based on this logical expression. Units of stop per mile normalized. How you can calculate?

Again, a simple formula is given as shown here, special rate, stop rate, stops per mile then H is the full stop rate. What is this full stop rate? This what you have calculated, incurred by the through lane group at the downstream boundary intersection, stops per vehicle. So, H is one component. And what is H other? Other is full stop due to other sources. So, this H you already know, how we have calculated, this step 6. That is what is H.

And H other, what could be other, say at mid-segment due to pedestrian crosswalk, due to bus stop, due to turns into access approach there could be in the mid-segment also, entry exit could be there. So, there could be additional stops which you have not considered while calculating this part because this is only basically at the signal.

So, in midblock also, a vehicle might stop due to some other reasons as I said by pedestrian crosswalk, bus stop or turns. So, these two together you take, length you consider segment length and accordingly you can calculate stops per mile.

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Operational Analysis for LOS

Step 9: Determine LOS

- LOS is determined separately for both directions of travel along the segment, and LOS is defined for two measures i) travel speed for through vehicles ii) volume-to-capacity ratio
- The volume-to-capacity ratio for TH movement is calculated as the TH volume divided by the TH movement capacity

Step 10: Determine Automobile Traveller Perception Score

- The automobile traveler perception score for urban street segments is provided as a useful performance measure
- It indicates the traveler's perception of service quality

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Then all are done now, you can calculate LOS. So, LOS determined for both directions of travel along the segment and two measures we are using already you know it, travel speed for through vehicles and another is volume to capacity ratio. So, LOS will be when volume to capacity ratio is greater than 1 and up to 1 the travel speed for through vehicles will determine what will be the LOS under V by C ratio less than equal to 1.

There is also one more calculation we do that is determining the automobile traveler perception score, many things we have calculated in between. So, the automobile driver perception score can be calculated using those values which are important and people travel and do care about those aspects.

And that is calculated as a useful performance measure. Now, it indicates basically traveler's perception of service quality, but we do not use that directly for measuring the LOS. LOS still based on the travel speed for through vehicles and V by C ratio, but all these are also important. So, you can actually calculate and check what is the traveler's perception score.

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Operational Analysis for LOS

$$I_{a,seg} = 1 + P_{BCDEF} + P_{CDEF} + P_{DEF} + P_{EF} + P_F \quad \text{-------(4.29)}$$

✓ $I_{a,seg}$ = automobile traveller perception scale for segment

✓ P_{BCDEF} = probability that an individual will respond with a rating of B, C, D, E, or F

✓ P_{CDEF} = probability that an individual will respond with a rating of C, D, E, or F

✓ P_{DEF} = probability that an individual will respond with a rating of D, E, or F

✓ P_{EF} = probability that an individual will respond with a rating of E, or F

✓ P_F = probability that an individual will respond with a rating of F

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So, how we calculate? There is some equation given like this, which is basically the automobile drive perception skill for segment and P_{BCDEF} is the probability that an individual will respond to it the rating of B, C, D, E or F. Similarly, P_{CDEF} is the probability that an individual will respond with a rating of C, D, E or F and so on.

Similarly, P_F is the probability that an individual will respond with a rating of F. So, it is basically collecting the behavioral data A 1, B 2 and so on. And then they analyze the data and then they develop different models. So, how we calculate this?

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Operational Analysis for LOS

• Scores of 2.0 or less indicate the best perceived service, and values in excess of 5.0 indicate the worst perceived service. Although this score is closely tied to the concept of service quality, it is not used to determine LOS for the urban street segment

$$P_{BCDEF} = \left(1 + e^{-1.1614 - 0.253H_{seg} + 0.3434P_{LTL,seg}}\right)^{-1} \quad \text{----- (4.30)}$$

✓ P_{BCDEF} = probability that an individual will respond with a rating of B, C, D, E, or F

✓ $P_{LTL,seg}$ = proportion of intersections with a left-turn lane (or bay) on the segment

✓ H_{seg} = spatial stop rate for the segment (stops/mi)

• Remaining probabilities are computed in similar manner

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Operational Analysis for LOS

$$I_{a,seg} = 1 + P_{BCDEF} + P_{CDEF} + P_{DEF} + P_{EF} + P_F \quad \text{------(4.29)}$$

- $I_{a,seg}$ = automobile traveller perception scale for segment
- P_{BCDEF} = probability that an individual will respond with a rating of B, C, D, E, or F
- P_{CDEF} = probability that an individual will respond with a rating of C, D, E, or F
- P_{DEF} = probability that an individual will respond with a rating of D, E, or F
- P_{EF} = probability that an individual will respond with a rating of E, or F
- P_F = probability that an individual will respond with a rating of F

I have just shown one equation here that how you can calculate. So, this gives you the probability value, and using proportion of intersections with the left turn lane on the segment, and special stop rate, and if that way you can get. So, similar kind of equation, this I have shown for P_{BCDEF}. Similar, kind of the coefficients are different, sometimes the sign may be different.

So, similar equations are also given in highway capacity manual for P_{CDEF}, P_{DEF}, P_{EF} and P_F. So, you can use those and get it. And what we want to say that score of two or less indicate the best perceived service, you can share that it is really good. And values in excess of five indicate the worst perceived service. So, that gives an indication.

So, I tell you the worst score, 2 or less is perceived to be the best. And 5, excess of 5 is basically the worst. Now, although this score closely tied with the concept of service quality, it may not be completely different in disagreement, completely in disagreement with the LOS, but we still do not use this score to determine what is the LOS. LOS is still determined based on the travel speed for through vehicle and volume to capacity ratio.

But still, this is useful because it tells us something more. And looking at the score, we can still decide that whether we need to take further interventions and we can also relate it to the actual LOS.

Summary

- Computational steps for determination of:
  - ✓ Traffic demand adjustment
  - ✓ Running time
  - ✓ Proportion of vehicle during green
  - ✓ Signal phase duration
  - ✓ Through delay
  - ✓ Through stop rate
  - ✓ Travel speed
  - ✓ Spatial stop rate
  - ✓ Automobile traveller perception score

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So, what we discussed here basically the computational steps for determination of LOS for a given segment. And all the steps starting from traffic demand adjustment, running time calculation, proportion of vehicle turning green, signal phase duration, through delays, through stop rates, travel speed, special stop rate and then how we can decide the LOS and also the automobile traveler perceptions. So, with this I complete this lecture. Thank you so much.