

**Traffic Engineering**  
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**Lecture 29**

**Intersection Control & Critical Aspects of Operation - III**

Welcome to Module E, lecture 3. In this lecture also, we shall continue our discussion about Intersection Control and Critical Aspects of Operation.

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### Recap of Lecture E.2

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- **Levels of intersection control**
  - ✓ **Semi-control**
    - Yield signs & stop signs
    - Channelization
  - ✓ **Active control**
    - Traffic signalization
    - Grade separation
- **Data requirements for justifying traffic control signals**
- **MUTCD warrants for traffic signal control**

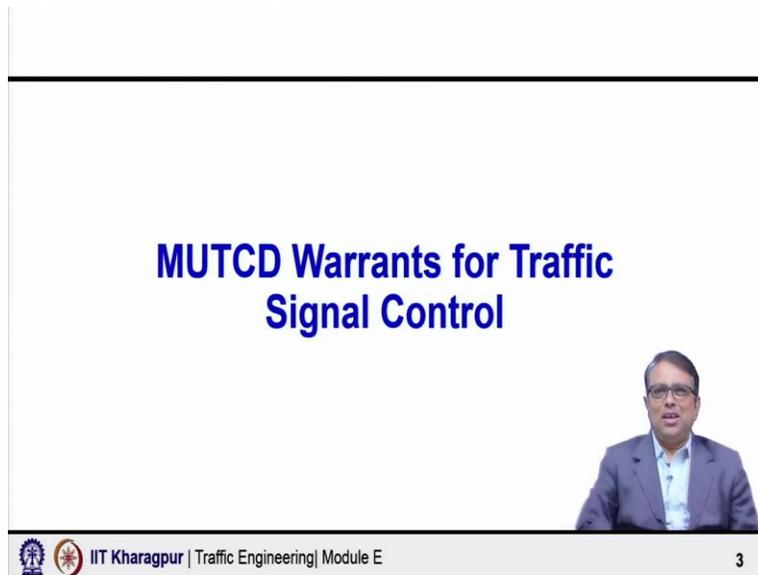


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In lecture 2, I mentioned to you about two types of control at intersections one is semi control primarily using yield sign or stop sign and also the usefulness of channelization. Then, we discussed about active control first by providing traffic signal time segregation of conflicting movements at grade intersection and then if that is also not able to produce satisfactory performance, then go for the next level of active control or highest level of control that is grade separation.

Then with a brief introduction about all three types of control, passive control, semi control and active control then, we started discussion on the data requirements for justifying traffic control signal. What all investigations field investigations and data are actually required to justify and then just quickly listed you are quickly listed various warrants, MUTCD warrants that are used to justify traffic signal control at an given intersection or for a given scenario.

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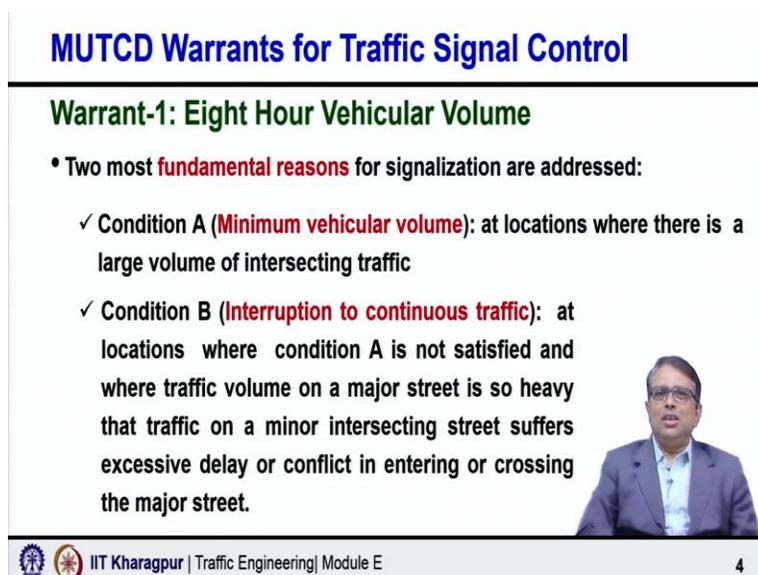
A presentation slide with a white background. The title "MUTCD Warrants for Traffic Signal Control" is centered in blue. A small video inset of a man in a suit is in the bottom right. The footer contains the IIT Kharagpur logo, the text "IIT Kharagpur | Traffic Engineering | Module E", and the number "3".

## MUTCD Warrants for Traffic Signal Control

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So, today, we shall discuss in details a little bit more details. Today we shall discuss in little bit more details about the MUTCD warrants for traffic signal control. Why I say a little bit more details because this actually lot of things are there. So, I shall mention to you about the key points and the key considerations, then you can always refer to this document this you can access this document it is available you can download and you can read in more details if you are interested.

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A presentation slide with a white background. The title "MUTCD Warrants for Traffic Signal Control" is at the top. Below it is "Warrant-1: Eight Hour Vehicular Volume" in green. A bulleted list follows. A small video inset of a man in a suit is in the bottom right. The footer contains the IIT Kharagpur logo, the text "IIT Kharagpur | Traffic Engineering | Module E", and the number "4".

## MUTCD Warrants for Traffic Signal Control

### Warrant-1: Eight Hour Vehicular Volume

- Two most **fundamental reasons** for signalization are addressed:
  - ✓ Condition A (**Minimum vehicular volume**): at locations where there is a large volume of intersecting traffic
  - ✓ Condition B (**Interruption to continuous traffic**): at locations where condition A is not satisfied and where traffic volume on a major street is so heavy that traffic on a minor intersecting street suffers excessive delay or conflict in entering or crossing the major street.

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First, warrant 1 is related to 8-hour vehicle volume and it tries to account for the two fundamental reasons for signalization. One is by vehicular volume, basically large volume of intersecting traffic that is one problem because we say that the major problems in efficiency in terms of delay in terms of queuing in terms of even safety all relates to basically the vehicle volume intersecting traffic, how much is that volume.

So, the condition A actually tries to tell you minimum vehicular volume threshold value beyond which the signalization may be justified. Condition B may be used where condition A is not, satisfying the existing situation does not qualify as per condition A, but condition B in that case, if it is satisfied, then also the signalization may be justified. So, condition B actually tries to consider traffic volume on major streets is so heavy that traffic on a minor intersecting street suffers excessive delay or conflict entering on crossing a major street.

That means it is typically the other consideration how much the traffic volume on the major streets. And also, on the minor street a combination always does not provide really the adequate opportunity to minor street traffic to do the required maneuver. Opportunity means, it provides opportunity definitely but with excessive delay or conflict in entering or crossing the major streets.

So, the first related to overall intersecting traffic the second basically the how the minor intersecting street traffic to what extent they are suffering in terms of excessive delay or conflict. So, these are the two major consideration. So, the first condition overall vehicle volume and here the opportunity for the minor street traffic to do the maneuver considering primarily the traffic volume on the major streets and also of course, the minor street volume.

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## MUTCD Warrants for Traffic Signal Control

- **Standard:** One of following conditions must be met for each of any 8 hours

- ✓ The vehicles per hour given in both of the **100 percent columns of Condition A** in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection

Table 4C-1. Warrant 1, Eight-Hour Vehicular Volume

Condition A—Minimum Vehicular Volume

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100% <sup>a</sup>	80% <sup>b</sup>	70% <sup>c</sup>	56% <sup>d</sup>	100% <sup>a</sup>	80% <sup>b</sup>	70% <sup>c</sup>	56% <sup>d</sup>
1	1	500	400	350	280	150	120	105	84
2 or more	1	600	480	420	336	150	120	105	84
2 or more	2 or more	600	480	420	336	200	160	140	112
1	2 or more	500	400	350	280	200	160	140	112



So, one of the following conditions either A or B should be satisfied for each of any 8 hours in a typical workday or weekday. So, you can see here first of all different configurations of major streets and minor street. So, one lane, two or more lane on major street single and on minor street. Two or more lane on major street two or more lane or minor street, single lane on major street, two or more lanes on minor street.

All different combinations for all different combinations the traffic volume threshold is given, now threshold is given for two roads major and minor both. So, the first one is vehicles per hour on major street. Total of both approaches. And the second one minor street traffic. So, vehicles per hour on higher volume minor street approach, please carefully observe that, it is higher volume minor street approach and therefore one direction only.

So, there are again further divisions here. Let us first consider about this 100 percent column here and 100 percent column there for minor street approach those are under regular condition. I shall explain you also that where we can or we should go consider b c or d. So, that means it is telling the vehicles per hour on major street is say 500 and more if the vehicle **per hour on** higher volume minor street is 150 or more and if minor street is also one lane then having one lane. Major street also is having one lane, then a signalization may be required or further investigation should be done.

You can see here the traffic volume when the major street is single lane then it is 500 both cases. So, first row 1 1 500 and again 1 and then 2 or more is also 500. And when the major street goes 2 or more than the threshold volume is obviously higher instead of 500 it is 600. Similarly, the minor street volume when only a single lane on minor street, it is 150 When two or more on minor street, lane on minor street then it is 200. So, that is what it is, what is b c and d I shall explain in the next slide.

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### MUTCD Warrants for Traffic Signal Control

✓ The vehicles per hour given in both of the **100 percent columns of Condition B** in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection

Condition B—Interruption of Continuous Traffic

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100% <sup>a</sup>	80% <sup>b</sup>	70% <sup>c</sup>	56% <sup>d</sup>	100% <sup>a</sup>	80% <sup>b</sup>	70% <sup>c</sup>	56% <sup>d</sup>
1	1	750	600	525	420	75	60	53	42
2 or more	1	900	720	630	504	75	60	53	42
2 or more	2 or more	900	720	630	504	100	80	70	56
1	2 or more	750	600	525	420	100	80	70	56

<sup>a</sup> Basic minimum hourly volume;

<sup>b</sup> Used for combination of Conditions A and B after adequate trial of other remedial measures;

<sup>c</sup> Used when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000;

<sup>d</sup> Used for combination of Conditions A and B after adequate trial of other remedial measures under c above

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So, this is condition A, similarly, there is a condition B, I said two condition, condition A and condition B. Now, condition B also exactly similar, major street and minor street are different configuration, there is also a threshold for vehicles per hour on major street and vehicles per hour on higher value minor street and here also similarly like one column 100 percent for major street, another column 100 percent for minor street.

Like here you can say, here the corresponding say for example, one major street one minor street the major street volume threshold was 500. But it is heavier than that. So that threshold here it is 750. For 2 or more the major street volume was 600. Here the threshold is 900. So, the major street volume is high, reasonably high. So, that minor street does not get adequate opportunity or they have to suffer excessive delay in order to get an opportunity to cross.

So, the minor street volume in this condition B, will be lower. Major street, will be higher, because that is the road we are trying to cross from minor street approach and the minor street volume will be little lower. So, that way the combination, so, just to tell you here, when there is one minor street the threshold value was 150 vehicles per hour and 2 and more 200.

Now, the corresponding values are here 75 and 100. So, lower, so the minor street volumes, are lower, but the major street volumes are higher, because the aspect what we are trying to capture through this condition A and condition B they are different aspects. Now, let me tell you what is b c and d.

Let first go to c, c is actually 70 percent of a that is where we considered 100 percent all cases, here also in condition B also in condition A you can consider c is 70 percent of a because if we consider 100 percent then it is 70 percent of that value major street minor street, condition A condition B always another scenario is created with where it is 70 percent value, that is the threshold. What is that condition?

That condition is when major street speed exceeds 40 mile per hour. Normally, we do not use miles per hour but because since the MUTCD warrants are used using mile per hour, I wanted to retain the same values, I did not want to convert or in an isolated community with a population of less than 10,000.

So, you have an isolated community and there if the roads are passing through an isolated community, means indirectly the local traffic the pedestrians indirectly all this consideration. So, they are even at a lower volume because it is within a population of less than 10,000 and the speed is more than 40 miles per hour. So, under the situation, even 70 percent of the normal values, threshold values would be considered that is the condition c, so everywhere abcd.

So, a you know under normal condition and c you know. Now, what is b and what is d. b used for combination of conditions A and B after adequate trial of other measures, that means, what threshold has said under column a is whether I am able to satisfy condition A yes go for considered for signalization at least make further investigation. Am I able to satisfy B yes, then 100 percent take that 100 percent column and say yes, and then go ahead.

But here neither A 100 percent is satisfied nor B alone 100 percent is not satisfied, but then you are considering a combination of both A and B satisfied, but not either this or this but both A and B that that is what it is. And you will see there will be a case, later on I will tell it in subsequent one of the subsequent slides where this 80 percent thing also will come. So, that is what is b.

Similarly, wherever you have condition like c, that means major street speed exceeds 40 mile per hour or in an isolated community with a population of less than 10,000, so either speed is higher or passing through an isolated road, is passing through an isolated community with a population of less than 10,000.

There also again, if either A or B, individually A and B with 100 percent are not satisfied. Neither 100 percent of A satisfied nor 100 percent B satisfied. But if we are thinking of A and B, both satisfied by 80 percent but 80 percent of now, this c condition B was 80 percent of A condition and d is 80 percent of c condition. So, 80 percent of 70 percent that is why it is 56 percent.

So, main A then if it is speed is higher exceeds 40 mile per hour or passing through an isolated community with a population of less than 10,000 then you have conditioned c, now both cases normal condition either A with 100 percent is satisfied or condition B with 100 percent is satisfied, then it is either this or this, but c and d are again with respect to their original condition like B, b and d with respect to their original condition a and c respectively.

So, in that case A and B both are getting satisfied at 80 percent level with reference to A situation that gives you scenario B and these again A and B neither of them getting satisfied with 100 percent but, both of them are getting satisfied at 80 percent level that gives you scenario d with a similar condition of like scenario c that means, the speed is higher than 40 mile per hour and it is or it is passing through isolated community with a population of less than 10,000.

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## MUTCD Warrants for Traffic Signal Control

### Warrant 2: Four-Hour Vehicular Volume

- Principal reason: Volume of intersecting traffic

**Standard:** For each of any 4 hours of an average day, the plotted points fall above the applicable curve for the existing combination of approach lanes

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## MUTCD Warrants for Traffic Signal Control

✓ The vehicles per hour given in both of the **100 percent columns of Condition B** in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection

Condition B—Interruption of Continuous Traffic

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
		100% <sup>a</sup>	80% <sup>b</sup>	70% <sup>c</sup>	56% <sup>d</sup>	100% <sup>a</sup>	80% <sup>b</sup>	70% <sup>c</sup>	56% <sup>d</sup>
Major Street	Minor Street								
1	1	750	600	525	420	75	60	53	42
2 or more	1	900	720	630	504	75	60	53	42
2 or more	2 or more	900	720	630	504	100	80	70	56
1	2 or more	750	600	525	420	100	80	70	56

a Basic minimum hourly volume;

b Used for combination of Conditions A and B after adequate trial of other remedial measures;

c Used when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000;

d Used for combination of Conditions A and B after adequate trial of other remedial measures under c above

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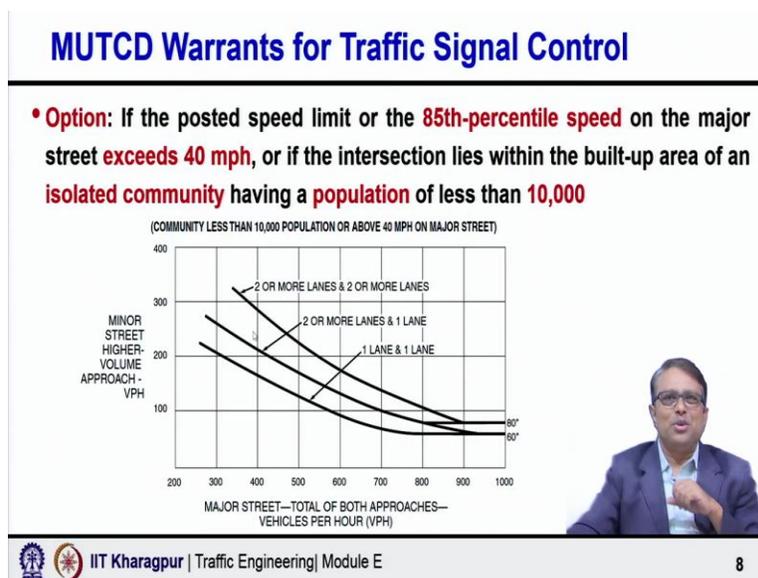
Now, next is instead of 8 hours now, we are considering 4 hour vehicle volume, everything else is conceptually very similar to warrant one, but only the vehicle volume we are considering is four hour vehicle volume. So, here again the volume of intersecting traffic typically morning and evening hours or so. And for each of the 4 hours of an average day, the plotted points fall above the applicable car for the existing combination of approaches.

Here I will see if I can see there is a major street traffic volume just like other case, remember that every table there is a major street traffic volume, there is a minor street traffic volume here also

the same thing that is a major street traffic volume in X axis, minor street traffic volume in Y axis and they are we considered four scenario 1-1, 2-1, 2-2, 1-2.

Here we are considering out of those 4, 3 scenario is more likely to give rise to this kind of conditions. So, 1-1, 2-1 and then 2-2, 1-2 is not considered. So, 2 or more lanes and 2 or more lanes major or minor both and then such kind of combinations are there. So, if you are existing 4 hour vehicle volume, if the point is above the corresponding line that means volume wise it satisfy, it will satisfy this warrant. So, that is what is then as you said, one is normal condition, another is again that 40 mile per hour or isolated community of having population up to 10,000.

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So, that again is considered So, one more similar plot is given same you have a major street traffic volume, you have a minor street traffic volume, but here the thresholds will be lower. You remember earlier condition A and you know Scenario a with 100 percent and then 70 percent. So, similar kind of here, there are two charts or graphs which are given. So, that first one we will use for an in a normal condition or second one again with 4 hour traffic volume we shall use when the speed is 40 mile per hour or higher than 40 mile per hour and or it is passing through a built up area in an isolated community head having a population up to 10,000.

Now these 40 miles per hour it could be posted speed limit or the 85th percentile speed on the major street. So that way you can see the very similar consideration but only the traffic volume

considered here is 4 hour vehicle volume instead of eight hour. And you have again as I said that you have one scenario here 100 percent a, 100 percent a and then 70 percent c 70 percent c, both cases. So, those combinations are coming, these are first one is with 100 percent 100 percent normal scenario and the second one is with that scenario where this speed is on the major street is more than 40 mile per hour or the road is passing through a built-up area of an isolated community having a population of less than 10,000.

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**MUTCD Warrants for Traffic Signal Control**

**Warrant 3: Peak Hour**

- **Principal reason:** Undue delay on minor-street traffic
- **Application:** Office or industrial complexes, or high-occupancy facilities that attract or discharge large numbers of vehicles over a short time
- **Standard:** Criteria in either of the two categories are met (Figure 4C-3)
  - ✓ Volume condition similar to Warrant 2
  - ✓ For any four consecutive 15-minute periods all three conditions are met
    - **Total stopped time delay:** 4 veh-hours delay for one-lane/ 5 veh-hours for two-lane approach

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Now, warrant 3 now, 8 hour we have considered then the 4 hour now, it is the peak hour. So, peak hour again application typically is for office or industrial complexes or high occupancy facilities that attract or discharge large number of vehicles over a short time maybe during opening closing time or so, and a lot of movements are happening when the starting time of the industries or you know, other high occupancy facilities starting and closing.

So, discharged large number of vehicles over a short time that is why we are not considering 8 hour or 4 hour but we are considering the peak hour volume. So, their criteria is either of the two categories are met, first there is a volume condition similar to what we have discussed earlier in warrant two, similar kind of condition there is a volume warrant, the second is something different. So, first let me show you the volume warrant.

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### MUTCD Warrants for Traffic Signal Control

Figure 4C-3. Warrant 3, Peak Hour

- Minor street volume: 100 veh/h for one lane traffic or 150 veh/h for two-lane traffic respectively
- Total intersection volume exceeds: 650 veh/h for 3 approaches or 800 veh/h for 4 or more approaches

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It is like this again major street traffic volume, minor street traffic volume everything is same again 1 lane 1 lane, 2 or more lane, 1 lane 2 lane or more and 2 lane or more major minor combinations.

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### MUTCD Warrants for Traffic Signal Control

- Option: If the posted speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-4 may be used in place of Figure 4C-3

Figure 4C-4. Warrant 3, Peak Hour (70% Factor)  
(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 40 MPH ON MAJOR STREET)

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And this is again similarly, with that 70 percent factor that means isolated community having 10,000 less than 10,000 population or the speed is on the major street is 40 mile per hour. So, as like 8 hour volume case four hour volume case in peak hour volume case also we have two scenario this is the normal scenario, traffic volume threshold and this is the we can say somewhat special

scenario where the major streets speed is more than 40 mile per hour or the road or the junction is located in an isolated community having a population of less than 10,000. So, these two are typical volumes are in very similar to scenario or warrant 2.

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**MUTCD Warrants for Traffic Signal Control**

**Warrant 3: Peak Hour**

- **Principal reason:** Undue delay on minor-street traffic
- **Application:** Office or industrial complexes, or high-occupancy facilities that attract or discharge large numbers of vehicles over a short time
- **Standard:** Criteria in either of the two categories are met (Figure 4C-3)
  - ✓ Volume condition similar to Warrant 2
  - ✓ For any four consecutive 15-minute periods all three conditions are met
    - **Total stopped time delay:** 4 veh-hours delay for one-lane/ 5 veh-hours for two-lane approach

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Instead of 4 hours, what we considered here in warrant 2, we are only considering here the peak hour. So, obviously, the threshold values are slightly different. Conceptually otherwise it is same that is one. Or the second warrant is multiple conditions to be satisfied together. So, for any 4 consecutive 15 minute period, all three conditions are met what are those three conditions one is total stock time delay, total stock time delay, 4 vehicle hours delay for one lane or 5 vehicle hour delay for two lane approach, the approach could be a single lane or two lane approach. So, if it is a single lane approach, you have total stop time delay at least is for vehicle hours. Or if it is a two lane approach then 5 vehicle hours, that is one.

Second, minor street traffic volume 100 vehicle per hour for one lane traffic or 150 vehicle per hour for two lane traffic that is the second condition which is to be satisfied. Third condition, total intersection volume exceeds 650 vehicle per hour for three approaches and 800 vehicle per hour for 4 or more approaches. So, one warrant is about the delay in the peak hour. The other warrant is minor street volume and the next one is total intersection volume. So, all the three are to be satisfied, all the three had to be satisfied.

Either all the three had to be satisfied or volume conditions only as I said very similar to warrant two. This graph and the special case the other graph, this volume conditions have to be satisfied. So, either these one of these two graphs or alternatively all these three conditions for any consecutive 15-minute period.

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## MUTCD Warrants for Traffic Signal Control

### Warrant 4: Pedestrian Volume

- **Principal reason:** Pedestrians experience excessive delay in crossing major street due to the heavy vehicular volume on major street
- **Standard:** One of the following criteria is met:
  - ✓ For any 4 hours of an average day, plots of total pedestrians crossing the major street and the total major street vehicular traffic falls over the line in Figure 4C-5, OR

TOTAL OF ALL PEDESTRIANS CROSSING MAJOR STREET PER HOUR (PPH)

Figure 4C-5. Warrant 4, Pedestrian Four-Hour Volume

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Now going to warrant 4, till this time it was all vehicle volume. Now, here it is pedestrian volume. So, one of the following criteria is made one based on the 4 hour average plot that means, what we are saying for any 4 hour of average day. Plots of total pedestrian crossing the major street and the total major street vehicle traffic fall over the line. So, similar to that major street minor street here what we are saying is two condition, the traffic motorized volume on the road and pedestrian volume.

So, it is a combination you can see here the major street vehicle volume per hour both ways and the y axis we are plotting the number of total of all pedestrians that are crossing. So, if my existing situation the point is actually above this line, then from pedestrian volume wise it is satisfied. Very similar only thing here pedestrian volume and vehicle volume actually on the road are considered.

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## MUTCD Warrants for Traffic Signal Control

- ✓ Any one similar **hourly plot** falls above the line in Figure 4C-7
- **Option:** Figure 4C-6 and Figure 4C-8 respectively may be used
- ✓ If the location is in a built-up area of a small community (population less than 10000) , OR
- ✓ Where posted speed limit or statutory speed limit or **85<sup>th</sup> percentile approach speed exceeds 35 mph**

Figure 4C-7. Warrant 4, Pedestrian Peak Hour

Major Street - Total of Both Approaches (VPH)	Total of All Pedestrians Crossing Major Street (per hour)
300	650
400	550
500	450
600	380
700	320
800	280
900	250
1000	220
1100	200
1200	180
1300	160
1400	150
1500	140
1600	130
1700	120
1800	110

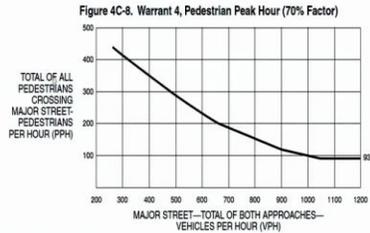
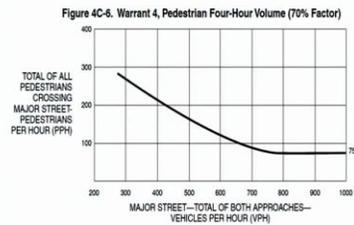
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So, one is for four-hour consideration, the other is anyone similar hourly plots for line figure 4C, this is pedestrian peak hour that was pedestrian 4-hour volume every hour per hour. And here considering the peak hour very similar case in volume case, we considered 4-hour volume, we also considered a different warrant for peak hour volume, so here in pedestrian case we are considering both one is the 4-hour pedestrian four-hour period and then looking at the pedestrian demand, vis-a-vis the vehicular demand and another condition based on the peak hour.

So, any of this is getting satisfied, you can think that pedestrian volume wise it is satisfying. And here also similarly, again the other aspect is there, as we have considered their population of less than 10,000 similarly, here or where the postage speed limit in this case exceeds 35 mile per hour on the major street.

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## MUTCD Warrants for Traffic Signal Control

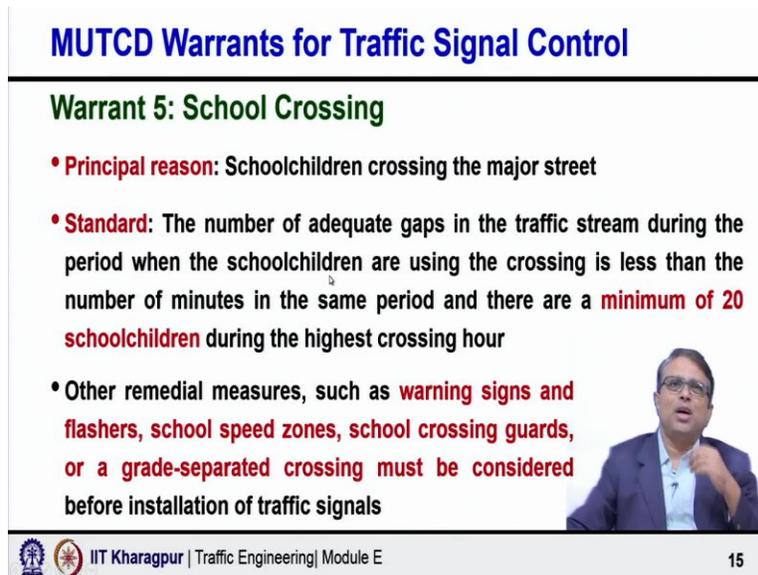


- A signal would **not be installed** under this warrant if there is **another signal within 300 feet** of the location



So, another equivalent condition those are shown here, you can see here, it is very similar to 4C and 4C 1 and 4. This is both with the 70 percent factor corresponding to this figure, this figure and this figure, so 4-hour period peak hour period normal condition and this is with that 10,000 up to 10,000 populations, isolated communities speed or speed is more than 35 miles per hour. So, similar kinds of things.

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**MUTCD Warrants for Traffic Signal Control**

**Warrant 5: School Crossing**

- **Principal reason:** Schoolchildren crossing the major street
- **Standard:** The number of adequate gaps in the traffic stream during the period when the schoolchildren are using the crossing is less than the number of minutes in the same period and there are a **minimum of 20 schoolchildren** during the highest crossing hour
- **Other remedial measures, such as warning signs and flashers, school speed zones, school crossing guards, or a grade-separated crossing must be considered before installation of traffic signals**

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Now, warrant 5 relates to school crossing, children's are crossing the road. So, their safety is very important. So, that is the condition which is trying to dictate or govern the decision about the installation of traffic signal. So, what is it saying here, the number of adequate gaps in the traffic stream during the period when the schoolchildren are crossing, school children are not crossing all the time, it is typically during school opening and closing hours.

So that time when the children are crossing the road the what is saying the number of adequate gaps in the traffic stream number of adequate gaps in the traffic stream during the crossing of schoolchildren is less than the number of minutes in the same period. Number of adequate gaps during a period is less than the number of minutes in the same period when the children are crossing and second there are a minimum of 20 school children during the highest crossing or at least 20 Children are crossing the road during the highest crossing.

And what it is saying other remedial measures that as installation of warning sign, flashers, school speed zones, school crossing guards or even the grade separated crossing also must be considered as that means all possibilities all other possibilities must be considered before installation of traffic signal.

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## MUTCD Warrants for Traffic Signal Control

### Warrant 6: Coordinated Signal System

- **Principal reason:** Progressive movement in a coordinated signal system sometimes necessitates installing traffic control signals at intersections in order to **maintain proper platooning of vehicles**
- **Standard:** One of the following criteria is satisfied
  - ✓ On a one-way street or a street that has traffic predominantly in one direction, the adjacent traffic control **signals are so far apart** that they do not provide the necessary degree of vehicular platooning



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Warrant 6 related to the coordinated signal system, I have not taught you till date the coordination of traffic signals it will come subsequently, but when typically you know a bunch of traffic in urban corridors along the urban corridors are moving then we need to act we can try to coordinate the green time so, that the bunch of vehicle when it reaches to the next signal the green time is given.

So, whole idea is they can pass through subsequent signals without stopping majority of vehicle, but this works. one very important consideration for this is that the vehicles have to move in platoon in a bunch. So, you have a green time, lot of vehicles are waiting, if give us some kind of green time and the vehicle get discharged. Now, this moving traffic stream or the bunch we are trying to pass through subsequent signal without stopping.

Obviously, if the platoon disperse too much, which happened due to differential speed criteria, different vehicle type different speed criteria, then the coordination will not be effective, because you give the same green time in all subsequent signals, then not all vehicles will be able to pass through. So, this could be a reason why you want to install a signal and create the platoon. That is what the main objective.

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## MUTCD Warrants for Traffic Signal Control

- ✓ On a two-way street, adjacent traffic control signals **do not provide the necessary degree of platooning** and the proposed and adjacent traffic control signals will collectively provide a progressive operation
- The coordinated signal system signal warrant should not be applied where the resultant spacing of traffic control signals would be **less than 1,000 feet**



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So, obviously, signal warrant should not be applied for the resultant spacing of traffic signal will be less than 1000 feet because they are already pretty close. So, in between we do not want to again Stop vehicles to recreate the platoons.

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## MUTCD Warrants for Traffic Signal Control

### Warrant 7: Crash Experience

- **Principal reason:** The severity and frequency of crashes
- **Standard:** All of the following criteria must be met
  - ✓ Adequate trial of alternatives with satisfactory observance and enforcement has **failed to reduce** the crash frequency
  - ✓ **≥ 5 reported crashes**, of types susceptible to correction by a traffic control signal, have occurred within a 12-month period; each crash involving personal injury or property damage



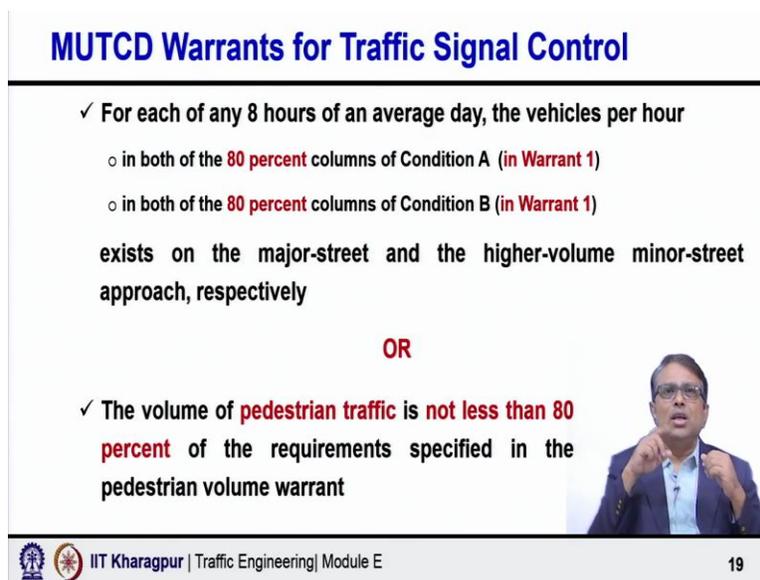
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Next, one of the most important reasons for installation of signal, is the crash experience. So here how the crash is happening? the crash history is really governing. So, for example, we have given adequate trial of alternatives with satisfactory observance and enforcement has failed to reduce the

crash frequency, not that crash happening to immediate reason is signal. No, you have tried other things but with is a satisfactory observance and enforcement but still failed to reduce crash frequency.

And you believe that the crisis is such that installation of traffic signal would actually benefit in reducing the crisis. So, what are the warrants may be greater than five reported crash of types susceptible to correction by traffic signal not any type of crash, which can be corrected you believe that by providing traffic signals, and that kind of five crashes occurred within the 12-month period. And each involving personal injury or property damage.

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**MUTCD Warrants for Traffic Signal Control**

- ✓ For each of any 8 hours of an average day, the vehicles per hour
  - in both of the **80 percent** columns of Condition A (in Warrant 1)
  - in both of the **80 percent** columns of Condition B (in Warrant 1)exists on the major-street and the higher-volume minor-street approach, respectively

**OR**

- ✓ The volume of **pedestrian traffic is not less than 80 percent** of the requirements specified in the pedestrian volume warrant

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Second, each of any eight hour or the average day, there is a volume warrant that is what is 80 percent of condition A 80 percent of condition B, that means 100 percent It would be 100 percent, then the 8-hour volume warrant would have been satisfied. But I said this somewhere I am going to come back here it is that neither condition A nor condition B satisfied with 100 percent but both are getting satisfied with 80 percent. So, that is what is very important quickly, I would like to go back and show you that slide. So that you can connect very well.

(Refer Slide Time: 34:14)

## MUTCD Warrants for Traffic Signal Control

- **Standard:** One of following conditions must be met for each of any 8 hours
  - ✓ The vehicles per hour given in both of the **100 percent columns of Condition A** in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection

**Table 4C-1. Warrant 1, Eight-Hour Vehicular Volume**  
Condition A—Minimum Vehicular Volume

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
		100% <sup>a</sup>	80% <sup>b</sup>	70% <sup>c</sup>	56% <sup>d</sup>	100% <sup>a</sup>	80% <sup>b</sup>	70% <sup>c</sup>	56% <sup>d</sup>
Major Street	Minor Street								
1	1	500	400	350	280	150	120	105	84
2 or more	1	600	480	420	336	150	120	105	84
2 or more	2 or more	600	480	420	336	200	160	140	112
1	2 or more	500	400	350	280	200	160	140	112



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You will remember here. So, condition B 80 percent of that. Here also minor street also 80 percent of that. That is the B Scenario B not conditioning but scenario abcd condition B again scenario abcd. So that 80 percent is coming back here.

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## MUTCD Warrants for Traffic Signal Control

- ✓ For each of any 8 hours of an average day, the vehicles per hour
  - in both of the **80 percent** columns of Condition A (in Warrant 1)
  - in both of the **80 percent** columns of Condition B (in Warrant 1)
 exists on the major-street and the higher-volume minor-street approach, respectively

OR

- ✓ The volume of **pedestrian traffic is not less than 80 percent** of the requirements specified in the pedestrian volume warrant

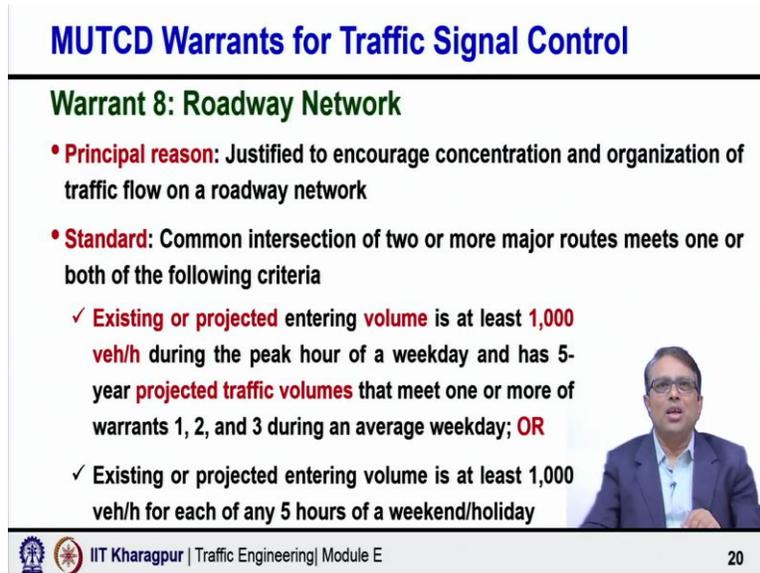


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So that is what it is, or the volume of pedestrian. Either the traffic volume wise it is satisfying, or pedestrian traffic is not less than 80 percent of the required 80 percent specified in this pedestrian volume warrant. So, there also you go back where we talked about the pedestrian warrant. So, that

is for whatever value was given there you have crashes, you have either vehicle volume warrant getting satisfying that 80 percent level both and or you have pedestrian volume wise it is qualifying at 80 percent of the only pedestrian consideration.

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**MUTCD Warrants for Traffic Signal Control**

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**Warrant 8: Roadway Network**

- **Principal reason:** Justified to encourage concentration and organization of traffic flow on a roadway network
- **Standard:** Common intersection of two or more major routes meets one or both of the following criteria
  - ✓ Existing or projected entering volume is at least 1,000 veh/h during the peak hour of a weekday and has 5-year projected traffic volumes that meet one or more of warrants 1, 2, and 3 during an average weekday; **OR**
  - ✓ Existing or projected entering volume is at least 1,000 veh/h for each of any 5 hours of a weekend/holiday

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The other one is basically what is called a road network justified to encourage concentration and organization of traffic flow on a road network. And it is common intersection of two or more major routes that means, a major route is growing and you want to basically organize the traffic encourage coordination concentration in a better way. So, here existing or projected entering volume is at least 1000 vehicle per hour during the peak hour of the weekday and has a 5-year projected traffic volume which are satisfying either warrant 1, warrant 2 or warrant 3.

Projected volume projected volumes satisfying either 8-hour volume or 4-hour volume or peak hour volume. So, one is the present volume is 1000 vehicle per hour during the peak and the projected volume satisfying one of the warrants, so warrant two or three and existing are projected volume entering is at least 1000 vehicle for any of each of any 5 hour of a weekend or holiday.

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## MUTCD Warrants for Traffic Signal Control

- A major route as used in this signal warrant shall have at least one of the following characteristics:
  - ✓ It is part of the street or highway system that serves as the principal roadway network for through traffic flow
  - ✓ It includes rural or suburban highways outside, entering, or traversing a city
  - ✓ It appears as a major route on an official plan, such as a major street plan in an urban area traffic and transportation study



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Some places weekend traffic also maybe there and not always for all routes, but a major route only we can consider for such warrant, where at least one of the following characteristics is satisfied one it is the part of the street or highway system that serves as the principal network for through traffic flow.

So, it is an important corridor it includes the rural or suburban highways outside entering or traversing a city and third it appears is a major route of an official plan such as the major street plans in an urban area traffic and transportation authority. So, certain priority certain type of route or then only this road network warrant can be considered only for such route, major route not that any route I take any location I take and I will apply this one no that will not be there. So, this is very important.

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## MUTCD Warrants for Traffic Signal Control

### Warrant 9: Intersection Near a Grade Crossing

- Intended for use at a location where none of the conditions described in the other eight traffic signal warrants are met
- **Principal reason:** Proximity to the intersection of a **grade crossing** on an intersection approach controlled by a STOP or YIELD sign
- **Standard:** both of the following criteria are met
  - ✓ A grade crossing exists on an approach controlled by a STOP or YIELD sign and the **center of the track** nearest to the intersection is **within 140 feet of the stop line or yield line** on the approach; and



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The next is near a grade crossing you have a level crossing and before that or nearer to that you have an intersection. So, level crossing is controlled by a stop or yield sign and there whatever is going to get discharged is now one of the actually one of the approaches is going towards the railway grade crossing with a stop or yield sign.

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## MUTCD Warrants for Traffic Signal Control

Figure 4C-9. Warrant 9, Intersection Near a Grade Crossing (One Approach Lane at the Track Crossing)

Figure 4C-10. Warrant 9, Intersection Near a Grade Crossing (Two or More Approach Lanes at the Track Crossing)

- During the highest traffic volume hour during which rail traffic uses the crossing, the plotted point falls above the applicable curve in Fig 4C-9 or Fig 4C-10 for the existing combination of approach lanes over the track and the distance D, which is the clear storage distance



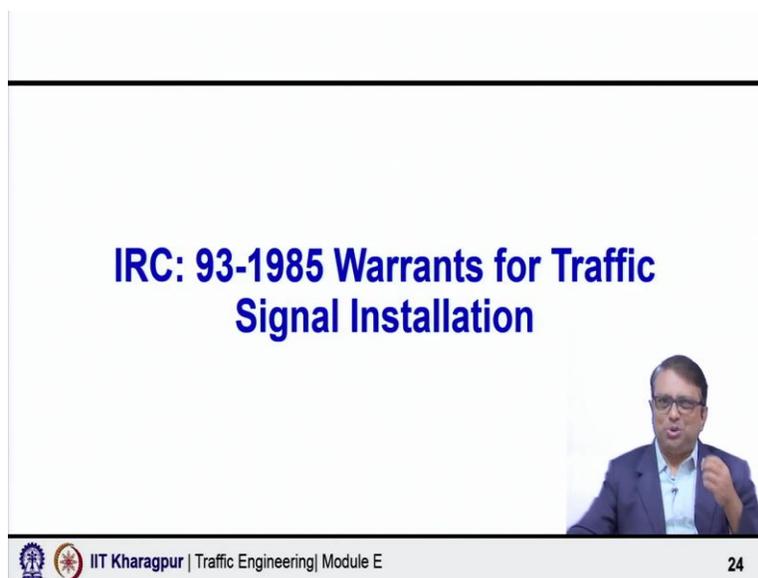
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So, here typically as I have shown here, you can see this is an intersection and this is the level crossing at a distance D. And this is you are considering whether to install signal here in this

intersection and this level crossing is stop or yield control. So, they are different values of D and different major street volume different minor street crossing volume are there and this is for one lane here on the approach on minor street.

And here there are two lanes on approach a minor street so the traffic volumes our volume thresholds are slightly different. So, this is again one scenario where you know you can consider the installation of signal. So, those are basically all the nine warrants. So, any one is getting satisfied. It is worth investigating further, if we require to install signal further investigations need to be done.

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The slide features a white background with a black horizontal line near the top. The main title, "IRC: 93-1985 Warrants for Traffic Signal Installation", is centered in a bold, blue font. In the bottom right corner, there is a small video inset showing a man in a blue suit and glasses speaking. At the bottom of the slide, there is a footer containing the IIT Kharagpur logo, the text "IIT Kharagpur | Traffic Engineering | Module E", and the page number "24".

Now, coming to the Indian roads, Congress guidelines, we have a guideline IRC 93-1985 Of courses, it is quite old and it is presently or fully getting upgraded very soon.

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## IRC: 93-1985 Warrants for Traffic Signal Installation

### Warrant 1: Minimum Vehicular Volume

- When for each of any 8 hours of an average day, the traffic volume given in Table exist on major street and on the higher volume minor street approach to the intersection

Number of lanes for moving traffic on each approach		Motor vehicles per hour on major street (total both approaches)	Motor vehicles per hour on higher volume minor street approach (one direction only)
Major Street	Minor Street		
1	1	650	200
2 or more	1	800	200
2 or more	2 or more	800	250
1	2 or more	650	250



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And I would like to mention these warrants because those who are working in India, we often follow the IRC guideline. So, here the warrant one minimum vehicle volume, it is 8 hours volume. It is similar to warrant one MUTCD very similar. So, that is one.

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## IRC: 93-1985 Warrants for Traffic Signal Installation

### Warrant 2: Interruption of Continuous Traffic

- When for each of any 8 hours of an average day, the traffic volume given in Table exist on major street and on the higher volume minor street approaching the intersection, and the signal installation will not seriously disrupt progressive traffic flow

Number of lanes for moving traffic on each approach		Motor vehicles per hour on major street (total both approaches)	Motor vehicles per hour on higher volume minor street approach (one direction only)
Major Street	Minor Street		
1	1	1000	100
2 or more	1	1200	100
2 or more	2 or more	1200	150
1	2 or more	1000	150



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Warrant 2, what you are saying interruptions to continuous traffic. It is again warrant one, condition B so this is warrant one condition A the total intersecting volume and here it is interruptions of continuous traffic you remember under warrant A1, MUTCD we considered

condition A and condition B total volume and interruption to continuous traffic. So, A and B of warrant one in MUTCD is taken as warrant one and warrant two.

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## IRC: 93-1985 Warrants for Traffic Signal Installation

### Warrant 3: Minimum Pedestrian Volume

- When for each of any 8 hours of an average day, the following traffic volumes exist
  - ✓ On the major street,  $\geq 600$  veh/h enter the intersection (total of both approaches) or where there is  $\geq 1.5$  m width raised median island,  $\geq 1000$  veh/h (total of both approaches) enter the intersection on major street
  - ✓ During the same 8 hours as in para above, there are  $\geq 150$  ped/h on the highest volume cross-walk crossing the major street



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Now, the third warrant is basically minimum pedestrian volume again in MUTCD, we have a pedestrian volume warrant it is very similar to that one considering the pedestrian number, of pedestrians that are trying to cross against the vehicular traffic. So, what would be the volume or to be the pedestrian volume traffic volume those are considered here very similar.

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## IRC: 93-1985 Warrants for Traffic Signal Installation

### Warrant 4: Accident Experience

- Accident experience warrant is satisfied when
  - ✓ Adequate trial of less restrictive remedies with satisfactory observance and enforcement have failed to reduce accident frequency
  - ✓  $\geq 5$  reported accidents, of types susceptible of correction by traffic signal control have occurred within a period of 12 months, each accident involving personal injury or property damage
  - ✓ The signal installation will not seriously disrupt traffic flow



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Accident experience it is again considered MUTCD has got a very you know similar warrant.

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**IRC: 93-1985 Warrants for Traffic Signal Installation**

**Warrant 5: Combination of Warrants**

- In exceptional cases, **signals may be justified** occasionally where no signal warrant is satisfied but where **two or more of warrants 1, 2 and 3, are satisfied to the extent of 80 per cent** or more of the stated
- Adequate trial or other remedial measure which causes less delay and inconvenience to traffic should precede installation of signals under this warrant



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And also, another is what I said condition C or condition B 80 percent of the you know individual warranties satisfied that means, what is said in exceptional case and signals may be justified occasionally where no single warrant is satisfied individually 1 2 warrant 1, 2, 3, 4 and not satisfied, but where two or more warrants of 1, 2, 3 are satisfied to the extent of 80 percent or more of the stated values. So, under that case, so, 1, 2, 3, 4; 1, 2, 3 volumes wise, pedestrian volume vehicle volume wise not getting satisfied 100 percent. But, two or more warrants getting satisfied yet 80 percent level there also you can go for signal.

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## Summary

- Warrants for traffic signal control
  - ✓ MUTCD warrants for traffic signal control
    - Warrants corresponding to eight-hour vehicular volume, four-hour vehicular volume, peak hour, pedestrian volume, school crossing, coordinated signal system, crash experience, roadway network, intersection near a grade crossing
  - ✓ IRC: 93-1985 warrants for installation of traffic signal
    - Warrants corresponding to minimum vehicular volume, interruption of continuous traffic, minimum pedestrian volume, accident experience, combination of warrants



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So, those are the things which are, So, whatever considerations are there in IRC grossly those are there in MUTCD but MUTCD got additional warrants additional consideration for example, the school zone part, for example, also the coordination of signal near at grade crossing. railway crossing, which are control which is which are controlled by stop or yield signal like that additional warrants are there.

So, what we discussed here altogether is the MUTCD warrants for traffic signal control all the warrants, we tried to explain you briefly at least and then a very quick mention to IRC 93-85 1985 warrants and just to show you that how the whatever is mentioned in IRC what all are mentioned in IRC, how they are connected to some of this MUTCD warrants. Thank you so much.