Traffic Engineering
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Lecture 54
Bus Priority Treatments

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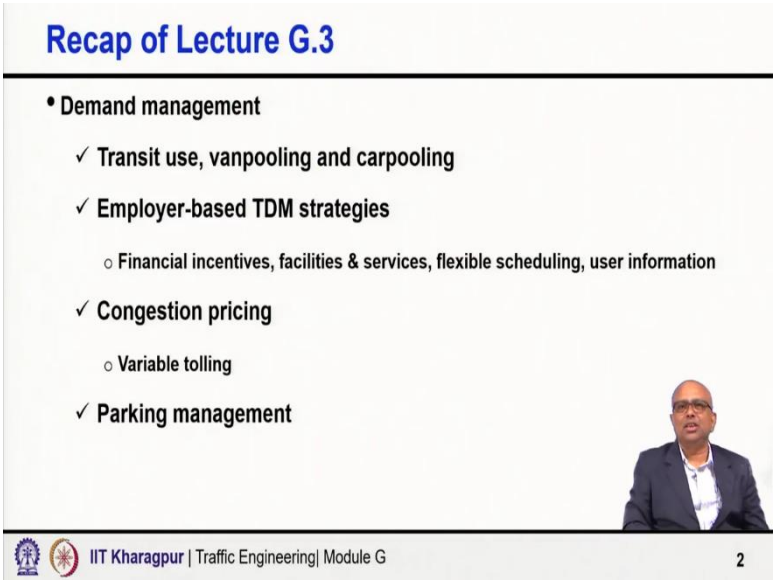

Welcome to Module G, Lecture 4. In this lecture, we shall discuss about Bus Priority Treatments. In lecture 3, I mentioned to you about various demand management strategies, why we need demand management? How they are linked with traffic management? What kind of benefit they can bring? and then there are different four broad ways of achieving or doing the demand management namely transit use, vanpooling, carpooling, then employer-based TDM strategies, congestion pricing and parking management and many cases we discussed in details, about what are the strategies, and further details about each of the strategies. So, you know that demand management is another very important part of the overall traffic management.

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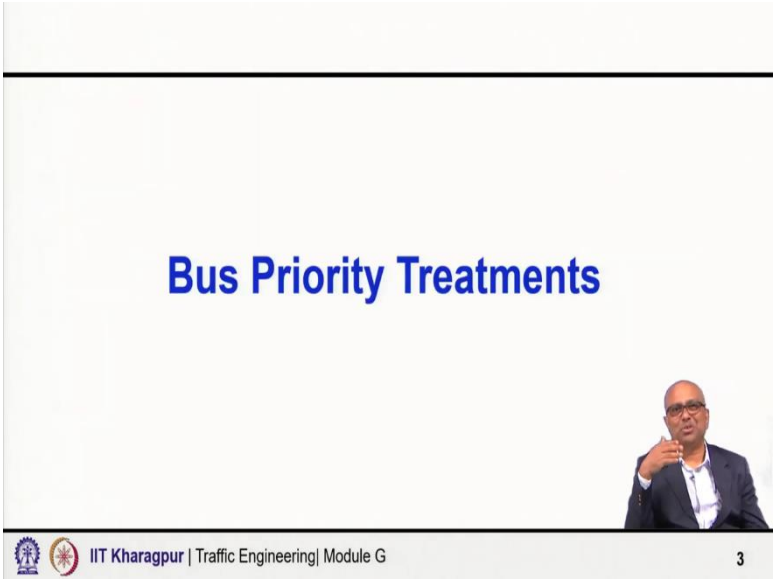

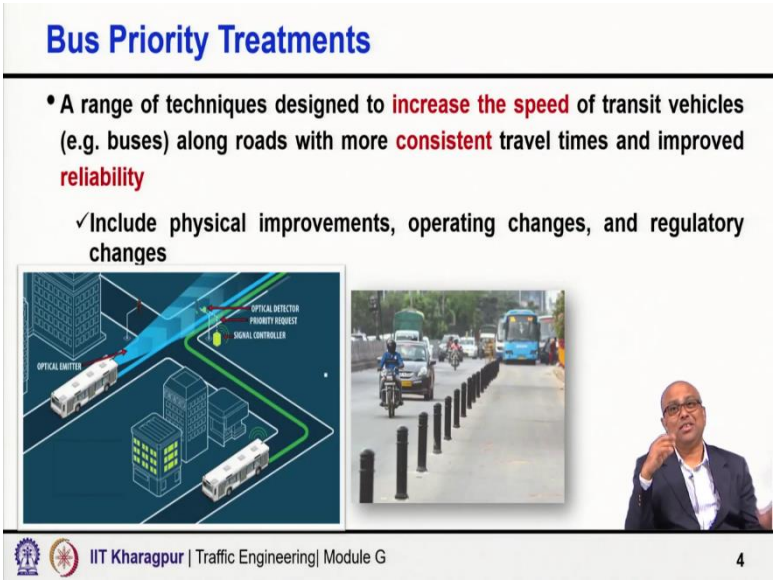

Now, with that background we are now switching over to another aspect which is bus priority treatments. Why it is so important? Because we said the traffic management, one basic objective is that how to make better use of existing facilities, and one very important thing is how we can shift more people to transit, and avoid use of single occupant vehicles.

So, if you want to use or push more people to transit most common cases common form of transit in urban areas is bus. So, if you want to put more people to buses, want more people to use buses, you have to make the buses attractive. And the major disadvantage with the bus is the longer journey time, because bus has to stop in so many stoppages, boarding, alighting, all this takes time, so the average journey time of bus is lower and not at all attractive in comparison to the journey time by car.

So, bus priority treatments include a range of techniques which are designed to increase the speed of transit vehicles, particularly buses along roads with more consistent travel time, and improved reliability, so overall attractiveness of the bus system will increase by doing so. And bus priority treatments may include physical improvement, operating changes, and also regulatory changes, all may include may be included within these bus priority treatments.

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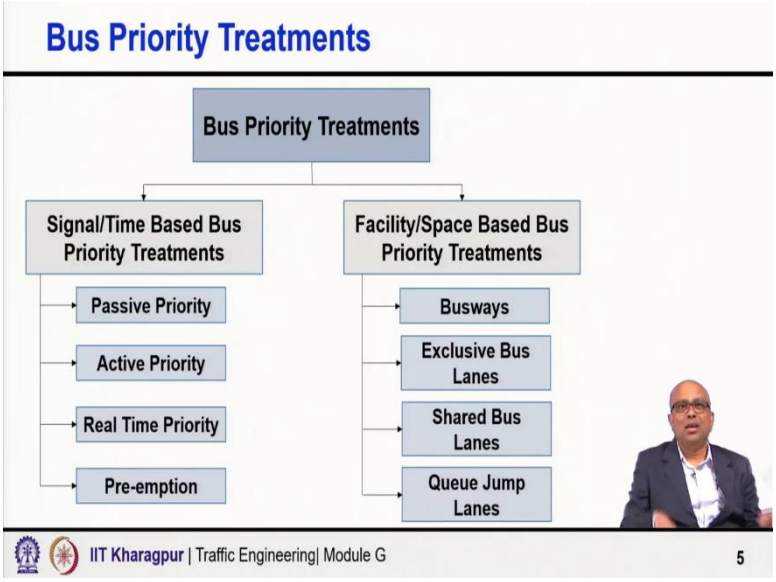

There are two broad classifications, I do not know whether I should call it classifications, but yes, okay. Let us call it classifications one is signal or time-based bus priority treatments the other is facility or space-based bus priority treatments. Under signal or time-based bus priority treatments there are four major things passive priority, active priority, real time priority, pre-emption. Similarly, the facility or space-based bus priority treatment may be achieved by providing bus ways, by providing exclusive bus lane, or shared bus lanes or even something called queue jump lanes.

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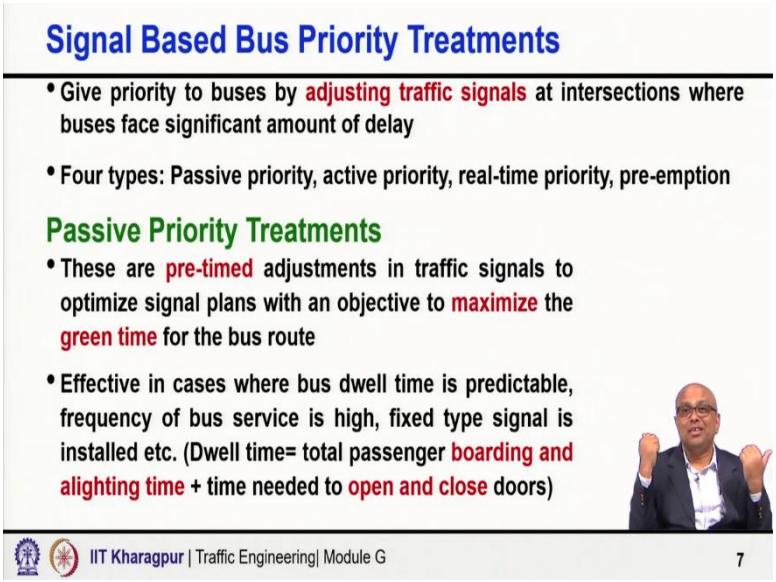

Let us go and discuss further. First, I will take up the signal-based bus priority. Signal based bus priority treatments aim to give priority to buses by adjusting traffic signals at intersections where bus face significant amount of delay. In urban areas, especially in emerging countries like India, the major delay occurs at the traffic signal.

Buses have to stop at designated stops for boarding and alighting of passenger, you cannot avoid that. So, if you want to really improve the overall bus journey time or journey speed, the options what is actually feasible what is left to you is you can try to reduce the delay to buses at traffic signals, because urban areas there will be so many traffic signals, so you can try to reduce the delay to buses and these traffic signals.

So, we are trying to give some kind of priority to buses by adjusting the traffic lights at intersections because these are the locations where bus face significant amount of delay. Now, how to provide priority to buses at traffic signals or using signal-based priority there are four types passive priority, active priority, real time priority, and pre-emption. What is or why what we understand by passive priority treatments? These are the pre-timed treatment or adjustment, that means you generally collect the data, you see how is the traffic volume? what is the signal setting? how many buses are on an average coming from an approach? and so on.

It is pre-timed, so you know pre-timed signal. So, you understand the meaning pre-timed. So, these are pre-timed adjustment in traffic signal not on a real time basis. I am not sensing buses, I am not sensing other traffic at a real time basis and providing priority, no, that will be actually active priority. So, passive priority all are pre-timed adjustment.

Generally, I have the traffic data, I know the volume, I know the bus volume from different approaches, I have decided based on that where and what movement I should prioritize? where I put priority bus priority? And then doing this pre-timed adjustment in the traffic signal.

To optimize signal plan with an objective, to maximize the green time for the bus route, the delay in a way proportional to the green time, if we consider all other aspects unchanged then, if we give more green time, there will be lesser delay. So, if we give the delay is in that way linked with the green time, if we give more green time, the delay will be lesser and such kind of passive priority treatments are effective where bus dwell time is predictable, frequency of bus is high and fixed type signal is installed at the signal.

Why I am saying bus service is higher not too high, in that sense but not lower because if the number of bus is very low you do not know sometimes a bus is coming, so if you give a fixed time priority most of the cases there will be not be any bus, so under that situation we cannot apply this kind of pre-timed treatment.

And what is the bus dwell time? Dwell time means total time required for the passengers for boarding and alighting in the bus stop plus the time needed to open and close the door. So, what we are saying, if the bus dwell time is predictable, if bus dwell time is not predictable, it varies, so much then the bus arrival itself also will be uncertain during every cycle. So, there is some sorts of sense, when we are making this statement.

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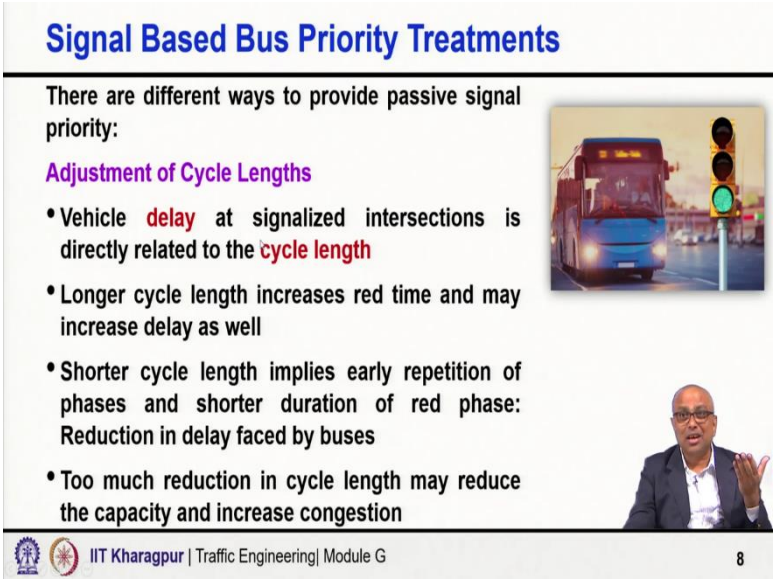

There are different ways to provide passive signal priority, so first we say, how we provide bus priority, passive priority, active priority, real time priority, pre-emption. Now, we say what is passive priority? And then, these are the different ways, what we are going to discuss, we can provide passive priority.

First, adjustment of cycle length, vehicle delay at signalized intersection is directly related to the cycle length. Longer cycle length increases red time and may increase the delay as well, so buses wait probably a longer time longer red you will get before the bus gets green. Short cycle length or rather shorter cycle length implies early repetition of phases and shorter duration of red phase, so therefore reduction in delay also may happen for the buses.

Buses are arriving at random and you are operating with shorter cycle length, then the bus delay really is expected to be reduced, but we must understand and appreciate that, too much reduction in cycle length may also impact the capacity in an adverse manner, because too much reduction in cycle length, it means my lost time will also increase, so I lose capacity and therefore eventually may increase congestion, so a balance is required between these two.

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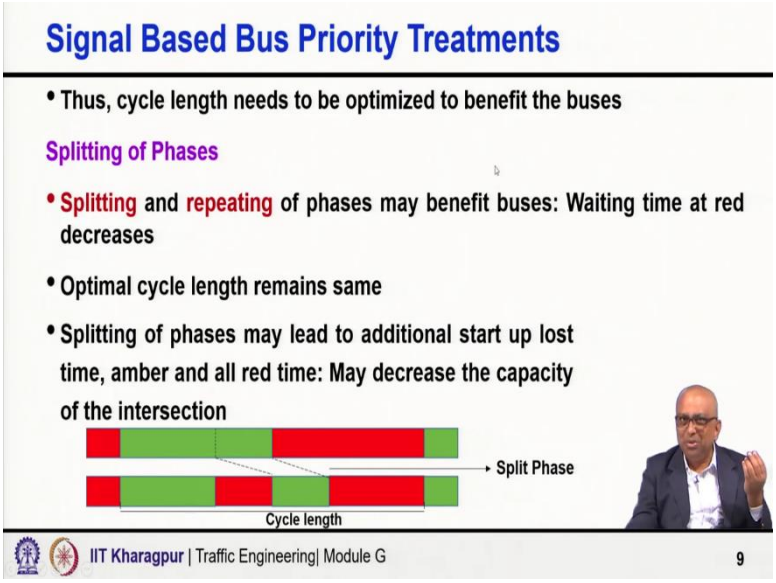

That is what I said thus cycle length needs to be optimized to benefit the buses. Second way of doing it, is splitting the phase. I am not changing the cycle length as I did earlier, but what I am doing, I am actually splitting the phase. So, splitting and repeating of phases may benefit bus users or buses because waiting time at red will decrease. So, the great advantage is that my cycle length calculation, I am not tampering, I am just keeping the optimal cycle length, maintaining that, only thing I am splitting the phases.

And you can see here, that is what you otherwise would have done in a normal way, but now what you have done, you split this make a red here, also split this make a green here. So, the gap between two green reduces, so my bus if it is arriving randomly, it is arriving the delay maximum delay waiting time or delay is actually getting reduced, but remember that again it was splitting the phase.

So, splitting the phase means the start-up loss time amber and all red time will get added more shorter cycle length, also more cycle means per cycle the loss time will be there depending on the phase. So, overall loss time in an hour will increase but within a cycle length, also if you have more phases then also the loss time will get impacted as that is what I am trying to say, right. So, that may impact the capacity, that you have to bear in mind.

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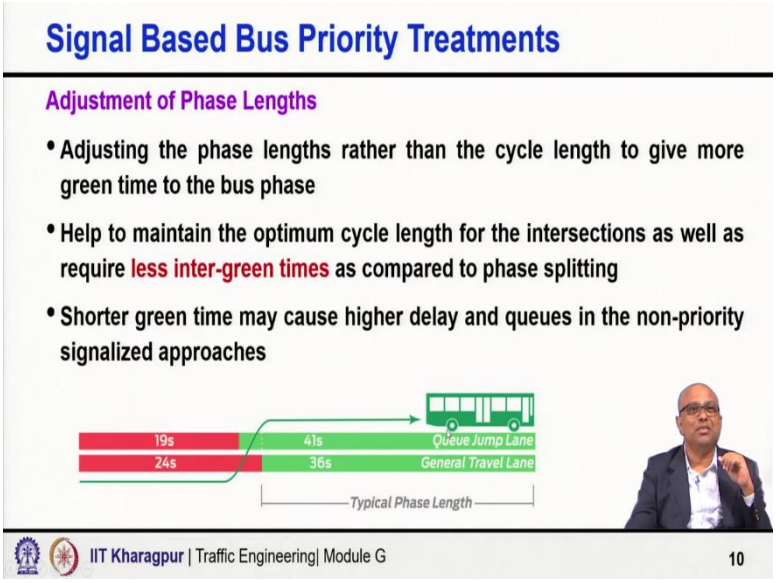

Third, adjustment of the phase length. I did not split but what I did, I adjusted the phase length, give little bit more green to those approach or that approach, those approaches or that approach where you want to give priority to buses. So, normally maybe it could have been general sense, 24 second a red, and 36 second green, I am actually adjusting the phase lengths and I am reducing the red to 19 seconds and giving green to 41 seconds, little higher green, I am giving, to give priority to buses, so the I want to reduce the bus delay.

So, what we are doing? essentially adjusting the phase length rather than the cycle lengths to give more green time to the bus phase and that way we help to maintain the optimum cycle length for the intersection as well as require less inter-green times as compared to phase splitting, those deficiencies we are trying to handle.

Shorter green time may cause higher delay and queues in the non-priority signalized approaches, because if you are taking this additional few seconds, if you are giving green to this bus side at some non-priority approach, you are actually cutting the green time, so there may be higher delay and queue in the non-priority signalized approaches but that you should keep in mind, you should see that how much additional delay is happening.

Is that impact very significant and which is something not acceptable, then you cannot do it, but not that always it will be very high impact and not acceptable, maybe the traffic is not so significant, so you little bit accept that that. I am ready to if this additional delay, the non-priority vehicle has to incur because my overall objective is to optimize the total passenger delay rather than the vehicle delay so it is, okay, for me if I give little bit.

And this delay whatever they have to wait additional time, but that is still within the acceptable threshold people do not that, really do not you know it is not so high that people will get irritated and it will simply not be acceptable to car users may be yes, little bit more delayed, it is still acceptable, so that way it is fine.

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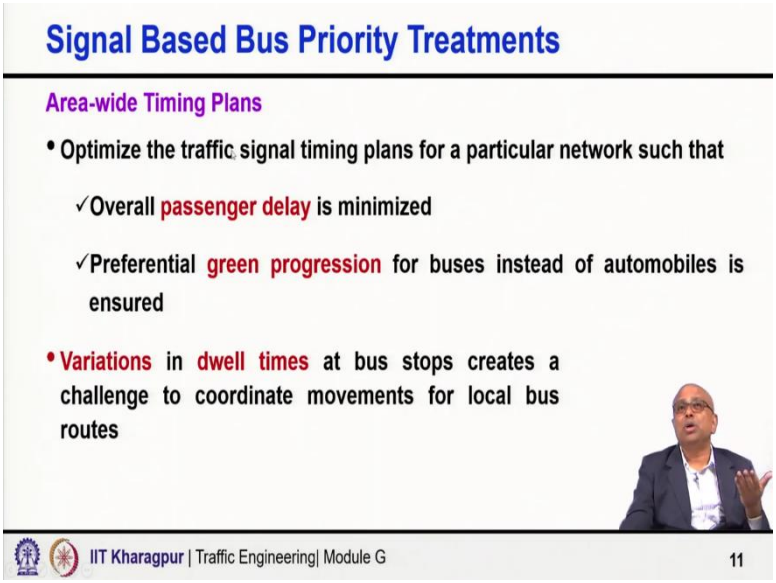

Next, area wide timing plan. Here, we try to optimize the traffic signal timing plan for a particular network such that the overall passenger delay is minimized not the vehicle delay but the passenger delay overall passenger delay is minimized and preferential green progression of buses instead of automobile is ensured, so we want green progression of buses, so my progression also the basic objective of doing the signal coordination or when I am looking at the progression, I am actually now focusing that green progression of buses instead of automobile.

Variation in dwell time at bus stops may create a challenge to coordinate movement of local bus routes, if you know that some stoppage, some buses must stop very long, some stop bus stops are very short then the coordination will get affected, but if there is not so much variation in the dwell time bus to bus or over the analysis period then you can do the coordination.

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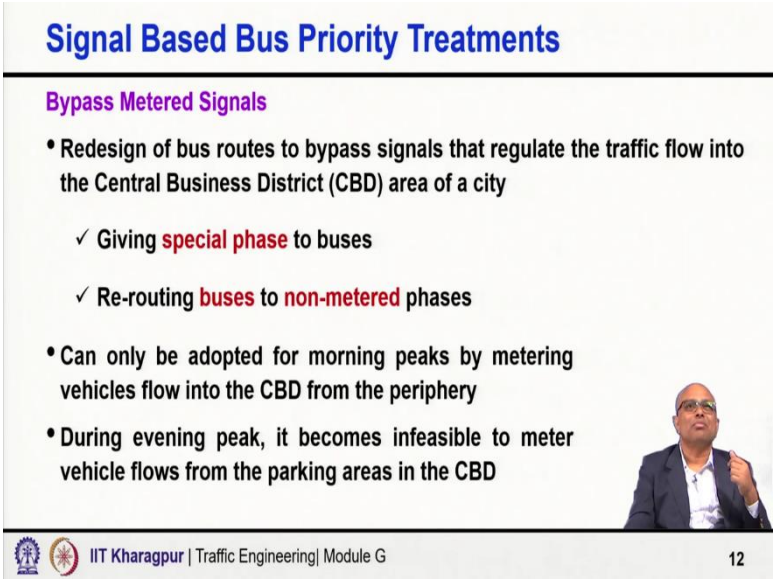

Next strategy could be bypass metered signals what is that sometimes when morning traffic towards CBD the major arterial entry to major arterial is actually metered, that means you know that another road is coming vehicle is entering, I will allow only so many vehicles per minute or per 10 minute or for 5 minute at that rate, only the that is the way the green will be given now the bus has to come in normal situation and along with car bus will wait but what you do, you want to give priority to buses, no, I will not stop buses. So, you do not force the bus to go and stand in the same queue, car join the same queue, you make a provision for the bus to bypass that.

So, bypass bus can bypass this metered signal other vehicles have to follow that, but for bus there is no metered signal, so you can install a separate signal for buses only that is for buses that way you may allow buses to go. So, bypass metered signal redesign of bus routes to bypass signals that regulate the traffic flow into the CBD area, you can do things either you have a special provision for buses and then just pass those buses do not meter the entry of buses or you change the route and allow the buses to get into the arterials through some other intersection, which is not metered, right, so that way.

But remember that morning time towards the CBD, it is very easy or that relatively easy, but return thing it is very difficult because during evening peak, it becomes infeasible to meter vehicle flows from the parking areas in the CBD in the reverse direction, it may not work. So, you can do such kind of things in the morning peak when the travel is happening towards the CBD. That is all about different ways to achieve passive priority. So, what we discussed so far,

all these measures are under passive priority treatment. Next, we are going to discuss active priority within the signal-based priority.

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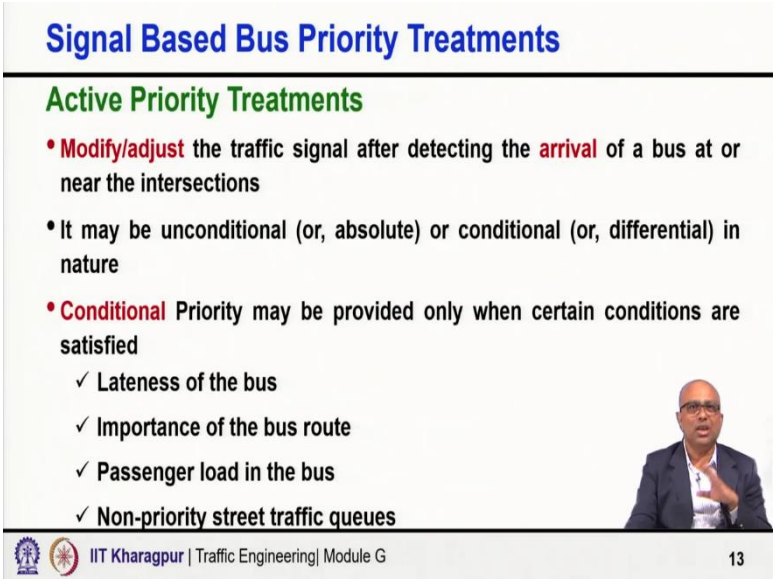

So, active priority means, we try to modify or adjust traffic signals, after detecting the arrival of a bus at or near the intersections, nothing pre-timed. We detect a bus, that a bus has arrived and then may modify or adjust the traffic signal to give priority to buses, so such priorities are given only when you detect that a bus has arrived, that is why it is active priority, not pre-timed.

Now, such kind of active priority may be unconditional that means you detect a bus, bus is arrived, just keep priority every time, you identify bus, just give priority, so that is unconditional or it could be conditional that means, yes, I will give priority looking at so many other things, whether the bus is running on time or as per schedule or running late. If it is running late, I will give priority, I want to help the bus to make up the journey time, if it is on time, fine, I may not or arriving even before, then I do not need to give priority.

Also, I look at the how important this bus route is it regular commute route that actually are taking people or encouraging people to use bus instead of cars because of this attractiveness. What is the passenger load in the bus? If the bus is really carrying some beyond certain threshold passenger, then I can think of giving priority.

How much is the queue in the non-priority state? If the queue is beyond certain threshold value, longer than that maybe I will not give priority to versus such kind of things, examples only, so

it could be unconditional, just a bus is arrived give priority or it could be conditional based on all such or similar kinds of things.

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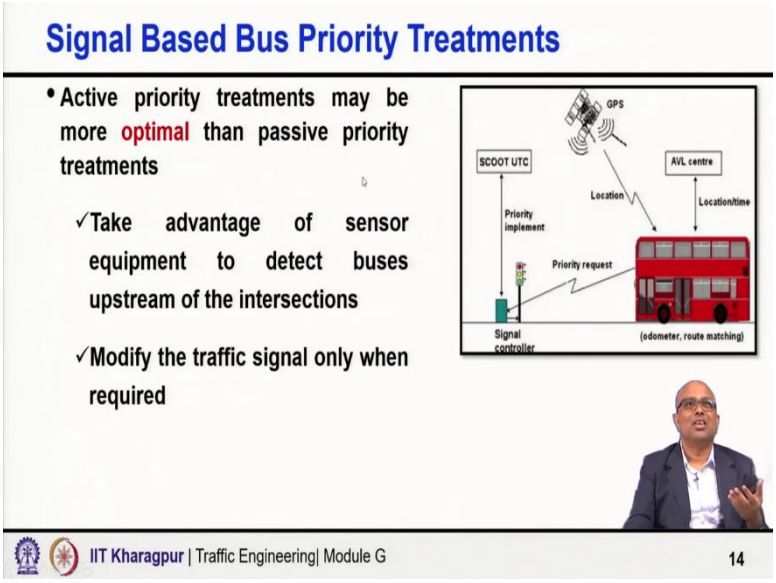

Active priority treatments may be more optimal than passive priority obvious reasons because I know that the bus has arrived, I know the traffic state and therefore I am giving the priority. So, it takes advantage of the sensor equipment to detect buses upstream of the signal or intersection and modify the traffic signal, only when required because. Why I say only when required, because it could be conditional, so not that always you will simply just modify the signal.

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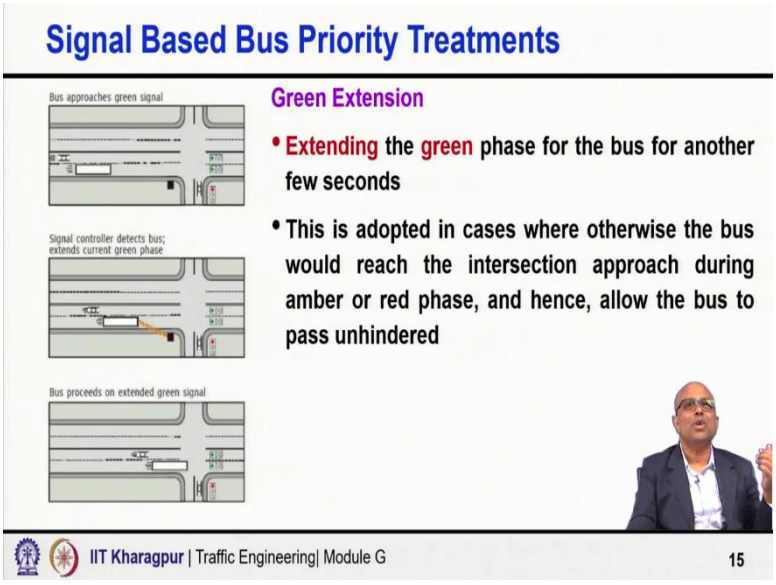

There are different ways I can provide this active priority let us discuss one by one. First thing is the green extension, suppose, in this case if green is about to be over and the signal is supposed to change to red and you detect that the buses arrived, so you extend the green for another few seconds to allow the bus to cross that intersection, that is what is the green extension. You can see here, the bus is there signal is green but then the signal was supposed to change to red, but then a bus is detected.

So, the green is extended you do not change it to red immediately, just to allow the bus to cross that pass through that signal and then the signal becomes red, so you give the green extension. So, extending the green phase for the bus for another few second and this is adopted in case where otherwise the bus would reach the intersection approach during amber or red phase and hence, allow the bus to pass unhindered, you just extend the green let the bus pass through.

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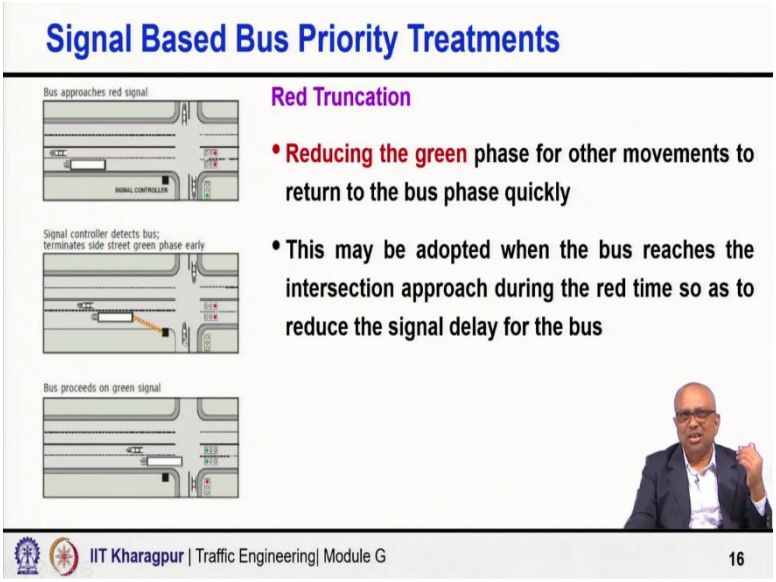

Next, red truncation reverse, here the bus is reaching when the signal is red and you are sensing you know that detector has detected that the bus is arriving and the signal is red, so it actually truncates the red, green for non-priority approach and make the signal red early, make the signal green early, sorry, make the signal green early.

So, I am truncating the red and thereby allowing the bus to pass through in green rather than waiting in red. So, in this case reducing the green phase for other movements to return to the bus phase, quickly, this may be adopted when the bus reaches the intersection approaches during the red time, so as to reduce the signal delay for buses.

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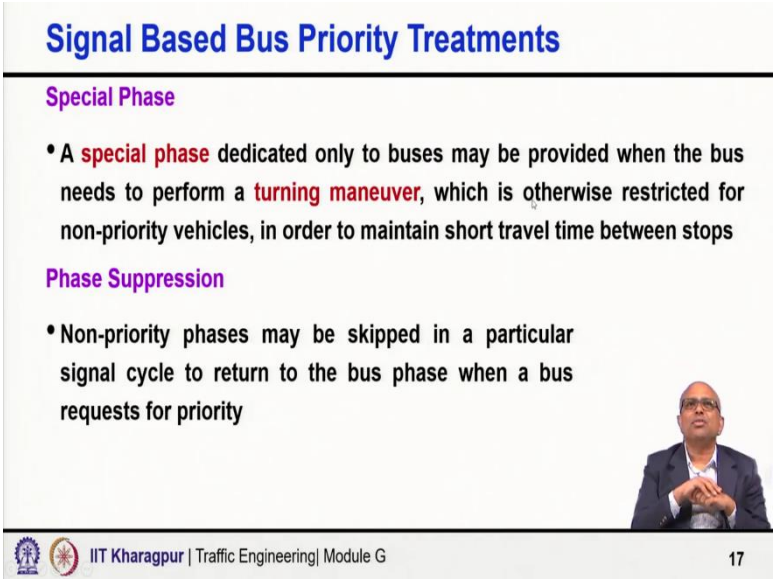

Special phase, a special phase dedicated only to buses may be provided when the bus needs to perform a turning manoeuvre which is otherwise restricted for non-priority vehicle, and why we are allowing this in order to maintain short travel times between stops. So, suppose the right turn is not allowed at an intersection but you give a special phase only to allow buses to take right turn, because you want the bus to gain in terms of generally type between two stops.

Next alternative, phase suppression, what we do here? Non-priority phases, non-priority phases not the bus, bus phase is the priority phase, so where there is you do not want to give priority to buses that kind of movement, that phase, so non-priority phases may be skipped in a particular signal cycle totally, but in a signal cycle to return. To the bus phase, when the bus request for priority, bus has arrived, so you do not want the bus to wait, so you said skip some non-priority phase, did not give green in that cycle, skip that phase directly come to the bus phase and allow the bus to pass through.

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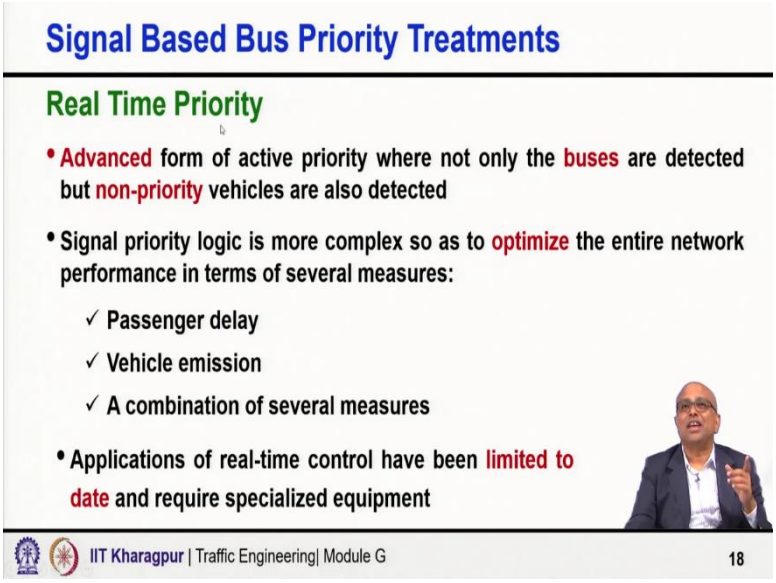

Third, so active passive priority active priority, then third is real time priority, all under signal-based priority treatment. What is real time priority? this is advanced form of active priority where not only buses are detected, but non priority vehicles are also detected. I am not only detecting buses, but I am detecting all vehicles, so it is more holistic in a way.

So, signal priority logic here is more complex so as to optimize the entire network performance in terms of several measures such as passenger delay, vehicle emission, recombination of several measures, and then accordingly I am taking decisions. So, I am taking decision not only by the detecting buses but I am detecting all vehicles and overall, more holistic optimization as per my objective I am able to do. Application of real time control have been limited to that and it requires really specialized equipment and larger framework for application.

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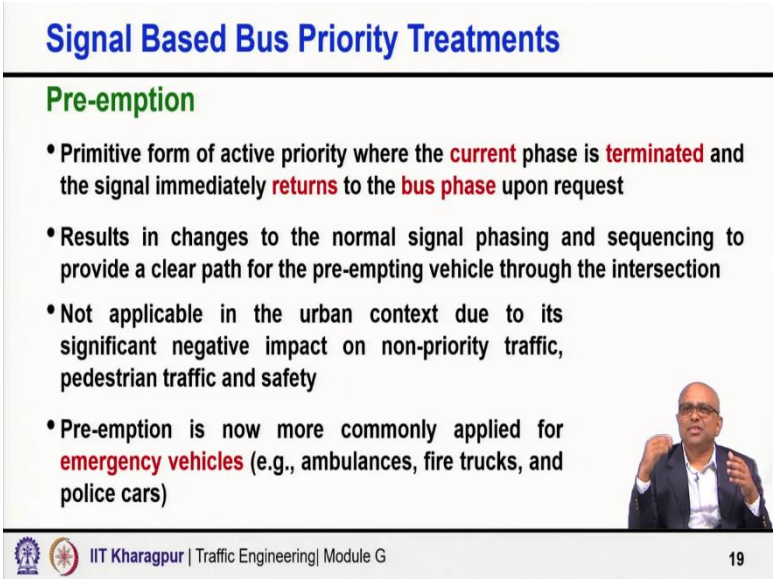

Fourth, pre-emption, pre-emption is the most primitive form of active priority, where this simply the current phase which is not a priority phase, is simply terminated and the signal immediately returns to the bus phase upon request. So, most primitive form, bus is approaching the moment the bus is detected, everything else is given, not given priority, truncated, and directly the green is given to buses.

This results in change to the normal signal phasing, because you are simply disrupting the whole thing, you are not following any cycle length, you are not following the sequence of phases, everything the top priority is the moment the bus is detected give it. So, results in the change in the normal signal phasing and sequencing to provide a clear path for pre-empting vehicle through this intersection and therefore such kind of things are generally not applicable not suitable in urban context, due to significant impact on non-priority traffic even the pedestrian traffic and the overall safety, right.

So, what still we use pre-emption, pre-emption is mostly used these days for emergency vehicles not for buses, fire brigades, fire engines are approaching, ambulances are approaching, police cars are approaching, yes, you can use pre-emption, but generally not used for buses.

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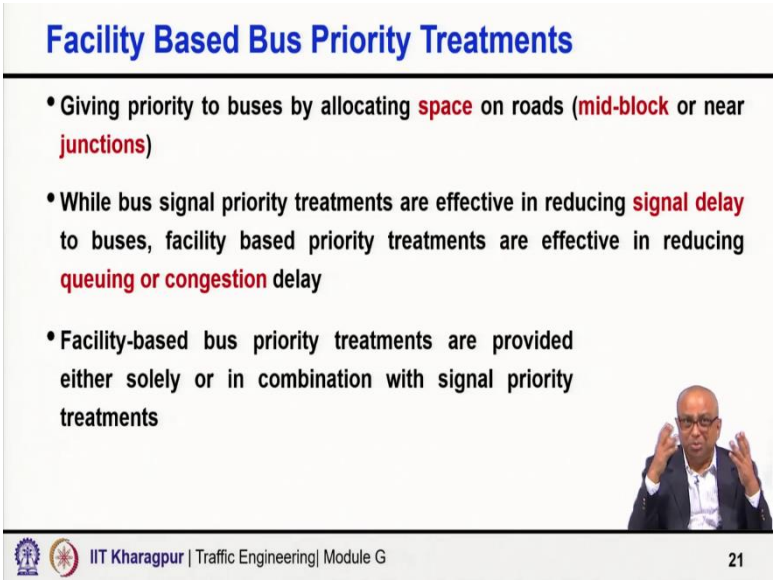

With this, we complete our discussion about the signal-based priority treatment, now going to the other part, facility-based priority treatments. What we mean by that? giving priority to buses, what we mean by facility-based treatments? Giving priority to buses by allocating space on roads it may be mid-block or near the junctions. Understand the difference between the signal-based priority, what we have discussed, and facility-based priority.

Bus signal priority treatments are effective in reducing signal delay to buses, that means I am reaching up to the signal and I was stopping because normally, the I was receiving red, so I had to wait so that red and my delay is reduced, I am giving early green or to reduce my waiting and that way the priority is given. So, signal based treatments are effective in reducing signal delay to buses, but bus has to reach up to the signal.

Often, what you find in the upstream of the signal there will be a long queue. So, bus has to first experience delay because of queuing or position, buses to reach up to the stop line, then only the signal priority can be given. How to reach to this thing, because if the buses to simply remain along with other vehicles, then buses to be there in long time in the queue. So, the facility-based treatments are actually to reduce the queueing delay or congestion delay. So, can I do some facility-based priority, so that bus can early reach to the up to the stop line and then you give signal priority, so bus will pass the signal, across the signal.

So, facility-based priority treatments are provided either solely or in combination with signal priority treatment. You may even decide I will not give priority any separate priority signal, I will simply allow the bus to reach closer to the stop line, that itself is the priority, then let bus pass through, that is also fine, and you may give facility-based priority plus signal-based priority, both.

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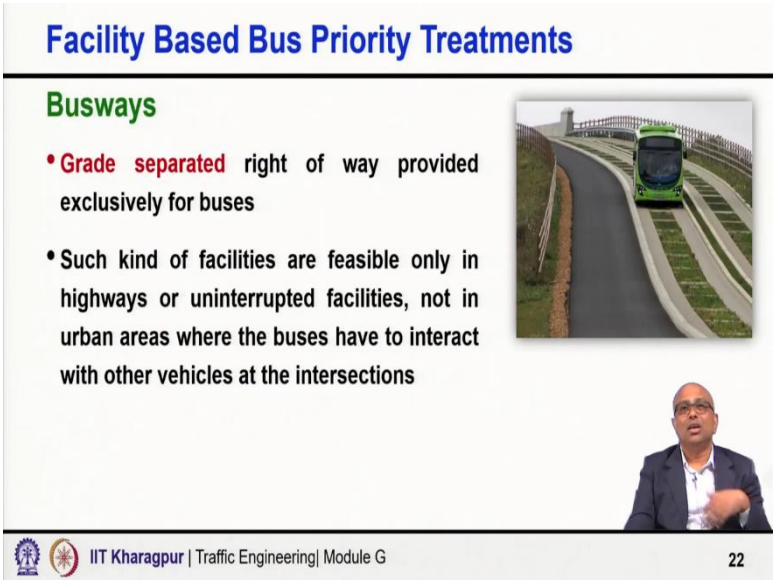

There are different ways we can provide, facility-based priority, first is the bus way. This is a grade separated facility where grade separated right of way is provided exclusively for buses, you can see the photograph. Such kind of facility are feasible only in highways or uninterrupted facilities, not in urban areas where the buses have to interact with other vehicles, especially at the intersections such kind of exclusive facility is really rare. Practically, having this kind of facility is also a problem.

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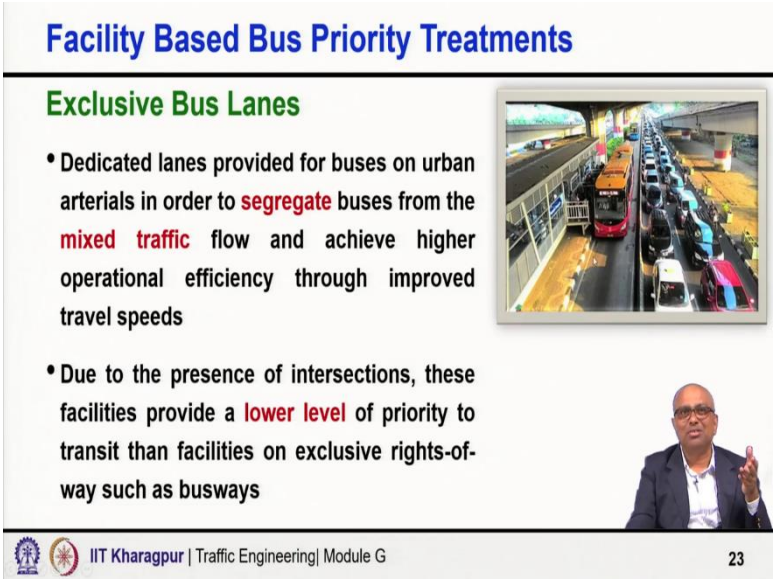

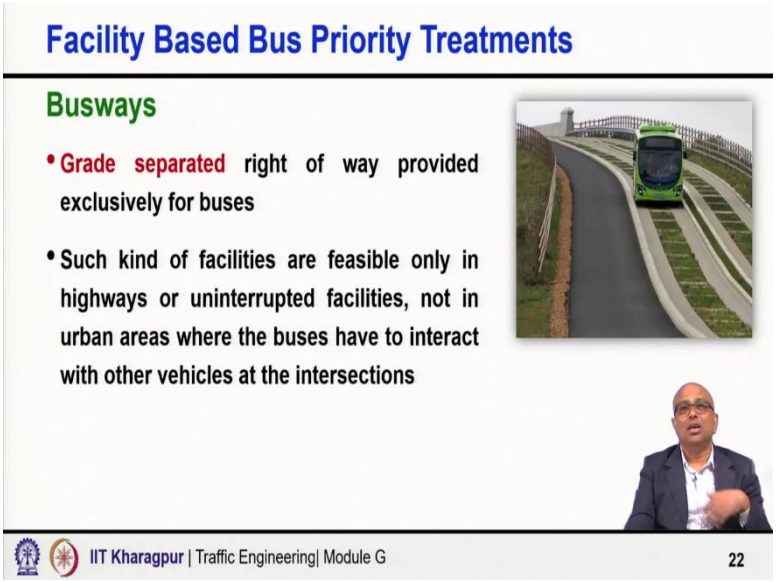

Next is exclusive bus lanes, exclusive bus lanes as you can see in the photo, it is dedicated lane provided for buses on urban arterials, so you are actually segregating bus clearly giving a dedicated lane for buses which cannot be used by other vehicles. So, you can see and this lane is for buses only, so the congestion will not be high, always the congestion will be lower as compared to the congestion on adjacent lanes which are for other vehicles.

So, dedicated lanes provided for buses on urban arterials in order to segregate buses from the mixed traffic flow and therefore or thereby achieve higher operational efficiency through improved travel speed. Now, due to the presence of intersection, these facilities provide a lower level of priority to transit than facilities on exclusive right of ways, such as Busways.

Busways even at intersections is exclusive the whole thing, is exclusive facility that is what I say that, we cannot provide such exclusive facilities in urban area, the availability of land and you know developing such kind of facilities itself is problem, in the presence of so many intersections, so how many through and through you pass take the grade separated facility, right, that is very difficult.

But here the intersections are at grade, where the bus is mixing so the priorities overall you are giving some facility benefited buses are benefited, but in signals it has to interact with other vehicles because this will be simply at grade facilities. So, as I said that due to the presence of intersection, these facilities provide a lower level of priority to transit than facilities on exclusive right of ways such as Busways.

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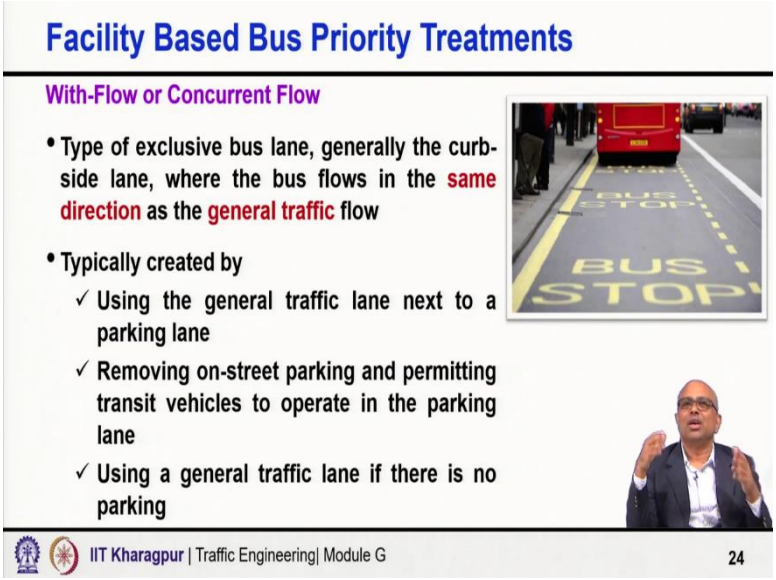

Third, now this exclusive bus lane could operate in so many ways, let us discuss about those. First, with-flow or concurrent flow that means, the way the traffic movement is happening in the same direction my bus is also moving. So typically, type of exclusive lane, generally the curb side lane, right, where the bus flows in the same direction as the general flow.

So, how we create, we typically created create such facilities by using the general traffic lane next to the parking lane. Sometimes, removing on street parking and permitting transit vehicles to operate in the parking lane, using a general traffic lane if there is no parking, that is are the alternative ways, we can create the lane.

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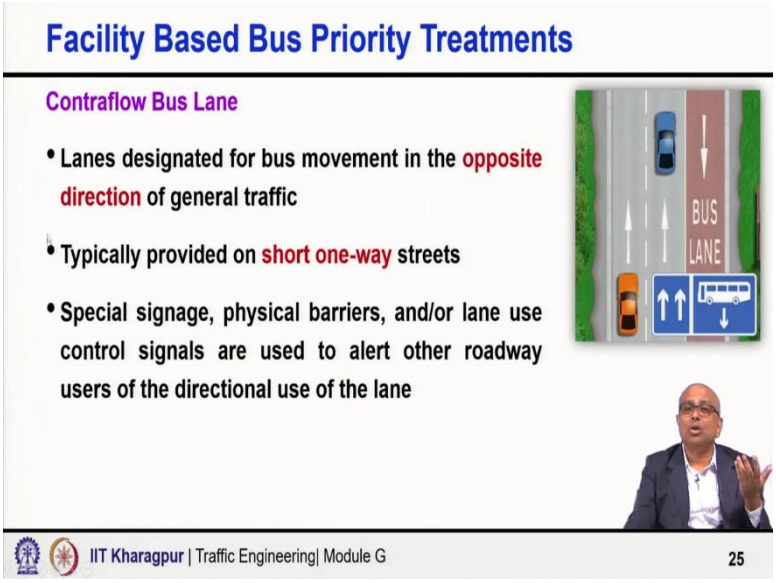

It could be, as I said it could be concurrent flow, with-flow or concurrent flow, it could be contraflow bus lane, you understand. The general vehicle moving in one direction, bus is moving in another direction, sometimes we do that to gain some benefit, right, because the side friction will be too much, if the bus is moving in the curb side lane as shown for the concurrent flow facility.

So, you sometimes use contraflow bus lane, so lanes designated for bus movement in the opposite direction of general traffic and typically provided such kind of contraflow bus lane is only for short one street, may be in general its one-way street but you allow the bus also to travel in the other direction.

Of course we need to use special signage, physical barrier, and or lane use control signals to alert other roadway users of the direction use of the lane, because people generally do not expect, because it is a one way street people need will move in one direction, so they do not expect the bus to come from the opposite direction, so you have to do everything to avoid any confusion and clearly communicate to other road users, that yes, that is for the bus, and the bus is allowed to travel in the opposite direction or in the contra-flow direction.

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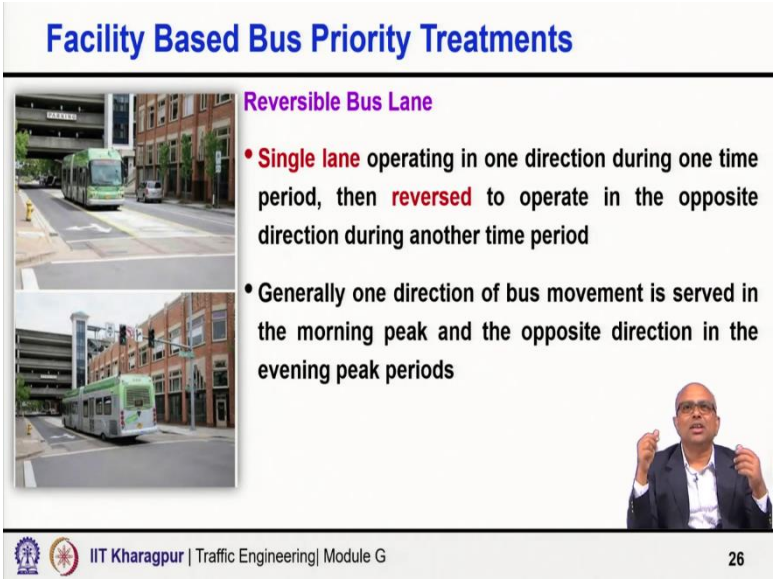

Third, reversible bus lane. It is a single lane operating in one direction during one time and then reverse to operate, reverse to operate in the opposite direction during another time. Generally, one direction of bus movement is served in the morning peak and the opposite direction in the evening.

So, morning may be north to south, evening south to north, same facility, a single lane morning operating in one direction, afternoon operating in another direction. Generally, it is done like this, so that is called is reversible bus lane. So, single lane in one direction during one-time period and then reverse to operate in the opposite direction during another time period.

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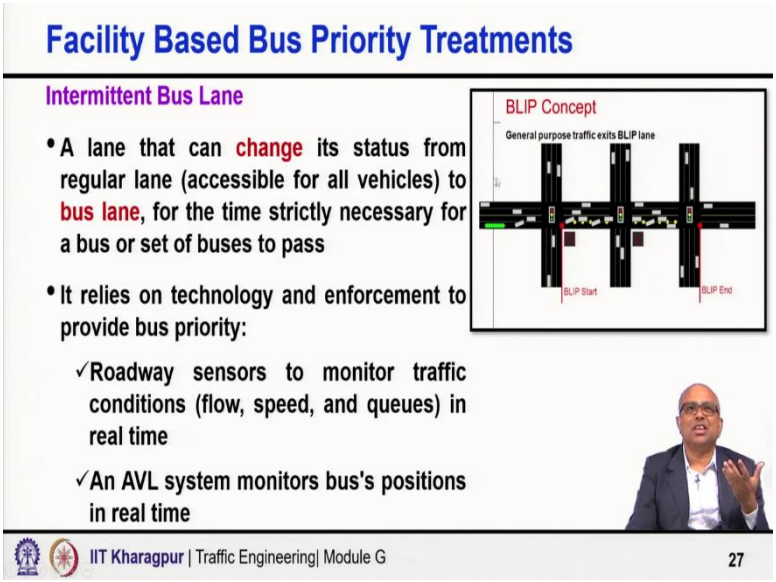

It could also be not so common, but intermittent bus lane, what does it mean? a lane that can change its status from a regular lane, which can be used by all vehicles, to a bus lane for the time strictly necessary for a bus or a set of bus to pass, when there is a bus, then that is the bus, when there is no bus, there is just like other lanes, basically optimizing the use of the facility, that is the objective.

Of course, it relies on technology and enforcement to provide bus priority because you know, otherwise it will be confusing when it is operating as a bus lane and when it is operating just like a normal lane, that is to be communicated, and that is to be recognized in a very nice manner, without any confusion. So, it relies on technology and enforcement to provide bus priority. Roadway sensors to monitor traffic conditions that is required in real time and an automatic vehicle location systems AVL system monitors, buses position in real time.

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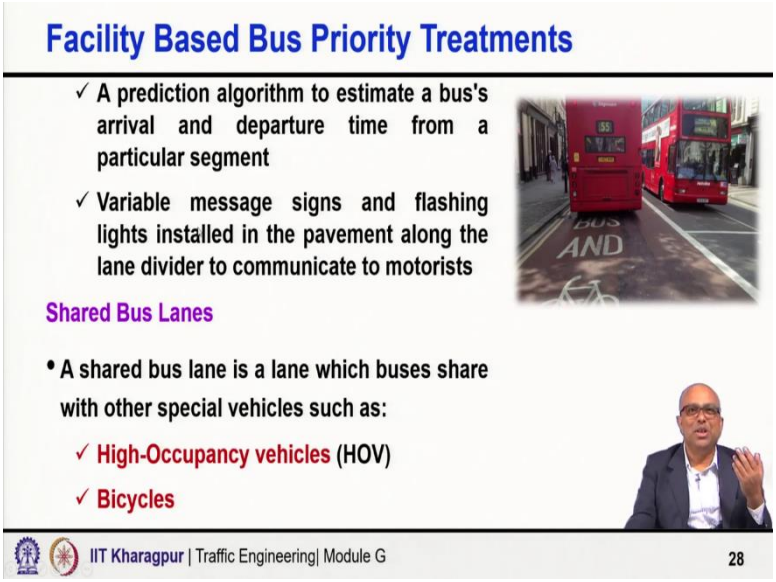

A prediction algorithm to estimate buses arrival at departure time for a particular from a particular segment, that also is necessary and variable message sign and flashing light installed in the pavement along the lane divider to communicate to motorist, when it is operating as an exclusive bus lane or it is working as a bus lane.

Then, another good form could be shared bus lane. Here, it is not only buses but also for high occupancy vehicles, sometimes bicycle but not very desirable as well. With other high occupancy vehicle it is fine, because motorized and non-motorized mix buses and cycles going together that may not be really desirable, unless the volume wise both are less, so that

practically there is hardly any interaction, then it is different but most of the cases it may not be so. So, shared means it is not only bus but also high occupancy vehicle.

You know that where car sharing is happening, then pooling is happening, so not non-sov, not single occupant vehicles, right, non-SOV vehicles, so for their that they are also allowed, so they are, they and bus, they share the same priority length.

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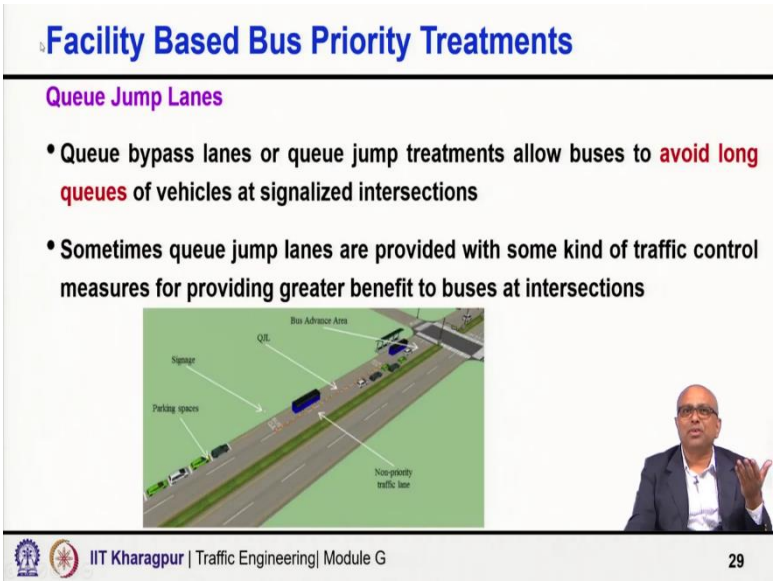

The queue jump length is the next part. As I said, queue jump pass by pass the lane or queue jump treat treatments allow buses to avoid long queues of vehicles at signalized intersection, what happens as I say especially important specially, especially, important for signals and very very useful when you are actually doing a signal priority also, you use a queue jump lane, so you give facility based priority and then give the signal base priority, that really works very well.

So, what is the thing? the bus will jump the queue however bus will jump bus cannot fly that it will jump. So, you create a portion some sort segment looking at the how much is generally the queue length, so it has to be, you know upstream, of that the entry point. Otherwise if the queue is extending bus cannot even enter into this queue jump length.

Otherwise the idea is restricting this segment only for buses, so if there are other vehicles, it has to join the queue, go straight and join the queue, if it is buses, bus will take left or right as appropriate, in this case this is shown like this, so it is on the Indian condition driving, so it is left side, it could be on the right side also, depending on which way the buses are turning left turn, right turn or going straight, depending on all those.

One has to decide but bus lane entry to the queue jump lane, sorry, entry to the queue jump lane is permitted only for buses. So, other vehicles will go and join the normal queue, bus will take the queue jump lane and go ahead, and then come in front of the signal. Sometimes, there may be bus advance area also, so the bus will go and wait there. So, many other form, there could be a free signal, the bus may use the queue jump lane and then go to the bus advance area, and whereas other vehicles will be restricted, little bit before.

So, what we are allowing, otherwise bus would have come and joined the queue, and then they have to giving delay will be really too much for the buses. So, what we are allowing just by providing this facility-based priority? We are allowing the pass as if to jump the queue, and going in front of that, so that is what it is. So, queue jump, sometimes queue jump lanes are provided with some kind of traffic control measure for providing greater benefit to buses at intersection.

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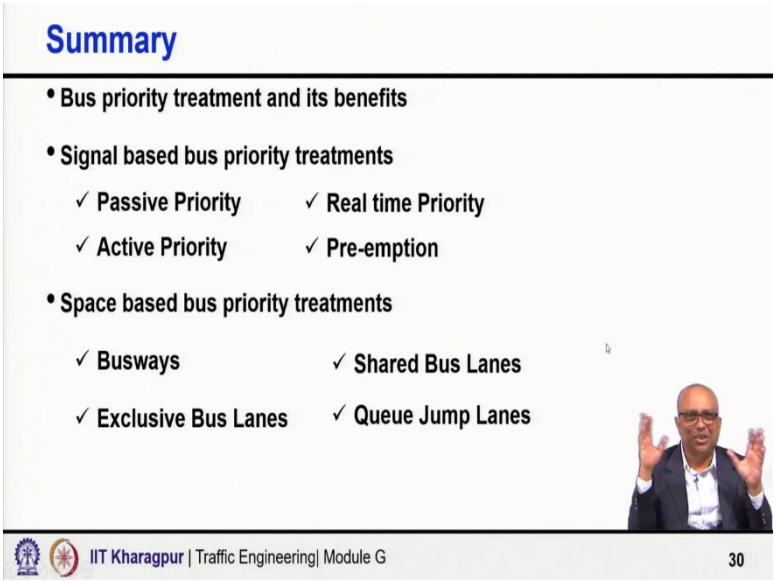

So, with this I close this lecture. So, what we discussed about the various bus priority treatments and its benefit. Primarily, to classification signal-based bus priority, facility-based bus priority, signal based bus priority could be active priority, passive priority, real time priority, pre-emption, and space or facility-based priority may include bus ways, shared bus lane, exclusive bus lane, or it could be queue jump lane as well, right. So, with this background, I close this lecture. Thank you so much.