APPENDIX P1

Traffic Measures of Effectiveness

Traffic: Measures of Effectiveness

Introduction

The Highway Capacity Manual[1] and the *Highway Capacity Software*[2] procedures document the methodology used for modeling levels of service and average vehicle delay at both signalized and unsignalized intersections. Level of service is a measure of the operational quality of an intersection; level of service A is the highest, most efficient level, and level of service F is the lowest level. The operational quality of an intersection is based on the average amount of time a vehicle is delayed. Levels of service are examined by 'lane group', the set of lanes allowing common movement(s) on an approach. Approaches to intersections are assigned primary directions for clarity as depicted on the traffic volume figures.

Use of the *Highway Capacity Software* is consistent with the New York State Department of Transportation policy requiring use of capacity analysis software consistent with the most recent version of the Highway Capacity Manual.

The *Highway Capacity Software* modeled results are applied to peak hour periods only. During off peak periods, which is the majority of the time, drivers typically will find operations better than the modeled peak hour results. During peak periods the experience of individual drivers can vary, because the model calculates average delay.

Peak 15 minute traffic flows typically do not all occur in the same 15 minute period in the peak hour. The *Highway Capacity Software* conservatively assumes 15 minute peak approach volumes occur simultaneously.

As traffic increases the relationship between the peak hour and four times the peak 15 minutes moves closer being equal. For approaches with volumes under 50 vehicles the this relationship expressed as the peak hour factor (peak our traffic divided by four times the peak 15 minute traffic) tends to be below 0.78. This reflects the high variability in arrival times for low volume approaches. In some cases where the peak hour traffic is more than doubled default peak hour factors are utilized as minimum peak hour factors. The default peak hour factors based on Poisson arrival probabilities as suggested by SYNCHRO[3] for 50, 100, 200, and 500 approaching vehicles are 0.78, 0.83, 0.87, and 0.92 respectively. These are used to establish the minimum peak hour factor for low volume approaches that have increased a minimum of 100 percent and exceed 50 vehicles. These factors are also used for any new intersection approaches or any approach currently without an existing peak hour traffic volume.

For existing approaches without any volume one or more trips is assigned to establish the measure of effective should a vehicle have arrived during the peak hour.

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[1] Highway Capacity Manual, National Academy of Sciences, Transportation Research Board, National Research Council, Washington, DC, 2000.

[2] Highway Capacity Software, Computer software, Version 5.4, Mctrans, Gainsville, Florida, 2008.

[3] Trafficware, Synchro Studio 7, Sugarland, Texas, 2006, page 6-4.

Level of Service Criteria Signalized Intersections

When analyzing activity at signalized intersections, an understanding of the definition of level of service is essential:

> Level of service for signalized intersections is defined in terms of control delay, which is a measure of driver discomfort, frustration, fuel consumption and increased travel time.[4]

These levels of service are:

> *Level of Service* A describes operations with low control delay, up to 10 *seconds per vehicle*. The level of service occurs when progression is extremely favorable and most vehicles arrive during the green phase. Many vehicles do not stop at all. Short cycle lengths may tend to contribute to low delay values.
>
> *Level of Service* B describes operations with control delay greater than 10 and up to 20 *seconds per vehicle*. This level generally occurs with good progression, short cycle lengths, or both. More vehicles stop than with *Level of Service* A, causing higher levels of delay.
>
> *Level of Service* C describes operations with control delay greater than 20 and up to 35 *seconds per vehicle*. These higher delays may result from only fair progression, longer cycle lengths, or both. Individual cycle failures may begin to appear at this level. Cycle failure occurs when a given green phase does not serve [all its] queued vehicles, and overflows occur. The number of vehicles stopping is significant at this level, though many still pass through the intersection without stopping.
>
> *Level of Service* D describes operations with control delay greater than 35 and up to 55 *seconds per vehicle*. At *level of service* D, the influence of congestion becomes more noticeable. Longer delays may result from some combination of unfavorable progression, long cycle lengths, and high *volume to capacity* ratios. Many vehicles stop, and the proportion of vehicles not stopping declines. Individual cycle failures are noticeable.
>
> *Level of Service* E describes operations with control delay greater than 55 and up to 80 *seconds per vehicle*. These high delay values generally indicate poor progression, long cycle lengths, and high *volume to capacity* ratios. Individual cycle failures are frequent.
>
> *Level of Service* F describes operations with control delay in excess of 80 *seconds per vehicle*. This level, considered unacceptable to most drivers, often occurs with oversaturation, that is, when arrival flow rates exceed the capacity of lane groups. It may also occur at high *volume to capacity* ratios with many individual cycle failures. Poor progression and long cycle lengths may also contribute significantly to high delay levels.[5] (Underlines added for emphasis, italic words unabbreviated for clarity, bracketed words added for clarity)

The table below summaries the levels of service criteria for signalized intersections.

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[4] Highway Capacity Manual, National Academy of Sciences, Transportation Research Board, National Research Council, Washington, DC, 2000, page 10-15.

[5] Ibid, page 10-16.

Signalized Intersections Level of Service Criteria	
Level of Service	**Average Control Delay (Seconds Per Vehicle)**
A	less than or equal to 10
B	greater than 10 and less than or equal to 20
C	greater than 20 and less than or equal to 35
D	greater than 35 and less than or equal to 55
E	greater than 55 and less than or equal to 80
F	greater than 80
Source: Highway Capacity Manual, National Academy of Sciences, Transportation Research Board, National Research Council, Washington, DC, 2000.	

The New York State Department of Transportation (NYS DOT) generally seeks a minimum level of service D (delay of 55 seconds or less for a signalized intersection) for all lane groups however,

> In some cases, it may be necessary to accept level of service E or F on individual lane groups due to unreasonable costs or impacts associated with improving the level of service.[6]

Level of Service Criteria Unsignalized Intersections

The table below presents the levels of service criteria for unsignalized intersections. Average control delays are different from signalized intersections. Major street lane groups that do not include left turning movements are considered free flowing (effectively operating at a level of service A) and are not analyzed.

Unsignalized Intersections Level of Service Criteria	
Level of Service	**Average Control Delay (Seconds Per Vehicle)**
A	less than or equal to 10
B	greater than 10 and less than or equal to 15
C	greater than 15 and less than or equal to 25
D	greater than 25 and less than or equal to 35
E	greater than 35 and less than or equal to 50
F	greater than 50
Source: Highway Capacity Manual, National Academy of Sciences, Transportation Research Board, National Research Council, Washington, DC, 2000.	

[6] NYS DOT, Highway Design Manual, (page 5-92).