Appendix A: Planning and Designing Signalized Intersections Using Multi-Modal Level-of-Service Standards

This Appendix includes information necessary for evaluating Charlotte's signalized intersections from a multi-modal perspective. It includes 1) a brief introduction to Charlotte's new approach to intersection design, 2) a table and related notes to be used for evaluating and designing specific intersections, and 3) a step-by-step process for planning and defining intersection improvement projects in Charlotte. The intent of this information is to ensure that intersection design reflects the goals inherent in Charlotte's Urban Street Design Guidelines, specifically the desire to increase transportation choices by making travel by pedestrians, cyclists, and transit users safer and more convenient. Major changes to the evaluation procedure, as outlined below, include a two-hour standard for evaluating motor vehicle "level-of-service" (LOS) at an intersection, and the inclusion of a pedestrian and a bicycle LOS standard.

As shown on Table 1, the volume/capacity (V/C) ratio of a signalized intersection is used as a surrogate for motor vehicle LOS and as a threshold or trigger to investigate any operational or physical capacity increases at the intersection. The "conditions" listed are directly related to the street classification(s) at the intersection, as defined by the Urban Street Design Guidelines. In general, the more pedestrian-oriented the intersection classification, the more stringent the V/C threshold condition. The inclusion of a two hour V/C threshold condition for most street types is a major departure from the previous method used by CDOT to evaluate intersections and is intended to ensure a context-sensitive, multi-modal approach to planning and designing intersection "improvements". Note that signalized driveways should be evaluated as if they are Local Streets.

The V/C ratio must also be balanced against the level-of-service (LOS) expected for pedestrians and cyclists for a given intersection type, which is another major departure from the traditional approach to intersection planning and design. Both LOS methodologies were developed by CDOT for use at all signalized intersections. The LOS ratings shown on Table 1 are objectives to strive for when designing or re-designing an intersection. A detailed description of the LOS methodology for pedestrians and bicyclists is provided in Appendix B.

Finally, there are several steps that should be taken before any physical capacity increases are provided. For the analysis of existing motor vehicle operating conditions, multiple year trends should be analyzed. Capacity increases would be considered when:

- the above thresholds are met for multiple years,
- operational solutions are analyzed and deemed unworkable, and
- additional connections/route options are also investigated.

Once these steps are taken, then physical capacity increases for motorists would be considered, in conjunction with whatever physical and design features would be necessary to maintain the pedestrian and bicycle LOS, as shown on Table 1.

Table 1. Thresholds for Analysis Based on Conditions of Motor Vehicle Travel and Level of Service Objectives for Pedestrian and Bicycle Travel at Signalized Intersections

Travelers / Street type	**Threshold Conditions for Motorists**[1]	**Level of Service Objectives for Pedestrians**	**Level of Service Objectives for Bicyclists**
Main Street	Local: Condition 1 Main: Condition 1 Avenue: Condition 1 Blvd: Condition 2	Local: A Main: A Avenue: B Blvd: B	Local: N/A[2] Main: N/A[2] Avenue: B[3] Blvd: B[3]
Avenue	Local: Condition 2 Main: Condition 1 Avenue: Condition 2 Blvd: Condition 2 Pkwy: Condition 2	Local: B Main: B Avenue: B Blvd: B Pkwy: D	Local: B[3] Main: B[3] Avenue: B Blvd: B Pkwy: C/D
Boulevard	Local: Condition 3 Main: Condition 2 Avenue: Condition 2 Blvd: Condition 3 Pkwy: Condition 3	Local: B Main: B Avenue: B Blvd: C Pkwy: D	Local: B[3] Main: B[3] Avenue: B Blvd: C Pkwy: C/D
Parkway	Local: Condition 4 Avenue: Condition 2 Blvd: Condition 3 Pkwy: Condition 4	Local: D Avenue: D Blvd: D Pkwy: D	Local: C[3] Avenue: C/D Blvd: C/D Pkwy: D
Local	Local: Condition 1 Main: Condition 1 Avenue: Condition 2 Blvd: Condition 3 Pkwy: Condition 4	Local: A Main: A Avenue: B Blvd: B Pkwy: D	Local: N/A[2] Main: N/A[2] Avenue: B[3] Blvd: B[3] Pkwy: C[3]

[1] These conditions (existing or projected) for vehicular travel at signalized intersections establish the thresholds for proceeding with the analysis of levels-of-service (LOS) for motor vehicle, pedestrian and bicycle travel.

[2] The application of the CDOT bicycle LOS methodology is not recommended for intersections of Local or Main streets. The methodology assigns high positive values to the separation of bicyclists from motor vehicles, specifically by bike lanes and/or bike boxes. Local and Main streets do not need bike lanes because they are generally comfortable and safe for most cyclists.

[3] Intersections of this type shall be analyzed based on the averages of only the Avenue, Boulevard, or Parkway approaches. For example, when analyzing the intersection of a Main street and a Boulevard, the two values obtained for the Boulevard approaches should be averaged.

Defined Threshold Conditions

- Condition 1: V/C (volume/capacity) >= 1.0, for two consecutive AM or PM hours
- Condition 2: V/C (volume/capacity) >= 0.95, for two consecutive AM or PM hours
- Condition 3: V/C (volume/capacity) >= 0.95, for **BOTH** one AM and PM hour
- Condition 4: V/C (volume/capacity) >= 0.90, for **BOTH** one AM and PM hour

Applying LOS Standards to Project Definition

The previous discussion describes the new philosophy of and standards for intersection design for the City of Charlotte. The following steps describe the appropriate application of that philosophy to planning and, specifically, to defining intersection projects based on the Street Design Guidelines' recommendations.

1. Analyze all signalized intersections for am and pm peak hour traffic operational conditions, and for accident trends and problems.

2. Based on the analysis of operational conditions and accident data, develop initial list of locations that could include traffic congestion and/or safety mitigation measures.

3. Calculate pedestrian and bicycle LOS for current operating and design conditions for the intersections that appear on the list in step two.

4. Define ways that those intersections can be improved for autos by operational changes alone and those that require roadway changes (i.e., widenings).

5. If two or more intersections in the vicinity are classified for possible changes that affect pedestrian and bicycle LOS, the scope of analysis will be expanded to include the arterial corridor or an area.

6. When operational changes alone can be made to improve auto level of service at signalized intersections, CDOT staff will proceed with implementing those changes – provided those changes do not worsen pedestrian and/or bicyclist level

of service for crossing those intersections. If operational changes will result in degradation to pedestrian and/or bicyclist level of service, then Systems Division personnel will meet with Planning Division personnel (e.g., pedestrian and bike planners) before implementing changes. Personnel responsible for phasing and/or signal timing modifications will identify and try to mitigate those conditions in the Pedestrian and Bicyclists Level of Service Methodology that worsen pedestrian and bicyclist level of service.

7. If it is determined that operational changes alone will not affect auto level of service, then additional capacity analyses will be performed based on an expanded time period - beyond the am and pm peak hours analyzed in step one. The number of hours to be analyzed will vary according to the level of service standards set forth in the street design guidelines. For locations that meet or exceed these standards, solutions that provide improved auto level of service may be developed, provided pedestrian and bicyclist level of service are not worsened. Staff from both the Planning Division and Systems Division will work together to develop possible project alternatives.