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MEMORANDUM

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To: Kevin Luecke
Organization: City of Madison
From: Adam Wood, AICP, Theja Putta, HaoChe Hung
Project: Madison Pedestrian and Bicycle Planning (SS4A)

Re: Pedestrian Crossing LTS Methodology

This memo summarizes the findings and methodology used in Toole Design's review of pedestrian crossing conditions, using a Pedestrian Crossing Level of Traffic Stress (PxLTS) model. Our review focused on a citywide assessment of pedestrian crossing stress to establish context for the development of pedestrian recommendations as part of the City of Madison Pedestrian Plan project.

This memo describes three steps of the analysis:

1. The creation of intersection and crossing point datasets
2. The calculation of base level pedestrian crossing stress
3. Adjustments to the base stress rating to account for the presence of crossing enhancements (e.g., median islands, RRFBs, etc.)

Data Creation

Intersections

An intersection dataset for Madison was developed by creating a point where three or more street centerline segments intersect.

Off-street path or trail crossing locations were added as well. The off-street path crossings were automatically considered low stress if they were grade-separated. At-grade crossings were treated as any other pedestrian crossing, including adjusting the stress level where pedestrian signals or flashing beacons are present. Path crossings within 150 feet of street intersections were ignored and treated as part of the nearby intersection in order to avoid duplication.

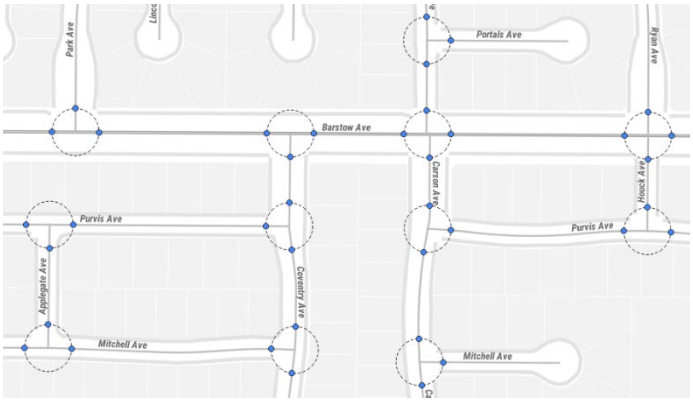

Figure 1 – Screenshot showing multiple crossing points at each intersection.

Crossing Points

To create the crossing points dataset, a buffer was created around each intersection, and a point was added where that buffer meets the street centerline. These points are meant to approximate where a person may cross the street, and do not necessarily

represent marked crossing locations. This method allows for intersection, street centerlines, and crosswalk attributes to be joined efficiently between the three datasets using a common unique identification number (ID).

Calculate Pedestrian Crossing Level of Traffic Stress (PxLTS)

The Oregon Department of Transportation (ODOT) developed a framework for evaluating pedestrian traffic stress—that is, how comfortable or safe it feels to cross a street as a pedestrian. The framework applies the simple logic of the bicycle level of traffic stress to pedestrian crossings. The methodology considers basic details including the speed of cross traffic, distance to cross, and mitigating features like signals and refuge islands. The thresholds identified by ODOT result in a Pedestrian Level of Traffic Stress score from 1 through 4 representing the following conditions, as described in ODOT's *Analysis Procedures Manual*[1] (PxLTS descriptions are quoted from the manual with edits for clarity):

Table 1 – PxLTS Levels and Descriptions

Category	PxLTS Level	Description
Low Stress	1	Represents little to no traffic stress and requires little attention [by the pedestrian] to the traffic situation.
	2	Represents little traffic stress for most adults but requires more attention to the traffic situation than young children [defined as ages 10 and younger] may be capable of.
High Stress	3	Represents moderate stress; a higher level of attention to traffic is needed, and adults may feel some discomfort using this facility
	4	Represents high traffic stress. Only pedestrians with limited route choices would use this facility.

ODOT's manual identifies PxLTS 2 as a reasonable target for most situations.[2] PxLTS 2 conditions are considered appropriate for people of all ages and abilities. Note that this analysis does not include an assessment of accessibility for people with disabilities. Lack of ADA-compliant curb ramps, poor pavement in the crossing, and other factors impact accessibility and therefore the real-world comfort of crossings.

The methodology used by Toole Design and described in this memo includes several modifications to the original ODOT tables to better reflect conditions within the Madison study area. As with the original ODOT methodology, these modifications are informed by FHWA's *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations* and FHWA's Crash Modification Factors (CMF) Clearinghouse. Unless otherwise stated, the tables in this document refer to the configuration, speeds, and traffic volumes of the street that is being crossed.

Assumptions

To apply this analysis to all intersections in the study area, particularly where data is lacking for local streets, a series of assumptions are made based on street classification (e.g., functional class). Actual data on traffic speeds, volumes, and lane configuration should be used when available.

[1] https://www.oregon.gov/ODOT/Planning/Pages/APM.aspx See Chapter 14 Section 5
[2] https://www.oregon.gov/ODOT/Planning/Documents/APMv2_Ch14.pdf Section 14.5.3 (page 14-37)

Table 2 Street Configuration Assumptions When Data is Incomplete

Classification of street being crossed	Speed of street being crossed	Average daily traffic (ADT) of street being crossed	Intersecting Street Classification	Signalization Status	# of Lanes crossed at unsignalized intersection*	# of lanes crossed at signalized intersection*
Local	20	500	Local	Unsignalized	0	0
			Collector and above	Unsignalized	0	0
Collector	25	5,000	Local	Unsignalized	2	3
			Collector	Unsignalized	3	3
			Minor Arterial and above	Unsignalized	3	3
Minor Arterial	30	12,500	Collector and below	Unsignalized	4	5
			Minor Arterial and above	Signalized	4	5**
Principal Arterial	35	20,000	Collector and below	Unsignalized	6	7***
			Minor Arterial and above	Signalized		

**At intersection; total, both directions.*

***Assumes 4 through lanes, plus left or right turn lanes*

****Assumes 6 through lanes, plus left or right turn lanes.*

Threshold Tables

Two sets of threshold tables and adjustment factors are provided below. For purposes of this analysis, crossings with pedestrian hybrid beacons (PHBs) are considered **signalized** crossings. Locations with RRFBs, stop-controlled intersections, and uncontrolled crossings are considered **unsignalized.**

Unsignalized Crossings

The methodology for unsignalized crossings uses lane count, speed, and crossing island presence. The logic remains the same regardless of functional classification because it is important to assess the roadway as it actually operates. For example, if there is a collector road with speeds and volumes more in line with a typical arterial road, it makes sense that it should receive the same score as an arterial with the same characteristics. For Madison, unsignalized crossings include crossings at intersections both with and without stop signs. See Table 2.

Signalized Crossings

The methodology for signalized crossings differs significantly from the original ODOT methodology (which assumed all signalized crossings are PxLTS 1 or 2 with a few exceptions) and is based on Toole Design's professional judgment and experience regarding what makes a signalized intersection high or low stress. Notably, this methodology includes more nuance regarding the influence of number of lanes, left turn conflicts, and various traffic control treatments.

Because cross traffic is stopped by the signal, the speed and volume of traffic on the street that is being crossed has a different degree of influence on comfort and safety. Instead, roadway width and interactions with turning traffic are the primary factors for safety and comfort at signalized intersections. Various other factors influence the comfort and safety of a signalized intersection (including presence of turn lanes on the street being crossed and on the intersecting street, whether right-turn-on-red is allowed, whether left turn signals are "permissive" or "protected", and the speed and volume of turning traffic from the intersecting street), though these factors were not included in this analysis due to lack of data. See Table 3.

Table 3 – PxLTS for Unsignalized Crossings

Lanes Crossed*	AADT	Median / Island	Vehicle Speeds**			
			≦ 25 mph	30 mph	35 mph	40+ mph
1	Any	No	1	1	2	3
		Yes	1	2	2	3
2	0-1000	No	1	2	2	3
	1000-5000		1	2	3	3
	5001-9000		2	3	3	4
	9001 +		3	3	4	4
	0-5000	Yes	1	2	2	3
	5001-9000		2	2	2	3
	9001 +		2	2	3	4
3	0-1000	No	2	2	3	4
	1000-8000		3	3	4	4
	8001-12000		3	3	4	4
	12001 +		4	4	4	4
	0-1000	Yes	1	1	2	3
	1000-8000		2	2	3	4
	8001-12000		2	3	4	4
	12001 +		3	3	4	4
4+	Any	Any	4	4	4	4

**Total number of lanes in both directions, including turning lanes.*
***Posted speed or – if available – 85% percentile observed speeds*

Table 4 – PxLTS for Signalized Crossings

Configuration of the intersecting ("walking along") street*	Total Lanes Crossed*				
	2 Lanes	3 Lanes	4 lanes	5 lanes	6+ Lanes
PHB/HAWK at midblock locations**	1	2	3	3	3
2 Lanes	2	2	3	3	4
3 Lanes	2	3	3	4	4
4 Lanes	2	3	3	4	4
5 Lanes	3	3	4	4	4
6+ Lanes	3	4	4	4	4

**Total number of lanes in both directions, including turning lanes.*

***Including stand-alone path crossings of streets.*

PxLTS Adjustment Factors

The Base PxLTS is adjusted for crossings at intersections that contain certain features that either have demonstrated crash reduction factors (CRFs) or are otherwise considered best practices to lower stress at intersections. Adjustment factors for **signalized** crossings, shown in Table 4, are applied to the base score using the following protocol:

1. PxLTS scores are rounded up. For example, a street with a base PxLTS score of 3 that has a leading pedestrian interval will receive a score of 2.5, which would round back up to PxLTS 3. To achieve PxLTS 2, that crossing would need an additional treatment(s).
2. PxLTS scores at a signalized intersection can be adjusted a maximum of two points (e.g., the best possible score for an intersection with a base PxLTS score of 4 that has all of the treatments listed below is PxLTS 2).

Table 5 – Adjustment Factors for Signalized Crossings

Treatment	Adjustment	Notes
Pedestrian refuge (island or within median)	-0.5 (-1for PHB crossings)	CRF of 31.5% for vehicle-pedestrian crashes.
Pedestrian Countdown Timer	-0.5	CRF of 8.8% for vehicle-pedestrian crashes. It is assumed that all signalized locations have pedestrian countdown timers
Leading Pedestrian Interval*	-0.5	CRF of 13% for vehicle-pedestrian crashes
Protected Left Turn*	-0.5	CRF of 33% for vehicle-pedestrian crashes
No right turn on red*	-0.5	Not well studied from a crash reduction perspective, but believed to decrease stress

**These adjustments were NOT included due to lack of data. They are included here to illustrate how these factors reduce stress.*

Adjustment factors for **unsignalized** crossings, shown in Table 5, are applied to the base score using the following protocol:

1. PxLTS scores are rounded up as noted in the signalized crossing stress adjustment.
2. PxLTS scores at unsignalized crossings can be adjusted by a maximum of one point.
3. Adjusted PxLTS scores cannot reduce the base stress scores below a value of 2.

Table 6 - Adjustment Factors for Unsignalized Crossings

Condition	Adjustment	Notes
RRFB or Flashing Sign	-1	CRF of 47.4% for vehicle-pedestrian crashes.
Stop controlled	-1	Stop control is assumed to be present on the following streets when there is no traffic signal present • local streets intersecting collectors or arterials • collectors intersecting collectors or arterials • minor arterial intersecting other arterials
When crossing is present on a low-volume street (AADT < 5,000) intersecting a high-volume street (AADT > 20,000)	+1	When vehicles are crossing, turning onto, or turning from a very high-volume street to/from a much lower volume street, drivers will be more focused on finding gaps in traffic and navigating conflicts with other vehicles than on the pedestrian crossing parallel to the busier road.
Raised crosswalks	-1	Are only appropriate on streets that are <30 MPH and <9,000 ADT per FHWA countermeasure guidance.