CHAPTER 6.

FINDINGS AND FUTURE RESEARCH

The objective of this study is to develop recommendations to make the pedestrian LOS calculation more sensitive to pedestrian characteristics and environmental conditions and to establish new methodologies for urban pedestrian analysis in New York City. In Chapter 3, the comprehensive literature review, which serves as the backbone of this project, was presented. It allows the TD to understand where the HCM methodology originates, what others have done in the field, and how to collect pedestrian data. Lower Manhattan was subsequently used as the laboratory for this study, to test the theories developed from reading the various relevant literature. A large amount of pedestrian data was collected to validate some of the theories and assumptions of pedestrian analysis developed from experience and from the literature review. The analyzed data also serves as a guidepost for the next phase of this study, and will aid in reaching the objective of recommending modifications for the pedestrian LOS methodology for New York City.

In this section, the findings are presented as a result of the data analysis, valuable methodology developments that may be useful to other researchers studying pedestrian behavior in dense urban areas, and the recommendations for further research opportunities—including plans for the next phase of the project.

A. Findings and Methodology Developments

1. Findings Based on the Literature Review

The Highway Capacity Manual establishes the technical criteria for evaluating pedestrian LOS using the flow rate concept. The methodology provides relatively simple and easy to understand data collection and analysis techniques for users. Even though HCM suggests parameter adjustments considering unique local characteristics; those data are lacking in New York City. Based on the literature review, many researchers recommend a LOS that would be more sensitive to pedestrian, environmental and flow characteristics – factors that influence pedestrians' walking experience and performances. Therefore, the first step of this study was to collect New York City pedestrian characteristics data.

In addition, many researchers have studied the lateral space or obstacles' "shy distance" required by pedestrians in determining effective walkway widths to use as a basis for LOS evaluations (Pushkarev and Zupan; Fruin; Hoogendoorn). However, none of them have produced results that can be adopted for New York City. In this study, a methodology that can be used in collecting "shy distance" data is tested and recommended.

Also based on the literature review, it was considered how other researchers have collected their pedestrian data; this information was incorporated into this study's methodology.

2. Pedestrian Impedance and Delay Findings

It was found that the number of impeded pedestrians observed at a location was an excellent predictor of pedestrian speed and subjective interpretations of the sidewalk's level of service. During midday (MD) peak periods, the proportion of impeded pedestrians at a location was a better predictor of speed than the flow rate at that location. In the AM peak periods, the flow rate and pedestrian speed are high while the number of impeded pedestrians is low. In the MD peak periods, flow rates are still high, but the speeds are significantly lower. This suggests that flow rate alone may not be the most reliable predictor of pedestrian speed. A difference is that a higher proportion of pedestrians are impeded at the mid-day peak. This may be a result of other factors—trip purpose, and proportion of pedestrians walking in groups, for example—but it is still a single variable that explains pedestrian speed under all circumstances.

It was also found that the concept of pedestrian delay is useful as a method of evaluating LOS. This study's rather simple delay calculation (average unimpeded speed – average speed), was an effective way of comparing the actual speed vs. the ideal speed or "speed limit" of a section of sidewalk independent of the time of day or predominant trip purpose. In some ways this is similar to the vehicular LOS concept of percent-time spent following other vehicles discussed in Chapter 2.

Finally, the delay impacts faced by pedestrians in midblock sections of the sidewalk due to crowding are small relative to delays at signalized intersections and transit terminals. For example, it was found that a median of 5% of all the time on speed and delay walks was spent waiting at traffic signals—that is 5% of the time going 0 ft/s. What is more, in some of the speed walk trials, some walkers crossed against the traffic light—reducing overall delay by violating traffic rules.

The worst case from the midblock delay methodology was found at location 20S (Fulton Street between Nassau Street and William Street) during one mid-day visit. Here, based on the data, one would lose 34.26 seconds over 1,070 feet, assuming an unimpeded walking speed of 4.17 ft/s (the median unimpeded walking speed for this location). This results in the equivalent of 13.34% of time going 0 ft/s. That is a very significant delay. But the median loss for this location for all visits (losing 4.17 seconds over 1,070 feet and assuming the unimpeded walking speed above) results in only 1.7% of time going 0 ft/s. In addition, research indicates that commuters overestimate wait times in their trips. That suggests that a small reduction in these signalized intersection delays would have a significant effect on pedestrians' perception of trip length. In order to evaluate these delays, a more comprehensive commute trip delay study considering midblock and intersection delays is warranted.

3. Shy Distance Findings

Fruin, Pushkarev, Zupan, and others discuss the space that pedestrians tend to keep between themselves and obstacles on the edges of the sidewalk—the so-called shy distance. But, except for Hoogendoorn's hallway experiments, no empirical studies that the TD has found have been done to determine what this shy distance is for different types of obstacles and how it changes with different levels of sidewalk density.

Although data collection has not been completed, the TD's video-based methodology for measuring shy distance in the field is promising. Based on several trials, the distance pedestrians walk from obstacles while also controlling for variables such as the direction of travel, the number of other pedestrians on the sidewalk, and pedestrian characteristics are able to be measured. Based on the review of literature, this is a superior method of obstacle analysis because it meets the following criteria:

a. It is relatively easy to collect data. There are automated methods that seem easier, but they have reliability drawbacks and require expensive equipment.
b. It is reliable. A person collects the data so it is more reliable than the state of the art in computer vision.

c. It is robust. This method takes into account many other factors that contribute to shy distance: direction traveled, pedestrian characteristics, and pedestrian density on the sidewalk.
d. It is externally valid. Some studies of shy distance have controlled the environment in which pedestrians are analyzed and the pedestrian subjects themselves. These studies allow for causal inferences, but may not be transferable to chaotic New York City streets. This study's methodology requires minimal environmental intrusion.

B. Future Research

In the next phase of the pedestrian LOS project, the TD plans to focus on the following:

1. Developing an Opposing Flow Methodology
Weidmann found that opposing pedestrian flows reduce pedestrian flow capacity by up to 14.5% depending on the conditions (1993). In the pedestrian study, a simple method of evaluating the impact of opposing flows on pedestrian LOS was used. Given the differences in speed and impedance between AM peaks (when flows are predominantly unidirectional) and midday peaks (when flows are balanced), there is reason to believe similar reductions in capacity may be observed. Additional data collection and analysis are necessary.

2. Street Furniture Data Collection and Analysis
The TD will analyze the video collected so far, using the shy distance methodology to build a database of street furniture types and distances. This database will be useful for other pedestrian researchers and in the next pedestrian characteristic, speed, and count analysis.

3. Conduct Additional Pedestrian Characteristics, Speeds, and Counts
Another set of pedestrian characteristic, speed, and count data will be collected. Based on what has been learned in this study, the approach will be changed in several ways.

First, high flow locations will be the focus of data gathering. When the speed-flow curve was plotted, it was found that very few locations had flow rates at the upper end of the scale (> 5 ped/ft/min). As these are the most interesting data points in terms of pedestrian behavior, more of them need to be collected.

Second, the focus will be on collecting data during the AM and midday peak periods. It was found that the AM peak period is characterized by high speeds, low impedance, and homogeneous trip purposes. In contrast, midday peaks have mixed speeds and higher levels of impedance. PM peaks had fewer distinguishing characteristics and tended to have lower volumes than AM and midday peaks—perhaps because workers leave the office in the evening over a greater range of time.

Third, it is planned to reduce the number of pedestrian characteristics collected. It was found that some characteristics (PDA, pushing, and walking aide, for example) occur too infrequently to be consequential. A study in a more residential or retail-oriented location may be more appropriate for collecting some of these characteristics.

An additional variable for each location will be collected—the LOS perceived by the field research team at the time of data collection. When the TD returned to the office and calculated the LOS for each location according to the HCM, it was sometimes felt that the LOS did not reflect the sidewalk conditions remembered. This will allow us to compare the observed LOS of three independent judges against the actual calculated LOS at each location and against factors such as the speed, proportion of impeded pedestrians, and flow rate.

Finally, the TD's database of shy distances will be used as an additional factor in the analysis of pedestrian LOS at each location.

4. Comprehensive Pedestrian Delay Evaluation
In this study, the TD focused on delays faced by pedestrians in the middle of urban blocks. Although some significant impedance in these locations was

observed, these delays are relatively short and transient. Of more concern are delays faced by pedestrians at traffic signals. In New York, where north-south blocks are relatively short, a pedestrian may face a number of these intersections in a single walking commute. In addition, delays at signalized intersections lead to additional pedestrian platooning which, in turn, leads to midblock pedestrian delays. Quantifying the impacts of these delays on commute times and on platooning is a high priority.

One way to study pedestrian trip delays is by using an enhanced version of the speed and delay walk methodology. There were some problems with this methodology that may need to be resolved. First, and most importantly, the TD is not able to control for conditions at each sidewalk on each speed run, so it is not known if differences in speed were due to crowding or some other factor. Second, by conducting its own speed walks, the TD influences a significant factor associated with walking speed—the trip purpose. Third, following and timing anonymous pedestrians on their routes may be a valid approach, but gives us no control over the route. On the other hand, the speed and delay walk methodology allows us to study the exact delays faced by pedestrians at signalized intersections and to compute the average pedestrian walking speed on each sidewalk segment.

The TD may continue to perform speed and delay walks using a slightly different methodology. In particular, the speed and delay study may be a useful way to conduct a comprehensive evaluation of total delays faced by commuting pedestrians at the midblock and at intersections given standard walking speeds. While this may not allow us to associate certain midblock conditions with pedestrian delays, delay which may be due to conditions at intersections can precisely be determined.

5. Develop Pedestrian Impedance and Delay-based LOS

Pedestrian impedance and delay were found to be excellent predictors of pedestrian speed at a location. However, the TD still needs to do further analysis to validate these findings under different conditions and determine the cut-off points between different levels of service based on the delay.

In addition, the TD needs to consider midblock pedestrian delay as a subset of all pedestrian delay, including signalized intersection delays.

C. Phase II of Pedestrian LOS

Here are the steps for Phase II of the pedestrian LOS project:

1. The pedestrian LOS team will commence with Phase II of the data gathering and analysis effort, which will consist of:

   a. Seeking partnerships with academic or research institutions for collaboration in data analysis and LOS recommendations.
   b. Gathering more Lower Manhattan pedestrian characteristic, speed, and count data, based on the revised approach detailed in section B.3 above.
   c. Developing an opposing flow methodology to account for the "friction factor" of counter-flow traffic on the study sidewalks.
   d. Developing a modified version of the speed and delay walk methodology to gather data on intersection delay. The data from this effort will be combined with data derived from the midblock delay methodology (see Chapter 4) and the impedance data to help develop a pedestrian impedance and delay based LOS.
   e. Collecting more video data and using existing videos to gather and analyze street furniture and "shy distance" data.

2. In collaboration with partnered institutions, analyze all data gathered and develop possible recommendations for changes in LOS calculation, taking into account suggestions and concerns raised in internal review and technical advisory review.

3. Present findings and recommendations to the Transportation Research Board. With the accepted findings and recommendations from transportation professionals and academics, propose modifications in pedestrian LOS analysis in New York.