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Pedestrian Level of Service for Midblock Crossing

An Issue Paper

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FORWARD

As part of the State match to the Second Year Program of the National Center for Transit Research (NCTR) at the Center for Urban Transportation Research (CUTR), the Systems Planning Office of the Florida Department of Transportation (FDOT) initiated a research project to measure pedestrian level of service for midblock crossings. This overall project has been staged into two phases.

This issue paper and a spreadsheet model have been developed for the first phase pursuant to Contract #BC137, RPWO# 14. The paper develops a research design for the second phase and serves as the final deliverable for the first phase.

Xuehao Chu of CUTR developed the paper. A draft was completed in September 2000. This draft benefited from discussions with Michael Baltes of CUTR; Martin Guttenplan, Theo Petritsch, and Dave Blodgett of FDOT; and Linda Crider of the University of Florida during the monthly teleconferences for the project. It also benefited from comments and suggestions from Ed Miezejewski, Chris Hagelin, and Steve Polzin of CUTR during CUTR's internal review process. The draft was revised in January 2001. The revision benefited from comments and discussions with Martin Guttenplan, Theo Petritsch, and Dave Blodgett of FDOT and Linda Crider of the University of Florida. The final version was completed in February, 2001 and benefited from comments and suggestions from Martin Guttenplan of FDOT.

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INTRODUCTION

Background

Current methodologies for evaluating arterial level of service by the Florida Department of Transportation (FDOT) and local governments in Florida are limited to the automobile mode. These methodologies for detailed planning are contained in ART_PLAN, a spreadsheet template described in the *1998 Level of Service Handbook* (FDOT, 1998). It is recommended for use when a specific interrupted flow facility is being evaluated. It is the most appropriate technique to analyze arterial level of service in urbanized areas for local government comprehensive plans and for concurrency management systems.

The FDOT recently initiated a Multimodal Quality of Service Program to improve the methodologies contained in ART_PLAN so that they can be used to evaluate arterial level of service from a multimodal perspective (McLeod, 2000). This initiative was motivated by two factors. At the national level, the Transportation Equity Act for the 21st Century (TEA-21) and the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) have led to a national desire to know the levels of service for automobile users as well as for transit users, pedestrians, and bicyclists (McLeod, 2000). At the state level, the Florida legislature passed the *Urban Infill and Redevelopment Act*, requiring that local governments use professionally accepted methodologies for measuring Multimodal level of service and that FDOT develop these methodologies and provide technical assistance in their applications.

The FDOT has already developed a preliminary methodology for evaluating transit level of service at the generalized planning level (Karachepone, 2000). It evaluates transit level of service for transit route segments on an hourly or daily basis. The basic measure of effectiveness is transit frequency along the segments. For a daily transit level of service, it also takes into account daily transit service span. For either hourly or daily analysis, it further considers three pedestrian factors, including pedestrian level of service along route segments, sidewalk connections to transit stops, and pedestrian crossing difficulty. Both transit service span and the three pedestrian factors are proposed as multiplicative adjustment factors, which have not been subject to transit field calibration. The adjusted service frequency is then converted to a level of service designation based on numerical thresholds.

The FDOT has proposed to use a methodology developed by Landis et al. (1997) to evaluate bicycle level of service for riding along roadways (McLeod, 2000). It is based on five variables: average effective width of the outside through lane, motorized vehicle volumes, motorized vehicle speeds, large truck volumes, and pavement conditions. Thus, bicycle level of service is also based on multiple factors. Unlike the transit level of service methodology, which is based on actual frequency, the basic measure of effectiveness is perceived safety and comfort by bicyclists. Furthermore, the bicycle level of service methodology weighs the multiple factors by importance through statistical calibration with field data. The weights are then used to convert the factors into a numerical index. Just like the transit level of service methodology, the numerical index score is finally changed to a level of service designation, based on numerical thresholds.

The FDOT has also proposed to use a methodology developed by Landis et al. (1999) to evaluate pedestrian level of service for walking along roadways (McLeod, 2000). It is based on five factors: lateral separation of pedestrians from motor vehicle traffic, presence of physical barriers and buffers, outside lane traffic volume, motor vehicle speed, and vehicle mix. Just like the bicycle level of service methodology, the basic measure of effectiveness is perceived safety and comfort by pedestrians. The variables are also weighted by importance through statistical calibration using field data. The weights are then used to convert the factors into a numerical index. The numerical index score is finally changed to a level of service designation, based on numerical thresholds.

For pedestrian level of service, the FDOT has proposed to separately consider pedestrian levels of service for crossing streets at midblock locations and at intersections. Currently, there are no known methodologies for evaluating pedestrian level of service for street crossing at either midblock locations or intersections. The current issue paper is related to developing a pedestrian level of service methodology for crossing streets at midblock locations. A pedestrian level of service methodology for crossing streets at intersections is being developed in a separate research project.

Objectives

The current research project is aimed at developing a pedestrian level of service methodology for street crossing at midblock locations. This methodology is capable of providing a measure of effectiveness that indicates pedestrians' perceived quality of service in crossing roads at midblock locations. This measure of effectiveness can then be converted to a level of service designation. This methodology should be generally consistent with other level of service methodologies being developing as part of the FDOT's Multimodal Quality of Service Program. The study will attempt to determine what variables are correlated with pedestrians' perceived quality of service for midblock crossing. This will be done through a statistical calibration and validation process involving collecting actual site characteristics and stated levels of quality of service by a sample of persons at a sample of sites. These variables will include those that are most important to the FDOT and local governments for the purpose of improving pedestrian mobility, safety, and livability.

This issue paper documents a research design for developing the pedestrian level of service methodology for crossing streets at midblock locations. In addition, this issue paper describes background information in detail and outlines the various approaches that the FDOT could use to establish a pedestrian level of service methodology for crossing streets at midblock locations.

Related Studies

Based on a review of literature, there is a large body of work on pedestrian level of service. However, much of that work is limited to pedestrian level of service on uninterrupted pedestrian facilities and how crowded these facilities are. This work is parallel to what has been done on automobile level of service. Much of this work is summarized in the pedestrian chapter of the 1997 update of the *Highway Capacity Manual* (TRB, 1998).

On the other hand, there are few studies related to determining pedestrian level of service for crossing streets. First, there is the transit level of service methodology that has been developed as part of the FDOT's Multimodal Quality of Service Program. As mentioned earlier, the transit level of service methodology does incorporate a street crossing difficulty factor for pedestrians. However, this methodology is designed to generate an adjustment factor for considering pedestrian quality of service for street crossing in the transit level of service methodology. It is not designed to lead to a numerical score that can then be changed to a level of service designation. Nor has it been tested with field data. Finally it does not distinguish street crossing at midblock locations from street crossing at intersections.

Second, there have been studies measuring pedestrian crossing difficulty in terms of pedestrian delays or lack of crossing opportunities for midblock locations (Goldschmidt, 1977; Hunt and Griffiths, 1991; Hunt and Abduljabbar, 1993). Some of these studies are based on field observations of pedestrian crossings or the supply of traffic gaps, while others are based on analysis of hypothetical situations. They typically are not based on pedestrians' perception of delays or crossing opportunities. They are also narrow in what aspects of pedestrian quality of service for midblock crossing are considered. Much of the work on measuring pedestrian quality of service for street crossing in terms of pedestrian delays is summarized by Rouphail et al. (1998).

Third, there are three studies closely related to pedestrian level of service for crossing streets at intersections. A study by Palamarthy et al. (1994) develops models of pedestrian crossing behavior at signalized intersections. The motivation of this study was to get a better understanding of pedestrians' crossing behavior so that new strategies to deal with non-compliance of pedestrians with signals can be evaluated. It is based on a theory about pedestrians' decision to cross a street (i.e., the gap-acceptance theory). It was calibrated with field data from Austin, Texas. This study results in the identification of determinants of pedestrian crossing behavior at signalized intersections. The gap-acceptance theory used also provides a foundation to develop methodologies of pedestrian level of service for crossing streets. This study does not, however, lead to numerical scores that can be changed to specific level of service designations.

Another one related to street crossing at intersections is a proposed study by the Federal Highway Administration (FHWA, 2000a). The purpose is to develop mathematical models that can be used to identify engineering improvements to reduce pedestrian involvement in crashes with motor vehicles at intersections. Calibration will be based on reported statistics of pedestrian crash involvement rather than perceived levels of crossing safety. As a result, this methodology is inconsistent with those for evaluating bicycle level of service or pedestrian level of service along roadways.

The last study related to street crossing at intersections is summarized by Wellar (1998). The purpose is to develop an index to represent the level of safety, comfort, and convenience expected by pedestrians crossing streets at signalized intersections. A preliminary formation of the index is based on the amount of interaction between motor vehicles and pedestrians, which is further adjusted by five multiplicative factors: number of through lanes, number of turning lanes, street angles, street grade, number of legs, and number of channels at the intersection.

While what this index tries to measure is similar to what is being considered in the current project, both the intended purpose and the approach to developing this index differ from the current project. The index is intended for ranking intersections rather than for determining the pedestrian level of service for individual intersections. Selection of variables is based on opinion surveys of elected officials, professionals, and citizens. No data collection or statistical calibration is involved in developing this index.

Organization

The rest of the issue paper is organized as follows. The chapter following the introduction describes related statues of the State of Florida, the Department's Multimodal Quality of Service Program, and warrants related to engineering treatments for pedestrian midblock crossings. With this background, the next chapter discusses alternative approaches to dealing with the different components of the research project. These include the concept and determinants of pedestrian quality of service for midblock crossing, sampling and data collection, calibration and validation, and application. The last chapter proposes an approach for this research project based on the nature of the current project and the alternative approaches described earlier. Those references that are cited in this issue paper are listed under References, while those materials that are reviewed but not cited are listed under Bibliography.

BACKGROUND

This chapter sets the context for the research project and the issue paper including related state statutes, the FDOT's Multimodal Quality of Service Program, and related warrants.

Statutes

The statutes of the State of Florida contain three sections that are related to pedestrians crossing streets at midblock locations and the development of methodologies for determining level of service for such crossings. One requires the FDOT to develop multimodal level of service methodologies. One describes criteria for street crossing conditions that are hazardous to students who walk to and from school. The last one provides the law regarding pedestrian crossing at midblock locations.

Multi-modal Level of Service Methodologies

The requirement for the FDOT to develop multimodal level of service methodologies is contained in Section 163.3180, Item (1) (b):

"Local governments shall use professionally accepted techniques for measuring level of service for automobiles, bicycles, pedestrians, transit, and trucks. These techniques may be used to evaluate increased accessibility by multiple modes and reductions in vehicle miles of travel in an area or zone. The Department of Transportation shall develop methodologies to assist local governments in implementing this multimodal level-of-service analysis. The Department of Community Affairs and the Department of Transportation shall provide technical assistance to local governments in applying these methodologies."

Hazardous Crossing Conditions for Students

The criteria that define hazardous crossing conditions with respect to any road across which students must walk in order to walk to and from school are given in Section 234.021, Item (3) (b):

"1. If the traffic volume on such road exceeds the rate of 360 vehicles per hour, per direction (including all lanes), during the time students walk to and from school and if the crossing site is uncontrolled. For purposes of this subsection, an "uncontrolled crossing site" is defined as an intersection or other designated crossing site where no crossing guard, traffic enforcement officer, or stop sign or other traffic control signal is present during the times students walk to and from school."

"2. If the total traffic volume on such road exceeds 4,000 vehicles per hour through an intersection or other crossing site controlled by a stop sign or other traffic control signal, unless crossing guards or other traffic enforcement officers are also present during the times students walk to and from school."

Thus, a road crossing for students is considered hazardous if the average gap goes below 10 seconds for uncontrolled sites and if the average gap goes below 1 second for controlled sites.

Pedestrians Midblock Crossing Law

The Florida law that governs pedestrians crossing streets at midblock locations is given in Section 316.130:

"(10). Every pedestrian crossing a roadway at any point other than within a marked crosswalk or within an unmarked crosswalk at an intersection shall yield the right-of-way to all vehicles upon the roadway."

"(11). Between adjacent intersections at which traffic control signals are in operation, pedestrians shall not cross at any place except in a marked crosswalk."

"(12). No pedestrian shall, except in a marked crosswalk, cross a roadway at any other place than by a route at right angles to the curb or by the shortest route to the opposite curb."

Whether midblock crossing outside a crosswalk is legal seems to depend on whether the midblock is signalized at both intersections. If both intersections are signalized, it is illegal, regardless of how long this midblock is. If one or neither intersection is signalized, it is legal as long as one crosses the street at right angles and yields to motor vehicles. This law is not unique to Florida. Many US states have this law and even the exact statutory wording.

Multimodal Quality-of-service Program

Current methodologies for evaluating arterial level of service by the Florida Department of Transportation (FDOT) and local governments are limited to the automobile mode. These methodologies for detailed planning are contained in ART_PLAN, a spreadsheet template described in the *1998 Level of Service Handbook* (FDOT, 1998). The Department's Multimodal Quality of Service Program aims to improve the methodologies contained in ART_PLAN so that they can be used to evaluate arterial level of service from a multimodal perspective (McLeod, 2000).

Automobile Level of Service Methodologies

Automobile level of service methodologies for urban arterials are contained in a spreadsheet template called ART_TAB for generalized planning and in a spreadsheet template called ART_PLAN for detailed planning. Both are described in the *1998 Level* *of Service Handbook* (FDOT, 1998). The second column of Table 1 below lists the input variables and selected intermediate calculations in ART_PLAN.

Table 1: Variables in Current and Expanded Level of Service Methodologies

	Current	Expanded					
					Pedestrian		
	Auto/ Truck	Area Wide	Bus	Bike	Parallel Walking	Intersection Crossing	Midblock Crossing
Traffic Characteristics							
Annual average daily traffic	X			X	X		
Peak hour factor	X			X	X		
Adjusted saturation flow rate	X						
Percent turns from exclusive lanes	X						
Truck percentage				X	X		
Bus frequency			X				
Bus span of service			X				
Roadway Characteristics							
Area type	X						
Number of through lanes	X		X	X	X		
Roadway class	X		X				
Free flow speed	X			X	X		
Arterial length	X						
Median type	X		X				
Left turn bays	X						
Bike lane				X			
Paved shoulder				X			
Outside lane width				X			
Pavement condition				X			
Sidewalks			X		X		
Sidewalk lateral separation					X		
Sidewalk connection to transit stop				X			
Sidewalk/roadway barrier					X		
Control Characteristics							
Signalized intersections	X						
Signalized intersection distance	X		X				
Arrival type	X						
Signal type	X						
Cycle length	X						
Effective green time ratio	X						
Intermediate Calculations							
Midblock running speed	X			X	X		
Pedestrian segment QOS			X				
Pedestrian midblock difficulty			X				
Auto/truck level of service			X				

Transit Level of Service Methodology

The FDOT has already developed a preliminary methodology for evaluating transit level of service at the generalized planning level (Karachepone, 2000). It evaluates transit level of service for transit route segments on an hourly or daily basis. The basic measure of effectiveness is transit frequency along the segments. For a daily transit level of service, it also takes into account daily transit service span. For either hourly or daily analysis, it further considers three pedestrian factors including pedestrian level of service along route segments, sidewalk connections to transit stops, and pedestrian crossing difficulty. Both transit service span and the three pedestrian factors are proposed as multiplicative adjustment factors. These adjustment factors have not been subject to field calibration. The adjusted service frequency is then used as a score for quality of service and converted to a level of service designation based on numerical thresholds. The input variables for the transit level of service methodology are listed in the fourth column of Table 1 earlier.

Bicycle Level of Service

The FDOT has proposed to use a methodology developed by Landis et al. (1997) to evaluate bicycle level of service for riding along roadways (Mcleod, 2000). Bicycle level of service for street crossing is not explicitly considered. It is based on five variables: average effective width of the outside through lane, motorized vehicle volumes, motorized vehicle speeds, large truck volumes, and pavement conditions. Differences in bicyclist age and abilities are not considered. Thus, bicycle level of service is also based on multiple factors. Unlike the transit level of service methodology, the basic measure of effectiveness is perceived safety and comfort by bicyclists. Furthermore, the bicycle level of service methodology weighs the multiple factors by importance through statistical calibration with field data. The weights are then used to convert the factors into a numerical index. Just like the transit level of service methodology, the numerical index score is finally changed to a level of service designation, based on numerical thresholds. The input variables are listed earlier in the fifth column of Table 1.

Pedestrian Level of Service for Walking along Roadways

The FDOT has also proposed to use a methodology developed by Landis et al. (1999) to evaluate pedestrian level of service for walking along roadways (McLeon, 2000). It is based on five factors: lateral separation of pedestrians from motor vehicle traffic, presence of physical barriers and buffers between motor traffic and pedestrians, outside lane traffic volume, and motor vehicle speed, and vehicle mix. Just like the bicycle level of service methodology, the basic measure of effectiveness is perceived safety and comfort by pedestrians. The variables are also weighted by importance through statistical calibration through field data. The weights are then used convert the factors into a numerical index. The numerical index score is finally changed to a level of service designation, based on numerical thresholds. The input variables are listed earlier in the sixth column of Table 1.

Scaling for Pedestrian and Bicyclist Level of Service Measures

During the process of expanding ART_PLAN, the Department discovered that the A-F scales resulting from the newly developed methodologies for pedestrian and bicyclist level of service analyses are do not match real conditions well. This is based on comparing what the methodologies would predict for a given facility or service with the actual conditions of that facility or service. For pedestrians walking along a roadway or bicyclists riding along a roadway, the predicted level of service is systematically higher than the actual conditions in many cases, at least in Florida.

The Department recognizes the importance of having comparable scales for level of service analysis across modes in successfully implementing the *Urban Infill and Redevelopment Act*. Comparable scales for level of service analysis across modes better facilitate tradeoff analyses. Comparable scales also allow designing to a certain level of service for all modes present. Only scales for pedestrian and bicyclist level of service analyses that are consistent with actual conditions can pass tests of reasonableness to the public and elected officials.

The Department attributes the problem with the pedestrian and bicyclist level of service scales to the difference in how they are determined from how the automobile and bus scales are determined. For both automobile and bus level of service analyses, the scales are determined in three steps. First, an objective measure of effectiveness is selected to measure quality of service, which quantitatively represents the operational conditions. For automobile, the measure of effectiveness is speed. For bus, the basic measure of effectiveness is frequency. Second, the operational conditions are described for each of the six level-of-service grades. Third, the breakpoints in the measure of effectiveness are selected so that they are consistent with the corresponding operational conditions. These breakpoints determine the scale for level of service analyses.

For the two pedestrian and bicyclist methodologies that are already developed, the scales are determined differently from the automobile and bus scales. First, a sample of pedestrians or bicyclists from the general public is asked to state their perceived level of service from LOS A to LOS F for a sample of sites. It is assumed that the participants understand what operational conditions each level of service represents. Second, the perceived level of service is converted to numbers 1 through 6 and is calibrated with a set of site characteristics. Third, the predicted level of service from the calibrated model is broken down into six ranges, using the following breakpoints: 1.5, 2.5, 3.5, 4.5, and 5.5.

The Department approached this problem with the pedestrian and bicyclist scales by considering shifting them downward by a letter grade. For example, this would shift LOS D predicted by the current methodologies to LOS E. The Department, however, has dismissed this idea on the ground that there is no technical basis for a shift. The Department is also concerned about potential glitches that will arise when users are not aware of the shift when using the published methodologies.

We believe that the solution to this problem lies in the process with which the pedestrian and bicyclist scales are developed rather than making changes in the outcome of this process. Many aspects of this process could be the source of this scaling problem. While there is no technical basis for the arbitrary shifting as considered by the Department, there is a significant technical basis for adjusting the process. Several aspects of the process for potential adjustment are briefly discussed below.

Use of Volunteers

The participants who provided the initial perceived level of service are volunteers rather than a representative sample of the general population. One problem with volunteers is that they are likely to be more passionate about pedestrian issues and respond with a policy-response bias: Responding negatively might induce improvements. The effect of this issue on scaling would be a downward bias.

Survey Question

There are two potential issues with the question used to solicit the perceived level of service from the participants.

One potential issue is the assumption that participants know what operational conditions each of the six letter grades represent. It is unclear how valid this assumption is. Consider letter grade D, which is supposed to represent acceptable conditions. It seems that few parents would consider a school grade D to be acceptable for their children. The effect of this issue on scaling would be a downward bias.

Another potential issue with the survey question is the direct solicitation of qualitative levels of service. Conceptually, the designation of the different levels of service should be based on a measure of effectiveness that represents the quality of service of the operational conditions. The question should have solicited perceived quality of service. The calibrated model would then provide a measure of effectiveness. The level-of-service scales would finally be determined by breaking down the range of this measure of effectiveness into six appropriate intervals. The effect of this issue on the scaling is unclear at this point.

Treatment of Rating Data

The current process of developing the pedestrian and bicyclist scales uses the linear regression model, implicitly treating the discrete and ordinal levels of service as a continuous and cardinal one. As a result, it treats the difference between ratings of 1(A) and 2(B) the same as the difference between 4(D) and 5(E). In reality, however, one is likely to be far less preferable to the decrease in level of service from 4 to 5 than to the decrease from 1 to 2. The effect of this issue on scaling would be a downward bias, especially for the lower levels of service.

Arbitrary Breakpoints

The current process of developing the pedestrian and bicyclist scales uses somewhat arbitrary breakpoints in the predicted measure of effectiveness for designating the different levels of service. As stated earlier, the breakpoints are 1.5, 2.5, 3.5, 4.5, and 5.5. The selection of these breakpoints is also relied on the linear treatment of the discrete and ordinal responses from the participants. The effect of this issue on scale is likely to have a downward bias, especially for the lower levels of service.

Perception

The process of developing the pedestrian and bicyclist level of service scales is based on user perception. While this is not a shortcoming, it can be the source of the scaling problem with the existing pedestrian and bicyclist level of service measures. The effect of this issue on scaling is not definitive at this point. However, it is likely to have a downward bias on the scales. The reason is a discrepancy between the full range of possible operational conditions in real life and the limited range of operational conditions experienced by participants. If the worst operation conditions one participant has experienced are what LOS D would represent, this participant is likely to perceive conditions observed during a research project to be poorer than otherwise.

Role of This Project

To determine pedestrian level of service for street crossing, the FDOT has proposed to separately consider crossing at midblock locations and at intersections. A research project to develop pedestrian level of service for street crossing at intersections is underway. This project deals with street crossing at midblock locations.

The methodology from this project could be combined with those for the pedestrian level of service along a roadway segment and for crossing at intersections to determine pedestrian level of service for an entire roadway segment.

In addition, the methodology from this project could potentially be directly used to replace the preliminary method for measuring pedestrian crossing difficulty in the transit level of service methodology. However, this role of the current project will be not realized at this point for two reasons. First, the preliminary method in the transit module is based on segments (between two signalized intersections) rather than blocks (between two intersections), while the measurement in this project is expected to be based on blocks. Second, the preliminary method in the transit module includes both midblock and intersection crossings, while the measurement in the current project will not take into account intersections.

However, the methodology from this project could be indirectly used in the transit level of service methodology. Once the result from this project is combined with the other two modules of pedestrian level of service (walking along roadways and crossing at intersections) to form an overall pedestrian level of service at the segment level, this overall level of service at the segment-level can then be used as a direct input into the transit module. For example, the multiplicative factor would be 0.5 for a combined pedestrian level of service of F, 1 for D, etc.

Warrants

The pedestrian quality of service for midblock crossings may be improved through signalization and the installation of crosswalks and medians. This chapter briefly reviews the warrants for these engineering treatments. Warrants for signalization are adopted from the *2000 Manual on Uniform Traffic Control Devices* (MUTCD) (FHWA, 2000b), while those for crosswalks and medians are from the *Florida Pedestrian Facilities Planning and Design Handbook* (FDOT, 1999).

Some of these warrants are based on actual pedestrian volume. Some may argue that these warrants should also take into account latent demand for street crossing. Nobody may cross a particular street if the corresponding quality of service is extremely poor.

Signalization

There are two types of signalization for pedestrian midblock crossings: traffic control signals and pedestrian signals.

Traffic Control Signals

A traffic control signal may be warranted either for midblock crossing in general or for school crossing in particular.

<u>Minimum Pedestrian Volume Warrant</u>.

The Pedestrian Volume signal warrant is intended for application where the traffic volume on a major street is so heavy that pedestrians experience excessive delay in crossing the major street.

The need for a traffic control signal at an intersection or mid-block crossing shall be considered if an engineering study finds that both of the following criteria are met:

A. The pedestrian volume crossing the major street at an intersection or mid-block location during an average day is 100 or more for each of any 4 hours or 190 or more during any 1 hour, and
B. There are fewer than 60 gaps per hour in the traffic stream of adequate length to allow pedestrians to cross during the same period when the pedestrian volume criterion is satisfied. Where there is a divided street having a median of sufficient width for pedestrians to wait, the requirement applies separately to each direction of vehicular traffic.

The Pedestrian Volume signal warrant shall not be applied at locations where the distance to the nearest traffic control signal along the major street is less than 90 m (300 ft), unless the proposed traffic control signal will not restrict the progressive movement of traffic.

If a traffic control signal is justified by both this signal warrant and a traffic engineering study, the traffic control signal shall be equipped with pedestrian signal heads.

If a traffic control signal is justified by both this signal warrant and a traffic engineering study:

A. If installed within a signal system, the traffic control signal should be coordinated.
B. At an intersection, the traffic control signal should be traffic-actuated and should include pedestrian detectors. As a minimum, it should have semi-actuated operation, but full-actuated operation with detectors on all approaches might also be appropriate.
C. At non-intersection crossings, the traffic control signal should be pedestrian-actuated, parking and other sight obstructions should be prohibited for at least 30 m (100 ft) in advance of and at least 6.1 m (20 ft) beyond the crosswalk, and the installation should include suitable standard signs and pavement markings.

The criterion for the pedestrian volume crossing the major roadway may be reduced as much as 50 percent if the average crossing speed of pedestrians is less than 1.2 m/sec (4 ft/sec).

A traffic control signal may not be needed at the study location if adjacent coordinated traffic control signals consistently provide gaps of adequate length for pedestrians to cross the street, even if the rate of gap occurrence is less than one per minute.

<u>School Crossing Warrant.</u>

The School Crossing signal warrant is intended for application where the fact that school children cross the major street is the principal reason to consider installing a traffic control signal.

The need for a traffic control signal shall be considered when an engineering study of the frequency and adequacy of gaps in the vehicular traffic stream as related to the number and size of groups of school children at an established school crossing across the major street shows that the number of adequate gaps in the traffic stream during the period when the children are using the crossing is less than the number of minutes in the same period and there are a minimum of 20 students during the highest crossing hour.

Before a decision is made to install a traffic control signal, consideration shall be given to the implementation of other remedial measures, such as warning signs and flashers, school speed zones, school crossing guards, or a grade-separated crossing.

The School Crossing signal warrant shall not be applied at locations where the distance to the nearest traffic control signal along the major street is less than 90 m (300 ft), unless the proposed traffic control signal will not restrict the progressive movement of traffic.

If a traffic control signal is justified by both this signal warrant and an engineering study:

A. If installed within a signal system, the traffic control signal should be coordinated.
B. At an intersection, the traffic control signal should be traffic-actuated and should include pedestrian detectors. As a minimum, it should have semi-actuated operation, but full-actuated operation with detectors on all approaches might also be appropriate.
C. At non-intersection crossings, the traffic control signal should be pedestrian-actuated, parking and other sight obstructions should be prohibited for at least 30 m (100 ft) in advance of and at least 6.1 m (20 ft) beyond the crosswalk, and the installation should include suitable standard signs and pavement markings.

Pedestrian Signals

The design and operation of traffic control signals shall take into consideration the needs of pedestrian as well as vehicular traffic.

If engineering judgment indicates the need for provisions for a given pedestrian movement, signal faces conveniently visible to pedestrians shall be provided by pedestrian signal heads or a signal face for an adjacent vehicular movement.

Safety considerations should include the installation, where appropriate, of accessible pedestrian signals that provide information in non-visual format (such as audible tones, verbal messages, and/or vibrating surfaces).

Where pedestrian movements regularly occur, pedestrians should be provided with sufficient time to cross the roadway by adjusting the traffic control signal operation and timing to provide sufficient crossing time every cycle or by providing pedestrian detectors.

If it is desirable to prohibit certain pedestrian movements at a traffic control signal, a PEDESTRIANS PROHIBITED or No Pedestrian Crossing sign may be used.

Crosswalks

A midblock crosswalk is the portion of roadway designated for pedestrians to use in crossing the street at a midblock location. Midblock crosswalks are generally recommended at the following locations:

- Where a marked crosswalk can concentrate or channelize multiple pedestrian crossings to a single location.
- Where there is a need to delineate the optimal crossing location, due to confusing geometrics or traffic operations.
- Approved school crossings or at crossings on recommended safe routes to school.
- Other locations with a high number of pedestrian crossings (more than 25 pedestrians per hour) and/or a high number of pedestrian and vehicle conflicts.

- To reach channelized islands when the number of pedestrians times the number of vehicles exceeds 800 per hour.

Advance pedestrian warning signs should be used to warn motorists of pedestrian crossing activities. Adequate sight distance for the motorist and pedestrian should exist. Adequate street lighting should be available, particularly if nighttime crossings are common.

Midblock crosswalks may be inappropriate on moderate- and high-speed roads (e.g., with speed limits of 40 mph or above) or immediately downstream from bus stops, traffic signals, or other marked crosswalks.

Medians

Non-restrictive medians do not benefit pedestrians as much as restrictive ones or refuge islands. A two-way-left-turn lane, for example, exposes pedestrians to traffic from both directions. Motorists are looking for gaps in oncoming traffic and may not be watching out for pedestrians.

Restrictive medians or refuge islands for pedestrians are recommended for midblock crossings under the following conditions:

- Wide, two-way streets (four lanes or more) with high traffic volumes, high travel speeds, and large pedestrian volumes.
- Wide streets where the elderly, people with disabilities, and children cross regularly.

ALTERNATIVE APPROACHES

This chapter describes various approaches that might be used to consider and measure pedestrian level of service for midblock crossing. This is done separately for the five elements of the research project, including the concept of pedestrian level of service for midblock crossing, the determinants of perceived pedestrian level of service for midblock crossing, sampling and data collection, calibration and validation, and application.

Concept of Pedestrian Level of Service for Midblock Crossing

Several issues in defining the concept of pedestrian level of service for midblock crossing are discussed. The first two issues relate to what constitutes a block and a midblock. The second set of issues has to do with the concepts of level of service and quality of service in general and related measures of effectiveness. Another issue relates to the scale for which pedestrian level of service for midblock crossing is measured. The last issue relates to how one measures the level of service.

Blocks

In order to measure pedestrian level of service for midblock crossing, blocks may be defined in one of two ways. A block may be narrowly seen as the roadway section between two consecutive intersections, regardless of whether they are signalized or not. This view is in line with the traditional definition of a street block. Alternatively, a block may be broadly seen as the roadway section between two consecutive signalized intersections. This view is in line with what constitutes a highway segment for multimodal quality of service analysis by McLeod (1999).

Which of these two views to adopt depends on the role of the current project in the overall multimodal quality of service program of the Department. Given that the quality of service is separately measured for intersections, the narrow view of a block would seem to be more appropriate. As discussed before, the result of pedestrian quality of service for midblock crossing can then be combined with those of other components of pedestrian quality of service measures to form an overall pedestrian quality of service for transit route segments in measuring transit level of service.

Midblocks

One may define a midblock as the entire block, excluding its two intersections. This definition is theoretically fine with the current project. However, there is the possibility that potential pedestrians may unconsciously take into account intersection characteristics when asked for their perception of the quality of service for crossing a street near an intersection. To avoid such a concern, an alternative definition of a midblock may be the middle portion of a block. If this definition is adopted, one then needs to set a cutoff distance from intersections to define midblocks.

Levels of Service

Following the 1997 update of the *Highway Capacity Manual* (TRB, 1998), levels of service are qualitative indicators that characterize operational conditions of a facility or service and users' perception of these conditions. The descriptions of individual levels of service characterize these conditions in terms of several aspects. For the automobile mode, for example, these aspects include speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety.

Quality of Service

For the purpose of this project, quality of service is seen as a quantitative indicator of the operational conditions of a facility or service and users' perception of these conditions. In contrast, levels of service are qualitative indicators of such conditions and perceptions. Levels of service are defined on the basis of a quality of service indicator that best describe the operating quality of a facility or service.

Measures of Effectiveness

Qualities of service are represented by one or more operational parameters, called measures of effectiveness. The selected measures of effectiveness represent available measures best describing qualities of service for each facility or service. Levels of service are determined by breaking down the quality of service as quantified by a selected measure of effectiveness into six letter designations, with A describing the highest range of quality and F describing the lowest range of quality. Each level of service represents a range of operational conditions, as defined by a range in the measure of effectiveness selected.

A good starting point in developing a methodology for evaluating the level of service of a facility or service is to select a measure of effectiveness most appropriate for this facility or service. This selection involves determining what aspects of operational conditions are important for a particular situation. For some facilities or service, the most appropriate measure of effectiveness may be one that characterizes the operational conditions in terms of speed and travel time, or safety, or any single aspect of the operation conditions listed above. For other facilities or services, the most appropriate measure of effectiveness may be one that characterizes the overall operational conditions.

The selection of measures of effectiveness also involves determining how these operational conditions will be measured. An objective measure may be appropriate for some situations. One example is the objective measures typically used for automobile level of service methodologies. Another example is the use of transit frequency in FDOT's transit level of service methodology. A subjective measure indicating perceived values of an operational condition by users may be more appropriate for other situations. Examples of subjective measures include the perceived level of safety and comfort in FDOT's bicycle level of service methodology and the pedestrian level of service methodology for walking along roadway segments.

The selection of measures of effectiveness also depends on limitations on data collection and availability.

Measurement Scale

Pedestrian quality of service for midblock crossing may be measured for a particular point in a midblock or for the entire midblock.

Point Measurement

The point measurement focuses on the quality of service for crossing at an isolated midblock point, regardless of whether alternative midblock points may offer different levels of quality of service. The point measurement is relatively easier for a pedestrian to perceive the quality of service because they do not need to consider variations in quality of service across midblock locations.

From a behavioral point of view, the point measurement is also relevant. It is true that some people will look for the best crossing point on a block, including crossing at the two intersections. Most people, however, choose their crossing point under one of two scenarios. Under one scenario, the pedestrian reaches a midblock location and just wants to go to the other side of the street. As a result, the pedestrian may cross the street at where he or she is. Under another scenario, the pedestrian reaches a midblock location and has to go to some place on the other side of the street either down or up stream. In that case, the pedestrian may start to walk in the direction of his or her destination and look for a crossing opportunity. As a result, the pedestrian may cross the street whenever such an opportunity exists. Under either scenario, they cross the street not by searching for the best point in terms of facility alone, rather they cross the street at the most convenient location.

One issue of concern with the point measurement is how the variation in cross-sectional characteristics in a given midblock be treated in applying the point measurement. Will a given midblock have a single level of service for pedestrian crossing or multiple levels of service at its different locations of different cross-sectional characteristics? If a given midblock is to have a single level of service, will that level of service be measured for any single point in the given midblock? Or will that level of service be based on some weighted average of the predicted quality of service at its different locations with the cross-sectional characteristics used as the weights?

Segment Measurement

The segment measurement, on the other hand, takes into account all potential crossing points in a midblock. The segment measurement better fits the Department's Multi-modal Quality of Service Program in the following sense. In this program, there is already a measure of pedestrian quality of service for walking along a particular roadway block. In addition, it is planned to have a measure of pedestrian quality of service in terms of crossing at intersections. A segment measurement for street crossing completes the puzzle perfectly. With the point measurement, on the other hand, a segment measurement will have to be calculated first with the point-measurement result in order to complete the same puzzle.

Using traffic barriers against pedestrians as a measure of effectiveness for pedestrian crossing quality of service at midblock locations, Russell and Hine (1996) discuss several issues in measuring traffic barriers. In their words, traffic barriers are "the sum of inhibiting effects upon pedestrian behavior resulting from the impact of traffic conditions, including physical (observable) and psychological (unobservable) impediments to pedestrian movements." On the issue of measurement scale, they have the following arguments:

"Measures of traffic barrier effects should be defined over well-defined sections of roads. Coverage of a section reduces the problems resulting from the flexibility of pedestrians' crossing strategies and crossing points, which makes measures at any individual point of limited value. An ideal section should be bounded by formal crossing facilities."

To understand the relevance of the flexibility of pedestrians' crossing strategies and crossing points, one may ask these questions: Will a pedestrian who is close to a signalized intersection with a walk-cycle not go to this facility for crossing? Will midblock crossing be more likely chosen by a pedestrian who is away from a signalized intersection?

One issue of concern with the segment measurement is how the variation of cross-sectional characteristics in a given midblock be treated in developing the segment measurement. This issue comes up in applications with respect to the point measurement but in the development of the methodology with respect to the segment measurement.

Perceived Quality of Service

To get an objective measure of quality of service is one thing, to estimate a perceived measure of quality of service is a different thing. Typically, a stated-perception approach is taken to get a perceived measure. Under this approach, one derives the perceived quality of service by directly asking the participants of a research project about how they perceive the quality of service as a pedestrian or a bicyclist for a particular site. The studies by Landis and associates (1997, 1999, 2000) are examples of this approach.

An alternative would take a revealed-perception approach, under which one would derive the perceived quality of service from estimating a behavioral model that is based on hypothetical pedestrian choices of some kind. One example of such choices is whether a pedestrian would cross a street at certain locations under certain conditions. Variables used to characterize these conditions will be part of the behavioral model. The estimated utility functions from the model would be used as a measure of effectiveness. Such a measure of effectiveness would reflect the perceived quality of service for street crossing for two reasons. The estimation results in parameters of the variables that reflect how important each variable is to the pedestrians. In addition, the measure of effectiveness captures the overall satisfaction a pedestrian would receive from crossing a street. By basing the model on hypothetical pedestrian choices rather than actually observed ones, this alternative approach would also take into account potential latent demand for street crossing.

The choice between these two approaches affects the complexity of the task given to the participants. With the stated-perception approach, a participant typically is asked to pick a rating out of a scale from 1 to 6 for any given situation. With the revealed-perception approach, a participant faces a much simpler task of making a choice between two options (cross or not to cross). The choice between the approaches also affects whether the estimated quality of service model is based on a behavioral foundation. The stated-perception approach derives the quality of service model by directly linking the stated perception to its potential determinants, while the revealed-perception approach does that by modeling the crossing behavior of pedestrians. A model that has a behavioral foundation is more desirable. Finally, the choice between the two approaches affects the consistency of methods used across the different components of the Department's Multimodal Quality of Service Program. It is the stated-perception approach that has been taken for other modules in the program.

Determinants of Pedestrian Quality of Service for Midblock Crossing

One difficulty in understanding what determines pedestrian quality of service for midblock crossing is the lack of a framework in the literature to guide the selection of these determinants. This document takes a component approach, as illustrated in Figure 1. Specifically, we first examine the components of pedestrian quality of service for midblock crossing and seek to understand what determines these components. This approach turns out not to be fruitful. We then turn to examining the components of pedestrian crossing behavior at midblock locations and seek to understand what determines these components. This second approach proves to be helpful in identifying a set of potential determinants of pedestrian quality of service for midblock crossing. These two approaches are discussed separately below.

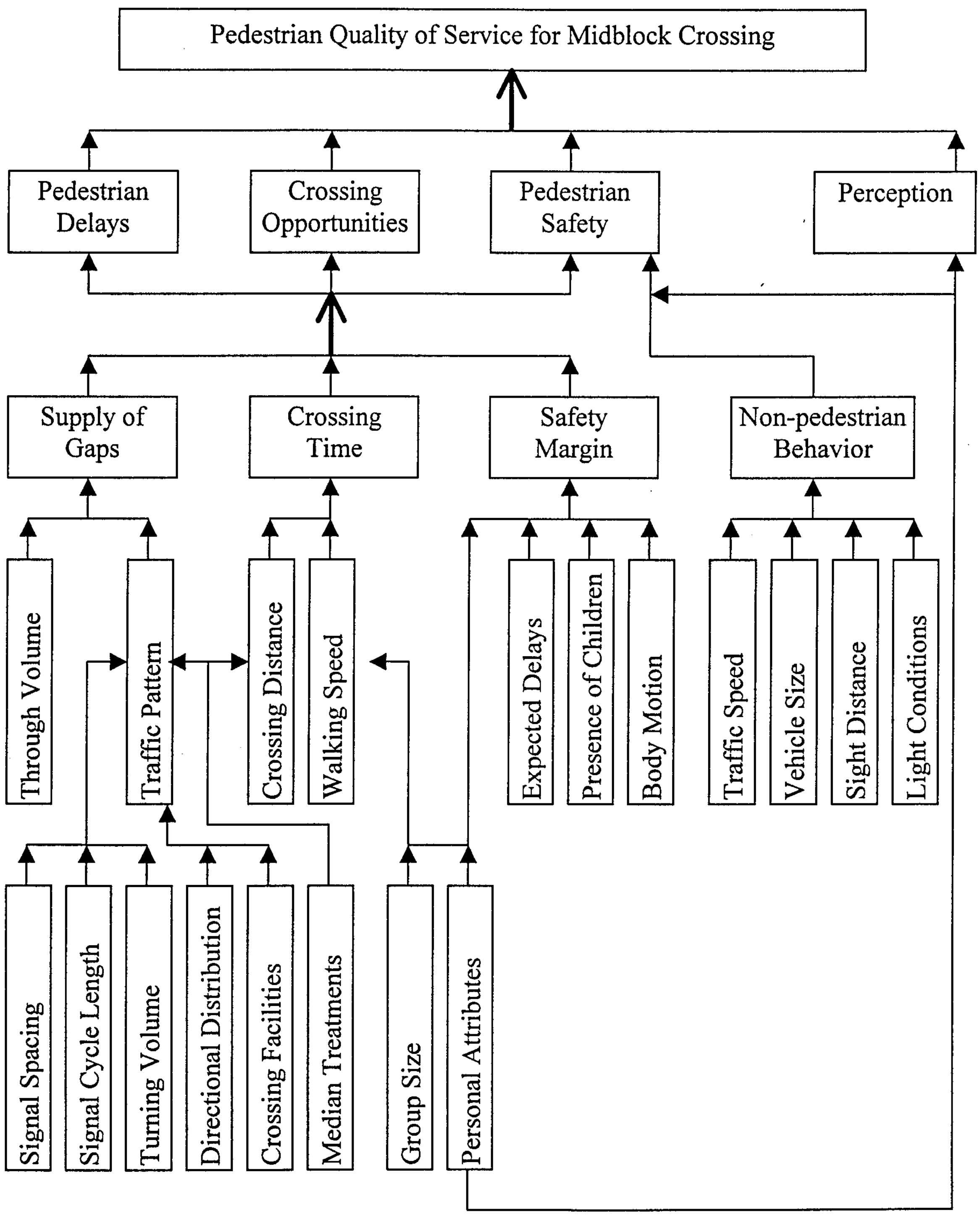
Components of Pedestrian Quality of Service for Midblock Crossing

In terms of pedestrian quality of service for crossing streets at midblock locations, three types of measures of effectiveness that have appeared in the literature could potentially be used. These include pedestrian delays, pedestrian safety, and crossing opportunities.

Pedestrian Delays

Pedestrian delays refer to any time spent waiting to cross, either at the curbside or at the middle of the road. It is natural to use pedestrian delays as a measure of pedestrian quality of service for midblock crossing. First, the amount of delay is typically used as the measure of effectiveness for intersections where conflicts frequently occur just as in the case with pedestrian midblock crossings. Second, the amount of delay also reflects several aspects of the operational conditions faced by pedestrians crossing streets at midblock locations. These include speed, travel time, and convenience.

Figure 1: Flowchart of Determinants



Average pedestrian delays for midblock crossings may be estimated in one of two ways. One may observe pedestrians in action and measure actual delays these pedestrians experience (Rouphail et al., 1998). These observed delays may then be related to the characteristics of these pedestrians and the site. Alternatively, pedestrian delays can be estimated with hypothetical situations defined by a certain combination of roadway width, traffic volume and speed, pedestrian volume, pedestrian walking speed, and vehicle arrival patterns (Hunt and Williams, 1982; Dunn and Pretty, 1984; Guo et al., 1998). In either case, average pedestrian delays are objectively measured.

Safety

Safety is one important aspect of the operational conditions that pedestrians face in the transportation system. Safety for pedestrian midblock crossings may be estimated in one of two ways. In one approach, pedestrian injuries and fatalities from crashes with motor vehicles or conflicts between pedestrians and motor vehicles are compiled for a midblock segment. One problem with this approach of objective measurement is that crashes or conflicts between pedestrians and motor vehicles rarely occur at any single location in the state. This rare occurrence creates a problem for getting good data. If crash statistics are the basis, one may need these statistics over many years. If field observations are to be used for measuring conflicts, a period of a few hours would cost a lot to collect data but would not be long enough to get good data. An alternative approach uses pedestrians' perception to measure safety. While safety has not been used as a measure of effectiveness for pedestrian midblock crossing, perceived safety and comfort is used by Landis et al. (1999) as a measure of effectiveness for pedestrians walking along roadway segments.

Crossing Opportunities

By basing a measure of pedestrian quality of service for midblock crossing on crossing opportunities, one assumes that what determines the quality of service is the number of time gaps in traffic that are long enough in time for pedestrians to safely cross the street. Hunt and Abduljabbar (1993) measure crossing opportunities by the proportion of time that an acceptable gap in the traffic is available. This idea is used in establishing the maximal number of adequate gaps per hour in the Minimum Pedestrian Volume Warrant for pedestrian traffic control signals.

An objective measure based on crossing opportunities has an advantage over an objective measure based on the other components. Both pedestrian delays and safety exclude suppressed demand for crossing. That is, those people who would have crossed the street at the midblock locations may either have avoided the trip all together or have selected to cross the street at another location. The perceived quality of service is lowest for these people. As a result, average pedestrian delay or safety does not reflect the quality of service for crossing at this midblock location and in fact overestimates the true level of quality of service. Measures based on crossing opportunities, on the other hand, do not suffer from this problem.

When combined, the three measures of effectiveness discussed above reflect most aspects of the operational conditions that levels of service attempt to address. Speed, travel time, and convenience are largely addressed through pedestrian delays. The aspect of traffic interruptions is largely addressed through crossing opportunities. Comfort and safety are largely addressed through pedestrian safety as a measure of effectiveness. The only aspect that is not directly addressed through these three measures of effectiveness is freedom to maneuver such as space per pedestrian. Unlike motor vehicles, however, pedestrians have far better freedom to maneuver by nature. As a result, freedom to maneuver is not an important aspect of the operational conditions that determine the quality of service for pedestrians crossing streets at midblock locations (McLeod, 2000). For the purpose of this project, these three measures of effectiveness are treated as three components of pedestrian quality of service for midblock crossing.

However, the three components of objective levels of pedestrian crossing difficulty share many of their determinants. As a result, it is inconvenient to use them as a vehicle to select the determinants of objective pedestrian quality of service for midblock crossing.

Components of Pedestrian Crossing Behavior

Instead we will decompose pedestrian crossing behavior and its major components and then use them as a vehicle to select the determinants. Fortunately, we have the gap-acceptance theory for pedestrian crossing behavior to guide us.

Gap-acceptance Theory

Pedestrian crossing behavior is largely governed by the gap-acceptance theory (Palamarthy et al., 1994). It states that each pedestrian has a critical gap. Upon arriving at the curb, the pedestrian would check if the current traffic gap is greater than the critical gap and decide whether to accept the traffic gap. If the current one is rejected, the next one is considered. This process continues until the pedestrian accepts a traffic gap or gives up. The critical gap consists of two parts. One part is the required crossing time and the other part is a safety margin. The safety margin is the difference between the time a pedestrian crosses the traffic and the time the next vehicle arrives at the crossing point. It is what is beyond the minimum crossing time for a traffic gap to be acceptable. The crossing time is what it takes a pedestrian to cross a particular street. This theory thus indicates that pedestrian crossing behavior is governed largely by three components: the supply of gaps, crossing time, and safety margin.

Supply of Traffic Gaps

It is no doubt that the supply of traffic gaps is the key determinant of pedestrian quality of service for street crossing at midblock locations. A direct measure of it is also doable with two video cameras (one for each direction).

There are two arguments, however, against using it as a variable for this particular project. Data for this variable will not be readily available or easily collected when the result of this project is applied. While data collection would not be a significant effort if the application is to a few blocks, it will be if an entire region is involved. In addition, the supply of traffic gaps is not a direct policy variable such as cycle length, crossing facilities, medians, or speed limit.

Instead of directly using it as a determinant, we may use the factors that influence the supply of traffic gaps as potential determinants of pedestrian quality of service for midblock crossing. The supply of traffic gaps, including both the frequency and duration of gaps, is determined by traffic volume and its patterns. Traffic patterns indicate both the spatial and temporal distributions of traffic. Spatially, it indicates, for example, whether vehicles arriving at a given crossing point are evenly distributed across the traffic lanes and traffic directions. Temporally, it indicates how vehicles arriving at a given crossing point are distributed in time. In general, the more uniform the traffic pattern, the fewer the large gaps that allow people to safely cross a street.

While traffic volume is relatively easy to measure, it is not as easy to measure traffic patterns, especially temporal patterns. As a result, it would be desirable to determine what characteristics of a street influence its traffic pattern. Once these are determined, one can use them as predictors of pedestrian quality of service for midblock crossing. A review of the literature and discussion with FDOT staff indicate that there are six major factors influencing traffic patterns. These include signal cycle, signal spacing, turning movements, crossing facilities, median treatments, and directional distribution of traffic.

Three of these factors, cycle length, signal spacing and turning movement, influence traffic patterns through their effects on the platooning of traffic. When traffic is light there is an ample supply of traffic gaps. As a result, there is little difficulty for pedestrians with no physical disabilities to wait for a gap and cross the road. When traffic is heavy, however, the supply of traffic gaps depends on traffic platooning (Hunt and Abduljabbar, 1993). With interrupted traffic, which is what is being dealt with in this project, platooning results from traffic signal cycles at intersections. Platooning is positive for street crossing because it is easier for pedestrians to cross traffic that is bunched into platoons separated with long time gaps than traffic that is more uniformly distributed.

An alternative approach to measuring the effects of traffic platooning may be the use of traffic arrival types (TRB, 1998). The 1997 update of the *Highway Capacity Manual* uses six arrival types to represent the quality of progression. Quantitatively, arrival types may be approximated by the ratio between the proportion of all vehicles in movement arriving during green phase and the effective green time ratio.

The other three factors influence traffic patterns either by creating gaps (crossing facilities) or by taking advantage of what gaps are available in the traffic stream that would otherwise be much less acceptable without the effects of such factors (median treatments and directional distribution of traffic).

Crossing Time

The time a pedestrian takes to cross a street is determined by the distance to be crossed, the walking speed of the pedestrian, and whether the median treatments allow the pedestrian to cross the street in two stages. When medians allow pedestrians to have a two-stage crossing, more traffic gaps become acceptable because the required crossing time is cut in half. Walking speed determines how much time a pedestrian takes to cover a given distance. It could be measured in the field if the participating pedestrians actually cross the street. One would need other variables in replacement to capture its effect if pedestrians do not do the crossing.

It appears that personal attributes such as age are good indicators for walking speeds on average (Coffin and Morrall, 1995; Hoxie and Rubenstein, 1994). The presence of disabilities certainly affects how fast one can walk. In addition, median treatments, crossing location, group size of pedestrians, and trip purpose appear to influence walking speed. According to Bowman and Vecellio (1994), the average walking speed is higher for roads with two-way-left-turn lanes than for undivided roads; and pedestrians tend to walk faster at midblock locations than at signalized intersections. According to Dipletro and King (1970), individual pedestrians crossed a street at midblock locations at higher speeds than groups. Finally, according to a review by Puchkarev and Zupan (1975), commuters and students walk at higher speeds than shoppers.

Safety Margin

It appears that the size of the safety margin is largely determined by certain personal attributes such as age and gender (Dipletro and King, 1970; Harrell and Bereska, 1992). It may also depend on some other factors, including whether the pedestrian was walking or standing still before stepping into the street (Oudejans et al., 1996), the expected pedestrian delays before the next gap comes (Palamarthy et al., 1994), the relative supply of traffic gaps in the two directions of traffic (Hunt and Griffiths, 1991), the group size of pedestrians (Dipletro and King, 1970; Harrell and Bereska, 1992), and the presence of children (Harrell and Bereska, 1992). Finally, several other factors can also influence pedestrians' choice of safety margin and perception of crossing quality of service. These include traffic speed at midblock locations, the presence of large vehicles in traffic, sight distance, and lighting conditions.

Determinants of Perception

Pedestrian quality of service for midblock crossing reflects not only the objective quality of service provided by roadway segments for midblock crossing but also pedestrians' perception of these objective quality of service. By definition, personal attributes determine how one perceives. How pedestrians perceive the lack of crossing opportunities depends on their safety margin. The perception of pedestrians on their delays is likely to be related to how urgent they are, how long the entire trip is, etc. How a pedestrian perceives the lack of safety depends on how much risk he or she is willing to take. How a pedestrian perceives the quality of service for street crossing is also likely to depend on his or her experience with street crossing.

Sampling and Data Collection

This section discusses sampling and data collection methods and four general approaches to survey for measuring pedestrian quality of service for midblock crossing.

Sampling

Sampling issues include sampling frames, specific sampling methods, and sample sizes. A sampling frame is made up of sampling units and represents the population. An example of the population is all households in Hillsborough County, while a sampling frame is the listed residential phone numbers in the telephone directory. A sampling method is a way to draw a sample from a given sampling frame. Standard methods include simple random sampling and stratified simple random sampling. With simple random sampling, each sampling unit in a frame has an equal probability to be sampled. With stratification, the frame is divided into sub-frames and simple random sampling is done within each sub-frame.

Ad hoc methods, however, are frequently used. Participants, for example, are typically solicited as volunteers through media campaigns. This sampling method was used in developing the pedestrian level of service for walking along roadways and the bicyclist level of service for riding along roadways. Another ad hoc method of sampling is to solicit volunteers through sponsor organizations.

Ad hoc methods potentially have serious consequences to the research results. There are at least two sources for such consequences. One relates to the sampling frame from which ad hoc methods draw samples. In the case of soliciting volunteers through media campaigns, for example, the sampling frame is limited to the population that has exposure to the median campaign. In the case of sampling through organizations, the sampling frame would be limited to people within these sponsors, which are not likely to be representative of the general population. Another source relates to the potential bias in the responses of participants sampled through ad hoc methods, especially volunteers.

Data Collection

Data collection issues include how characteristics will be collected from the selected sites, how personal and household characteristics will be collected from the sample of participants, and how data on the dependent variable will be collected. Ideally, data on site characteristics and the dependent variable should be concurrent in time.

The particular data to be collected from the participants for the dependent variable will depend on the general approach for obtaining pedestrian perception. As discussed earlier, one may take the stated-perception approach under which participants are asked to state their perceived quality of service for individual sites. Alternatively, one may take the revealed-perception approach under which participants are asked to state their choice with respect to street crossing and the perceived quality of service is derived from a pedestrian behavioral model of street crossing.

Even under the stated-perception approach, what is being asked of the participants may differ. With the concept developed at the beginning of this chapter, the participants should be asked for their perceived quality of service for midblock crossing. This perceived quality of service is a quantitative measure of the operational conditions for midblock crossing as perceived by pedestrians. Data collected on this perceived quality of service are used to develop a model relating perceived quality of service to a set of its determinants. The predicted value of perceived quality of service from this model is viewed as the measure of effectiveness for designating levels of service. This method of collecting data on the dependent variable and the subsequent use of the data is consistent with the traditional concept of transportation level of service.

In contrast, the method used by Landis and associates (1997, 1999, and 2000) is inconsistent of the traditional concept of transportation level of service. The traditional concept would call for a quantitative measurement of perceived operational conditions and the qualitative designation of levels of service based on ranges of this quantitative measurement of perceived operational conditions. The method by Landis and associates (1997, 1999, and 2000) would directly ask participants for their perceived level of service rather than their perceived operational conditions. This perceived level of service is conceptually qualitative but would be used as quantitative in correlating it with a set of its determinants. The predicted quantitative level of service value would finally be used in designating qualitative levels of service.

Mail-Back Survey

The mail-back survey would solicit information from people who recently crossed a midblock on foot in the Tampa Bay area. When this approach is taken, the revealed-perception approach to measuring perceived quality of service would not work.

Sampling

A sample of households would be randomly selected from the Bay area. Multiple survey forms would be mailed to each of these households. Any household member with a recent crossing would be eligible to participate.

Data Collection

In addition to their perceived quality of service of the most recent crossing, the respondents would also be asked to identify the midblock, day of week, and time of day. Such identification information would then be used to collect site characteristics after the mail-back surveys are received. The mail-back surveys would also contain questions on the household and personal characteristics of the participants.

Field Survey with Onsite Participants

A sample of roadway sections would be selected from the Bay area. People present at time of field surveys would be asked to participate. Participants could be either pedestrians or others present, such as shoppers. Similar to mail-back surveys, the revealed-perception approach to measuring perceived quality of service would not work with actual pedestrians.

Sampling

Ideally, a simple random sample of roadway sections would be selected from the Bay area. Practically, however, only roadway sections with reasonable volumes of trip generation or attraction would be considered.

Data Collection

Dependent Variable. Participants would be asked to rate the sites with respect to the quality of service they feel for crossing the road at these sites. For actual pedestrians, the survey would be done before they actually across the road.

Participant Characteristics. The survey form for rating quality of service would also solicit key household and personal characteristics of the participants.

Site Characteristics. Static site characteristics would be collected either before or after the field survey; dynamic characteristics, such as volume and its features, would be collected concurrently with the field survey.

Field Survey with Pre-selected Participants

A sample of participants from the general population would be selected to participate in the study. They would be asked to complete a survey in the field facing real-time traffic conditions. They would not actually cross streets. Unlike the two types of survey described above, either the stated-perception or revealed-perception approach may be used in this type of surveys.

Sampling

Sites. It is important that the selected sites have enough variation on each of the site characteristics. One way to accomplish this would be to assemble a computerized database of roadway blocks with information on key characteristics such as the number of lanes and AADT and then to sample blocks within each stratum defined by different combinations of these key characteristics. Alternatively, representative sites may be selected from a limited geography to facilitate the logistics of carrying out the field survey.

Participants. Ideally the participants should be selected from the general population through a sampling process so that they are representative of the population. It could be logistically difficult to do so. An alternative would be to recruit sponsors first and then select their employees or members as volunteers. Another alternative would be to recruit volunteers from the general population through some form of media campaign.

Data Collection

Dependent Variable. The participants would be brought to the selected sites. If the stated-perception approach is taken, they would rate the sites with respect to the quality of service they feel in crossing the road at these sites. If the revealed-perception approach is taken, on the other hand, they would reveal their choice with respect to whether they would cross the street, given the conditions they face at these sites.

Participant Characteristics. The participants would be gathered at a single location before the field survey and asked to complete a short survey form about their household and personal characteristics.

Site Characteristics. Static site characteristics would be collected either before or after the field survey. Dynamic characteristics, such as volume and its features, would be collected concurrently with the field survey.

In-House Survey with Field Videos

The steps include: 1) Select sites; 2) Select times; 3) Videotape conditions of these sites; 4) Select participants; and 5) Have participants view taped sites and rate them with respect to how difficult they would feel in crossing the road at these sites. Again, either the stated-perception or revealed-perception approach may be used in this type of surveys.

Sampling

Sites. It is important that the selected sites have enough variation with regard to site characteristics. One way to accomplish this would be to assemble a computerized database on roadway segments with information on key characteristics such as number of lanes and AADT and then to sample segments within each stratum defined by different combinations of these key characteristics.

Participants. Ideally the participants should be selected so that they are representative of the general population. Alternatives would be to recruit sponsors first and then select their employees or members as participants or to recruit volunteers from the general population through a media campaign.

Data Collection

Dependent Variable. The participants would be gathered in front of video screens. If the stated-perception approach is taken, they would be asked to rate the sites with respect to the quality of service they perceive in crossing the road at these sites. If the revealed-perception approach is taken, on the other hand, they would be asked to reveal their choice with respect to whether they would cross the street, given the conditions they face at these sites.

Participant Characteristics. The participants would be asked to complete a short survey form inquiring about their household and personal characteristics before the video survey.

Site Characteristics. Static site characteristics would be collected either before or after the field survey. Dynamic characteristics, such as volume and its features, would be collected concurrently with the taping of field conditions.

Pros and Cons

Mail-back Survey

The advantages include that nighttime could be covered and that random sampling or some other form of systematic sampling is possible because mail-back surveys require far less efforts from the participants than approaches involving field surveys. One cannot over-emphasize the importance of random sampling or some other form of systematic sampling to the validity of the research results. One major disadvantage is that site characteristics and perception are not concurrent.

Field Survey with Onsite Participants

One advantage of this approach over field surveys with onsite participants is that field surveys may be carried out on any day of week. The advantages of this approach over mail-back surveys include that perceptions are based on real-time conditions and that latent demand for street crossing is not excluded. One disadvantage is that sites would be limited to where large volumes of trip generation or attraction are present.

Field Survey with Pre-selected Participants

This approach has been used several times for research related to the Department's Multimodal Quality of Service Program. Its advantage over the approach of field surveys with onsite participants is its relative flexibility in selecting sites. Its advantage over the approach of mail-in surveys is its use of real-time perception, the possibility of concurrent data collection of perception and traffic conditions, and its inclusion of potential latent demand for street crossing at midblock locations.

One potential disadvantage is that times for field survey are limited to when traffic volumes are low because it almost requires all participants be surveyed at the same time, which is likely to be weekends. This may not be a serious problem for roadways of higher functional classification or roadways in tourist attraction areas. It could potentially prevent the project from including local streets as part of the study because of low volume. This issue also presents a problem in terms of site selection. Average annual daily traffic is likely to be one of the variables used in selecting potential sites for the study. However, heavy average volumes do not necessarily mean heavy average volumes on weekends. Another serious disadvantage of this approach is the use of ad hoc methods for sampling participants. As already discussed earlier, these ad hoc methods could have serious consequences to the validity of the research results.

In-house Surveys with Pre-selected Participants

The main disadvantage of this approach is the uncertainty in how accurately the participants can perceive the traffic conditions from the tapes. However, this uncertainty may be resolved to a large extent by conducting a limited experiment. A small number of volunteers would be randomly assigned to two groups: one will be subject to the approach of field surveys with pretended pedestrians while the other will be subject to this approach.

There are, however, several advantages, including: 1) there are no risks to the participants; 2) Specific variables can be presented to the participants in a controlled environment (For example, two participants asked to rate the same site at different times may be exposed to different conditions. Bias will result if these conditions are not measured on site.); 3) Sites from a larger geography can be selected; and 4) It saves time. Harkey et al. (1998) use this approach in developing a bicycle comparability index to measure bicyclist level of service for riding along roadways.

Another potential advantage of this approach over the approach of field surveys with pretended pedestrians is the possibility of selecting participants through random sampling. The main reason for this possibility is that significantly less effort is involved for the participants under this approach than under the approach of field surveys with pretended pedestrians.

Calibration and Validation

For future application, each of the site characteristics need to have a weight attached that reflects its relative importance in influencing pedestrian quality of service for midblock crossing. To accomplish this, one needs a mathematical framework to connect these site characteristics to pedestrian quality of service and a statistical approach to determine the relative weights within that mathematical framework. The choice of the mathematical framework should have a behavioral foundation. The statistical approach allows the weights for the site characteristics to be estimated. Such a statistical approach should be chosen with care so that the weights are estimated with precision and accuracy.

Framework

The framework refers to a structure that is used to link the determinants of pedestrian quality of service for midblock crossing to a measure of the quality of service. Approaches to this framework may be categorized in different ways. Three of them are discussed below, including the form it takes, the number of equations involved, and the statistical model selected.

Form

One method is to categorize them in terms of the form they take between equations versus tabular forms.

Equations. One convenient and commonly used form is mathematical equations that express pedestrian quality of service for midblock crossing as a function of these determinants. The exact determinants and the exact form of the function are to be determined.

Tabular. Another form appears as a table. Specifically, each determinant is entered as a dummy variable. That is, it takes 1 if a condition is satisfied and zero otherwise. An example is Dixon (1996). The steps include: 1) Identify factors that affect LOS; 2) Assign a score for each factor (which is stated as a dummy); 3) Group the total possible scores into five levels; 4) Determine the value of the dummy; 5) Add the individual scores; 6) Determine LOS by comparing the actual total score with LOS definitions. In essence, however, it is a particular version of the first form.

Pros and Cons. The advantages of the equation form are its compactness, its flexibility in terms of the number of variables included, the potential responsiveness to changes in continuous variables, and its ability to be statistically calibrated. The main disadvantage is the perceived complexity of mathematical equations to the general public. For the tabular form, on the other hand, its advantages and disadvantages are just the reverse of those for the equation form.

Number of Equations

When equations are used, there is the issue of a single equation versus multiple ones.

Single. A single equation is typically used. Examples include those by Landis and associates (1997, 1999, and 2000) and that by Harkey et al. (1998).

Multiple. In some cases, multiple equations are used for different components of quality of service with each component having its own equation. An example is Khisty (1994). The steps include: 1) Identify components of quality of service; 2) Rate sites for each of the components; 3) Aggregate these ratings for a given site.

Pros and Cons. A single equation in general is preferred unless emphasis is put on improvements in individual components of pedestrian quality of service, especially when these components move in opposite directions when certain changes are made to a site.

Statistical Model

When equations are used, there is the issue of selecting a statistical model that is most appropriate for the nature of the data collected. Data collected on perceived pedestrian quality of service are typically ratings on a scale from 1 through 6, for example. Such ratings are not continuous but discrete and ordinal.

Continuous Ratings. One modeling approach has been to treat the reported ratings as continuous. That is, the reported ratings are directly used to correlate with a set of potential determinants of pedestrian quality of service for midblock street crossing.

Once the model is estimated, levels of service are defined in terms of ranges of predicted values of the dependent variable. The definition of these ranges is largely arbitrary.

When applied to a specific midblock, the values of the model variables are determined first for this midblock. These values are then entered into the model and the quality of service of this midblock is calculated. The LOS is determined by examining the range in which the predicted quality of service falls.

Converted Continuous Ratings. One shortcoming of the continuous-rating approach is that the predicted quality of service for any single site can go beyond the rating scale from 1 to 6. In fact, predicted quality of service can even be negative. This can be avoided by first converting the reported ratings and then working with the converted values.

To describe it, we are going to use some mathematical symbols. Let R be the upper end of the rating scale, which would be 6 in our case. Let r be the reported crossing difficulty by a participant. We further let p be the ratio of r to R. This ratio will range between 0 and 1. Our statistical analysis will be on this ratio. Specifically, we will use the traditional linear least squares method to estimate a relationship as follows:

$$\frac{p}{1-p} = f(\beta; X) + \varepsilon$$

where X represents the set of determinants, β represent the corresponding parameters, and ε represent the error term that follows the standard assumptions of the ordinary least squares model. Once the above relationship is estimated, the following relationship can be used to predict crossing difficulty:

$$r = R\frac{1}{1+e^{-f(\hat{\beta};X)}}$$

where the β hat represents the estimated parameters. Since the ratio on the right hand side of the above relationship ranges between 0 and 1, the predicted values of r will stay within the rating scale from 0 to R.

In order to use this modified approach, however, the rating scale would need to start from 0 rather than 1. With this new rating scale and estimation method, level of service designations would be determined as follows: A=(**0**, **1**), B=(1, **2**), C=(2, **3**), D=(3, **4**), E=(4, **5**), and F=(5, **6**), where the bold numbers indicate which designations the breakpoints belong.

<u>Ordered Response</u>. An ordered response model takes advantage of the discrete nature of the data on the reported quality of service as well as its ordinal nature. Common models for dependent variables measured in discrete values are the logit and probit models. While these models take advantage of the discrete nature of the data, they ignore the additional information on the ordinal nature of the data. The most commonly used model for ordered data is the ordered probit model (Greene, 1990). Along with the coefficients of variables included, the estimation of this model will also produce estimates of the thresholds of quality of service that define the six discrete ranges. These ranges may directly define levels of service. Figure 2 compares this ordered-response approach with the continuous-rating approach.

<u>Pros and Cons</u>. The advantage of the continuous-rating approach is that it is the conventional approach and its relative mathematical simplicity. Simplicity becomes a non-issue once the chosen model is computerized. The advantage of the converted continuous approach is its constraint on the predicted quality of service. The main disadvantage of both of these two approaches is that they are inappropriate for the nature of data. Both implicitly treat the discrete and ordinal dependent variable as a continuous and cardinal one. As a result, they treats the difference between ratings of 1 and 2 the same as the difference between 4 and 5. The straight line in Figure 3 illustrates this. In reality, however, one is likely to be far more preferable to the increase in quality of service from 4 to 5 than to the increase from 1 to 2. This is the case illustrated by the curved line in the same figure. If the curved-line case is true, using the straight-line case would significantly overstate the quality of service for the low and medium ranges but understate for the high ranges. The consequence of this can be significant. Not only can the model coefficients be seriously biased but also the standard errors of these coefficients will be over-estimated.

Most of the advantages and disadvantages for the ordered-response approach to a large extent just reverse those for the other two approaches. In addition, however, the ordered-response approach provides an objective approach to obtaining the breakpoints for designating levels of service as illustrated in Figure 2. Also, the predicted quality of service from the ordered-response approach will actually be the underlying true quality of service, Y^*, rather than the rating, Y.

Figure 2: Calibrating Pedestrian Quality of Service Model

Let Y = 1, 2, 3, 4, 5, 6, which are observed ratings of pedestrian quality of service and Y^* = actual but unobserved pedestrian quality of service.

Continuous-Rating Approach

Model

$Y = f(X; a) + e$
a is a vector of parameters
e is the error term distributed normal
X is a vector of determinants

Estimation

Linear regression
Ordinary least squares method

Quality of Service (QOS) model

QOS = f(X; **a**)

where **a** is the estimated value of a.

LOS designations

Breakpoints: 1.5, 2.5, 3.5, 4.5, 5.5

LOS = A	if	QOS < 1.5
B	if	1.5 ≤ QOS < 2.5
C	if	2.5 ≤ QOS < 3.5
D	if	3.5 ≤ QOS < 4.5
E	if	4.5 ≤ QOS < 5.5
F	if	5.5 ≤ QOS

Ordered-Response Approach

Model

$Y^* = g(Z; c) + s$
c is a vector of parameters
s is the error term distributed normal
Z is a vector of determinants

Y =	1	if $Y^* < b_1$
	2	if $b_1 \le Y^* < b_2$
	3	if $b_2 \le Y^* < b_3$
	4	if $b_3 \le Y^* < b_4$
	5	if $b_4 \le Y^* < b_5$
	6	if $b_5 \le Y^*$

Estimation

Ordered probit
Maximum likelihood method

Quality of Service (QOS) model

QOS = f(Z; **c**)

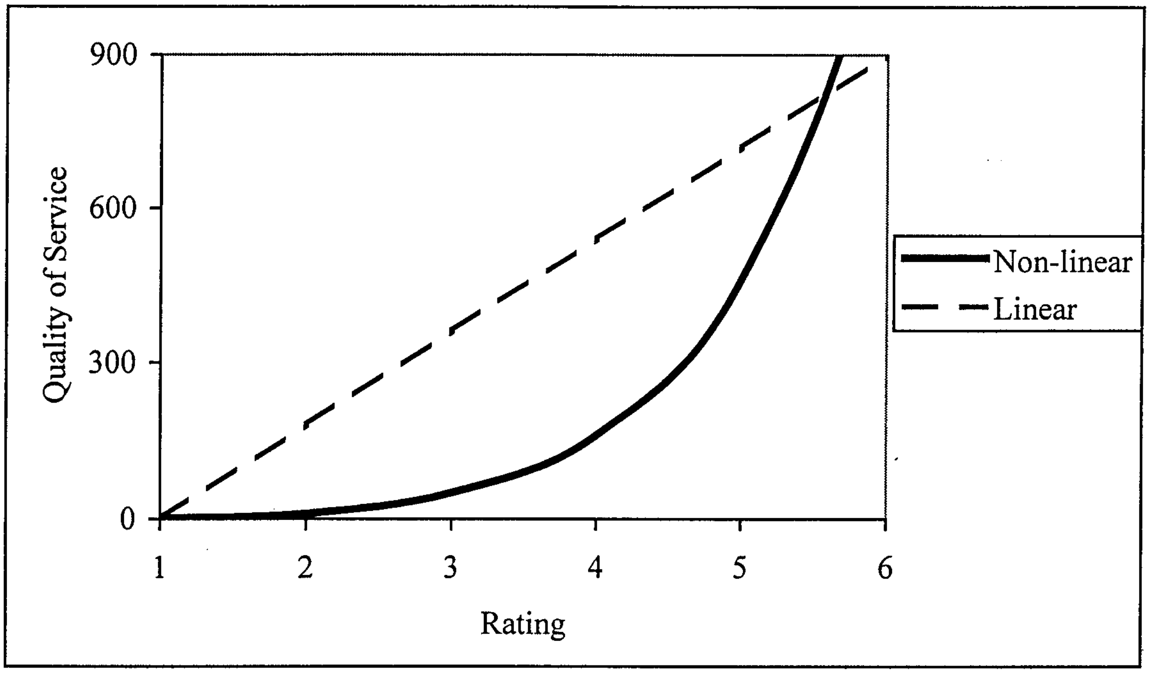
where **c** is the estimated value of c.

LOS designations

Breakpoints: $\mathbf{b_1}$, $\mathbf{b_2}$, $\mathbf{b_3}$, $\mathbf{b_4}$, $\mathbf{b_5}$, which are estimated values of b_1, b_2, b_3, b_4, b_5.

LOS = A	if	QOS < $\mathbf{b_1}$
B	if	$\mathbf{b_1} \le$ QOS < $\mathbf{b_2}$
C	if	$\mathbf{b_2} \le$ QOS < $\mathbf{b_3}$
D	if	$\mathbf{b_3} \le$ QOS < $\mathbf{b_4}$
E	if	$\mathbf{b_4} \le$ QOS < $\mathbf{b_5}$
F	if	$\mathbf{b_5} \le$ QOS

Figure 3: Hypothetical Relationship Between Reported Rating and the Underlying Quality of Service



Estimation

Once a basic mathematical framework is formed and data are collected, the system needs to be parameterized by selecting an appropriate weight for each of the variables. Appropriate statistical methods would be used to calibrate the model with the data collected. The particular method used will depend on the framework selected, how quality of service is measured, and the type of data collected. In any case, alternative specifications of the model may be considered, including variations in the variables, the mathematical framework, and the statistical approaches. The results include the particular functional form, variables, and their parameters.

One issue of particular importance is the nature of the observations obtained through hypothetical questions. Typically, any participant is asked to provide his perception of a number of sites or facilities. These different perceptions from the same individual are typically used as independent observations in statistical estimation. For example, each participant provided 21 observations in a study of measuring pedestrian quality of service for walking along roadways (Landis et al., 2000) and 30 observations in a study of measuring bicyclist quality of service for cycling along roadways (Landis et al., 1997). Similarly, multiple roadway sections from the same facility are selected.

One problem is that the perceptions by the same individual on different roadway sections are not likely to be independent. By treating them as independent, previous estimations over-estimate the R^2 but under-estimate the standard errors of coefficients. As a result, it is not uncommon to see claims that 90 percent of the variation is explained by the included variables. Also, variables that are not really significant at a given level of significance are claimed as significant. A similar problem arises from treating the perceptions on roadway segments from the same facility as independent.

A slightly conservative adjustment for the resulting t-statistics used in claiming significance levels is to divide these t-statistics by the square root of the number of observations from each participant. For the two examples above, the reported t-statistics would need to be divided by a value of 5 before the significance of variables is determined. With such an adjustment, any variable with an unadjusted t-statistic between 2 and 10 would no longer be statistically significant.

Validation

Three types of validation may be performed. The first one is theoretical and the other two are more practical.

Prediction Errors

The first compares predicted quality of service with actual perceptions. Specifically, a large portion of the data set (the estimation set) would be randomly selected to re-calibrate the alternative models estimated above. The other portion of the data set (the test set) would then be used to test the predictive accuracy of these alternatives. That is, the values of the site and volunteer characteristics in the test set will be used in the models to calculate the predicted quality of service and then compare the predicted ones with the stated ones in the test set. These alternative models can then be compared in terms of their prediction errors.

Reasonableness

The second type of validation examines the practical reasonableness of the predicted quality of service and the resulting level of service. Specifically, a set of six midblocks would be selected either among those used in the estimation or some others recommended by the research team or the advisory committee. Each of these six blocks represents a different level of service based on professional judgment. These levels of quality of service are then compared with those predicted ones for these blocks by the preferred model.

Sensitivity

The third type of validation examines how reasonable the responses of the preferred model to changes in key site characteristics are. For this purpose, pairs of midblocks would be selected. The two midblocks in each pair differ only in one key site characteristic, which varies across the pairs. The focus is on whether any differences in the predicted quality of service within a pair are reasonable.

These different types of validation are complementary to each other. Whether all or only selected types are conducted will depend on resources available and objectives desired. Validation based on prediction errors or sensitivity is relatively easy to do and probably should be done in any case. Validation based on reasonableness will take some resources. The results from validation may be feed back to the estimation phase to see if further changes in the models can improve them.

Application

Once a model is estimated, it can be used to estimate the quality of service of any site for which data are available for the variables included in the model. In order to determine the level of service for this site, however, one would need a conversion mechanism that translates the estimated quality of service to one of the level of service designations. Three approaches to conversion have appeared in the literature.

Distribution-Based

One is based on dividing the distribution of quality of service among a sample of sites into six segments. Under the distribution-based approach, a set of percentiles of the quality of service distribution among a sample of sites is selected and used to represent the breakpoints between the various level-of-service designations. The estimation sample typically is used for selecting the percentiles. Harkey et al. use this approach (1998) in developing a bicycle comparability index for bicycle riding along midblock locations of roadways. Specifically, the 5^{th}, 25^{th}, 50^{th}, 75^{th}, and 95^{th} percentiles are used as the breakpoints to designate six levels of service.

Range-Based

Another approach is based on a set of pre-selected breakpoints within the range of possible quality of service values among a sample of sites. These breakpoints are used to define the various level-of-service designations. Landis et al. (1999) use this approach in determining pedestrian level of service for walking along roadway segments. In fact, 1.5, 2.5, 3.5, 4.5, and 5.5 are suggested as the breakpoints on a rating range from 1 through 6.

Direct Estimation

A third approach is to use an ordered probit model to directly estimate the breakpoints as illustrated in Figure 3 in comparison to the second approach. This approach was partially tested in the context of measuring bus level of service by Madanat et al. (1994).

The main advantage of the direct-estimation approach over the other two is its objectiveness. Another advantage of this direction approach is that the designation of level of service will be based on the true quality of service rather than ratings. A disadvantage is its relatively complexity. Once computerized, however, this complexity is not a real problem.

RECOMMENDED APPROACH

This chapter describes one approach that the research team recommends for the current project. Following the structure of the previous chapter, this description is done separately for the five elements of the research project including the concept, the determinants of pedestrian quality of service for midblock crossing, sampling and data collection, calibration and validation, and application.

For those elements that are not unique to this particular research project, while alternative approaches to dealing with them have been discussed in detail in the previous chapter, a guiding principal of the recommendations is to maintain consistency with the approach taken for the already developed pedestrian and bicyclist level of service measures. These include the survey question on perception, the approach to measuring perception, sampling of participants, modeling, and level of service designation.

Legal Issues

As pointed out earlier in the background chapter, whether midblock crossing is legal depends on the presence of midblock crosswalks and whether the midblock is signalized at both intersections. If both intersections are signalized, midblock crossing is legal within a crosswalk but illegal outside a crosswalk, regardless of how long this midblock is. On the other hand, if one or neither intersection is signalized, midblock crossing is legal, with or without a crosswalk, as long as one crosses the street at right angles and yields to motor vehicles.

We propose that this project not be limited to legal midblock crossings. Limiting to legal midblock crossings will significantly reduce the universe of sites for inclusion in this project. From a research point of view, not limiting to legal midblock crossings does not create any problem if project participants do not cross any street as part of the project.

Concept of Pedestrian Quality of Service

Five aspects of the concept are specified here: delineation of midblocks, question on pedestrian perception, approach to measuring perception, measure of effectiveness, and measurement scale.

Delineation of Midblocks

Midblocks will be defined on the basis of traditional blocks, i.e., roadway sections between two consecutive intersections regardless of signalization. For a given block, it was suggested to consider only the middle portion of a block as midblock during discussions between the research team and FDOT staff. It was also suggested that the basis for defining this middle portion be the average distance beyond which a pedestrian would choose to cross a street at an intersection. At this point, however, there is no empirical evidence available to determine the average distance. As a result, it is planned to consider the entire block, exclusive of intersections, as midblock for this project.

Question on Pedestrian Perception

Instead of directly asking participants for their perceived level of service (Landis and associates, 1997, 1999, and 2000), one could ask them for their perceived quality of service for midblock crossing. This perceived quality of service is a quantitative measure of the operational conditions for midblock crossing as perceived by pedestrians. Data collected on this perceived quality of service would then be used to develop a model correlating perceived quality of service to a set of its determinants. The predicted value of perceived quality of service from this model is viewed as the measure of effectiveness for designating levels of service. While this would be our recommendation on a technical ground, we plan to directly ask for perceptions to be consistent with the other modules in the Department's Multimodal Quality of Service Program.

Approach to Measuring Perception

As discussed in the last chapter, there are potentially two approaches to measuring pedestrians' perception of quality of service for midblock crossing. The stated-perception approach directly asks the participants about their perceived quality of service. The revealed-perception approach first asks the participants about their hypothetical crossing decision and then derives their perception from an estimated model of street crossing behavior. While the revealed-perception approach has advantages, including a simpler task for participants and providing a behavioral foundation for the resulting quality of service model, we recommend the stated-perception approach for the current project so that it is consistent with the approaches taken for the other modules in the Department's Multimodal Quality of Service Program. We may also consider the revealed-perception approach for comparison.

Measure of Effectiveness

We recommend a broad measure of effectiveness for measuring quality of service related to pedestrians crossing at midblock locations. This measure should capture the operational conditions that the concept of level of service is designed to address, including speed and travel time, traffic interruptions, comfort and convenience, and safety to pedestrians. We may call this broad measure of effectiveness "pedestrian midblock crossing difficulty."

The challenge to make this measure of effectiveness work is to make sure that the participants all understand that it intends to include all of those operational conditions mentioned above. If some participants rate sites in terms of selected aspects of these operational conditions while others rate them in a broader sense, we will get biased responses and model estimates, especially for determinants that influence the different operational conditions differently.

There is the issue of compatibility to other components of the Multimodal Quality of Service Program in terms of operational conditions addressed. As recommended above, the measure is designed to address several aspects of operational conditions faced by pedestrians who cross roads at midblock locations. These include safety, delays, and traffic interruptions. Some measures of effectiveness for other facilities or services have used a narrower focus, however. One example is the roadside pedestrian environment that is developed by Landis et al. (1999) to describe pedestrians' perception of safety and comfort in walking along roadways. Whether this is a real issue depends on the type of facility or service being considered. In the case of pedestrians walking along roadways, many of the operational conditions applicable to pedestrians crossing streets at midblock locations largely do not apply. On the other hand, these same operational conditions may be more applicable to levels of service related to pedestrians crossing at intersections or areawide levels of service.

Measurement Scale

We recommend a narrow scale for measuring midblock pedestrian crossing difficulty. As discussed in the last chapter, the two options are point measurement versus segment measurement. One reason for this recommendation is that in-house surveys with pretended pedestrians may be possible with the point measurement. More important, however, our recommendation is based on the difficulty in dealing with variations of cross-sectional characteristics across midblock locations when statistically developing the midblock pedestrian crossing difficulty model. While similar difficulty also exists in applying the model based on the point measurement, it is believed that accurate measurement of these cross-sectional characteristics is more important in developing the model than in applying the model.

Determinants of Pedestrian Midblock Crossing Difficulty

The potential determinants discussed in the previous chapter have been narrowed down to a smaller set for consideration in the second phase of the project. A two-step process was used for this purpose.

In the first step, the full set of potential determinants from the previous chapter was grouped into several categories: those directly observed, indirectly observed, and irrelevant. Those indirectly observed include traffic patterns and walking speed. They are difficult to be observed in the field and are determined by those directly observed. Those not directly relevant to this project include the number of pedestrians crossing as a group, light conditions, the presence of young children, and body motion because it is expected the field survey will be done during day time and for individual persons without actually stepping into the street. This step was carried out largely by the project team without much involvement of FDOT staff or members of the Advisory Committee of this project. Those directly observed are candidates for further consideration in the next step.

In the second step, a large number of comments and suggestions were received on these directly observed variables from members of the Advisory Committee of this project. These comments and suggestions were then discussed and synthesized between the project team and FDOT staff. One outcome was to the decision to further separate the directly observed variables into two groups: most important and less important. Those determined to be less important are crossing experience, large-sized vehicles, and sight distance. Only the most important variables are to be included in the analysis.

Table 2 gives the final list of variables for analysis in the second phase. Also included in the table are how each variable will be measured both for calibration and application, the likely direction of effects, the form with which it will enter the model, and when the data will be collected. These variables are discussed below in terms of their measurement and expected effects. The collection of data for these variables will be addressed in a later section. These variables have been placed into four categories: personal, traffic, roadway, and control characteristics.

Table 2: Potential Determinants

Determinants	Measurement for Calibration	Measurement for Application	By Direction	Function Form	Data for Calibration	Data for Application
			Personal Characteristics			
Age 16-64	1 if age 16-64; 0 otherwise	Share 16-64	No		Concurrent question	Not in ART_PLAN
			Traffic Characteristics			
Traffic volume	Vehicles per hour per lane (VPH)	VPH from AADT	Yes		Concurrent taping	Available in ART_PLAN
Turning movements	Vehicles per hour from turning points	Same	Yes		Concurrent taping	Not in ART_PLAN
Traffic speed	Midblock running speed	Same	No		Concurrent taping	Available in ART_PLAN
			Roadway Characteristics			
Crossing distance	Feet from curb center	Same	Yes		Pre-survey	Not in ART_PLAN
Restrictive medians	Width in feet	Same	No		Pre-survey	Not in ART_PLAN
Non-restrictive medians	Width in feet	Same	No		Pre-survey	Not in ART_PLAN
Crosswalks	1 if crosswalks present; 0 otherwise	Same	No		Pre-survey	Not in ART_PLAN
Pedestrian signals	1 if signals present; 0 otherwise	Same	No		Pre-survey	Not in ART_PLAN
			Control Characteristics			
Signal cycle	Full cycle length in seconds	Same	Yes		Pre-survey	Available in ART_PLAN
Signal spacing	Feet between nearby signalized intersections	Same	No		Pre-survey	Available in ART_PLAN

Personal Characteristics

Person Age

Person age is likely to have a significant effect on walking speed and safety margin. It also makes large differences on how accurately a person perceives traffic gaps and how a person perceives crossing difficulty. In addition to the difference in effects, person age by broad ranges is relatively easily estimated in the field and is frequently used in engineering studies.

Measurement. A good way to measure person age for this project is whether a person is neither young nor old. Both the young and old behave differently in some ways from the middle-aged. Although these behavioral differences may result from different reasons between the old and the young, their effects on pedestrian quality of service for midblock crossing are expected to be in the same direction. As a result, we do not propose to use two variables, one for the young and one for the old, to account for the effects of age. To be specific, we propose to define the middle-aged as those who age 16 through 64. Age 65 used to define being old follows the convention in the literature of transportation safety among old persons. Alternative definitions will be used to test sensitivity.

In terms of calibration, this variable would be entered as a dummy variable. That is, it will take the value of 0 if one is middle-aged and 1 otherwise. In terms of application, this variable would be measured in proportions.

Expected Effects and Form. It is expected that this variable will have a positive coefficient. The rationale is that both the young and old would perceive midblock crossings to be more difficult than the middle-aged for any given site. We plan to specify this variable in the model so that it affects the predicted level of crossing difficulty as a multiplicative factor. Specifically, the multiplicative factor for the mid-aged population would be 1 if all pedestrians were mid-aged, which represent the ideal condition in terms of person age. If some pedestrians are young or old, this multiplicative factor would be greater than 1.

Traffic Characteristics

We recommend considering five aspects of traffic conditions: traffic volume, turning movements, and midblock running speed. The reasoning has been touched on in the last chapter and is discussed further below.

Traffic Volume

Traffic volume includes all movements by the crossing point at which perceived crossing difficulty will be collected. This would include both through volume and turning movements. The through volume on a roadway segment includes vehicles traveling straight from upstream in both directions.

Measurement. Traffic volume would be measured in terms of the total number of vehicles passing the observation point per hour per lane by direction. The variables would need to be converted from observed data in terms of actual counts by direction within a short period, say 5 minutes. For applications, the variable could be converted from average annual daily traffic using appropriate conversion factors.

Expected Effects and Form. We expect to enter the variable as a linear term. This variable is expected to have a positive coefficient. It is hypothesized that holding other factors constant, the supply of traffic gaps is smaller under higher volumes. Traffic volume is the product of traffic speed and traffic density. Traffic density determines the distance gaps in the traffic. For a given traffic speed, higher traffic volumes mean higher traffic density and shorter time gaps.

Turning Movements

Turning movements include vehicles turning right at the two intersections of a block under consideration, from driveways in both sides of the block, and from U-turn openings. Turning movements are included because they can influence traffic pattern at midblock locations by filling the traffic gaps created at signalized intersections.

Measurement. Turning movements would be measured in terms of the number of such turning vehicles per hour by direction. The variables would need to be converted from observed data in terms of such vehicles within a short period, say 5 minutes.

Expected Effects and Form. The variables are expected to have positive coefficients. It is hypothesized that turning vehicles would affect traffic patterns by filling up gaps in through traffic created at traffic lights. Holding other factors constant, higher turning movements would result in fewer crossing opportunities and increased pedestrian delays. As with personal age, we plan to specify this variable in the model so that it affects the predicted level of crossing difficulty as a multiplicative factor. Specifically, the multiplicative factor would be 1 if turning movements are present, which represent the ideal condition in terms of turning movements. If some turning movements are present, this multiplicative factor would be greater than 1.

Traffic Speed

Given the amount of traffic volume, traffic speed may affect the supply of traffic gaps through its effect on traffic density. Traffic speed can also potentially affect the distribution of speed and consequently lead to the break down of traffic platooning. Finally, traffic speed can potentially influence pedestrians' safety and their perception of crossing difficulty.

Measurement. We expect to measure traffic speed as the general midblock running speed during a short period. We do not plan to compute the 85th percentile or any average speed. For applications, the calculated midblock running speed in ART_PLAN could be used.

Expected Effects and Form. It is expected that traffic speed will have a positive coefficient. Holding traffic volume constant, higher speeds on urban arterials lead to higher traffic density and shorter traffic gaps. Also, the higher the speed on urban arterials, the greater the likelihood of a wide speed range and the break down of traffic platooning at midblock locations. In addition, it is hypothesized that pedestrians facing a traffic stream of high speed would choose large safety margins. They may do that, for example, because they perceive that it takes longer for vehicles moving at high speeds to slow down. It is also hypothesized that pedestrians perceive a crossing with vehicles moving at high speeds as more difficulty, holding other factors constant. They may do so because they perceive that they could be more severely injured if they ended up in a crash with high-speed vehicles.

Roadway Characteristics

These roadway characteristics describe several physical characteristics of the roadway segment under study. We recommend considering three here: crossing distance, median treatments, and crossing facilities.

Crossing Distance

Measurement. We plan to measure crossing distance by direction. For each direction, it will be measured from curb to the edge of the median if present and to the centerline if a median is not present. Parking lanes will not be included unless moving traffic can use them. We will not adjust for non-perpendicular crossings.

The number of through lanes is frequently used as a proxy for roadway width. While this may be accurate enough for many purposes, it is unlikely to be good enough for determining the effect of crossing distance on crossing difficulty. The reason is that crossing distance is expected to have a dominant effect on crossing difficulty and that this effect increases much faster than increases in crossing distance. As a result, it is extremely important to have accurate measures of crossing distance. Many characteristics of a roadway cross section would make the number of through lanes a poor proxy for crossing distance. These include turning lanes, shoulders, and width differences in through lanes themselves.

Expected Effects and Form. It is expected that crossing distance correlate positively with crossing difficulty. That is, the longer the crossing distance, the more difficult to cross a street, holding other factors constant. In addition, we do not expect to enter crossing distance as a simple linear term into the model. Holding other factors constant, doubling the crossing distance may lead to more than doubling the level of crossing difficulty. The exact form may take some experiments and model testing.

Median Treatments

Measurement. Medians will be separated into two broad groups: restrictive and non-restrictive. Restrictive medians refer to either raised or grassed medians. Non-restrictive medians refer to painted ones, including two-way-left-turn lanes. We will use two separate variables for these two groups. For a given midblock location, these variables will capture the width of the median. If no median is present, both variables will be zero. If a restrictive median is present, the variable for restrictive medians will measure the actual width of the median, while the other variable will be zero.

Expected Effects and Form. The median variables are expected to show negative coefficients. Medians influence the levels of crossing difficulty in two ways. They allow pedestrians to take advantage of traffic gaps by direction. The result is more crossing opportunities and fewer delays. They also simplify the pedestrians' crossing task by allowing them to concentrate on vehicle movements in one direction at a time.

We plan to enter the variables linearly into the model. However, we will also try alternative specifications for these two variables because a linear form will not be able to capture the interactive effect of medians with different ranges of traffic volume. It has long been hypothesized that the positive effects of medians are especially strong for wide roadways or heavy traffic volumes.

Crossing Facilities

Measurement. We plan to separate crosswalks and pedestrian signals by using two dummy variables, indicating their presence. The dummy variable for crosswalks, for example, will take the value of 1 if a crosswalk is present and 0 otherwise.
The traditional measure of effectiveness for pedestrian travel has been the amount of space per pedestrian (TRB, 1998). As a result, the width of crosswalks should also be considered. If the hypothetical situation for field surveys assumes a single-person crossing, as proposed for this project, crosswalk width is not an issue. On the other hand, the presence of a sign of an approaching midblock crosswalk for motor vehicles may give pedestrians the perception that drivers would look out for pedestrians. However, it is expected that this effect would be relatively small. To limit the number of variables for analysis, different crosswalk types, e.g., painted versus raised, will not be separately measured.

Expected Form and Effects. We expect that the crosswalk variable will enter linearly and has a negative coefficient. That is, the presence of crosswalks would reduce crossing difficulty, holding other factors constant. Crosswalks help create traffic gaps and tend to reduce pedestrian delays (Hunt, 2000). Crosswalks may help create traffic gaps because at least some drivers may slow down or even stop for pedestrians. Although crosswalks may have a negative effect on pedestrian safety due to a false sense of security on the part of pedestrians (Palamarthy et al., 1994), we feel that the positive effects of crosswalks should overwhelm any negative effects.

We also expect that the variable for pedestrian signals will enter linearly. However, its sign is unknown at this point. Signal controls at midblock crossings create traffic gaps but tend to increase pedestrian delays on average at these crossings (Hunt, 2000). Consequently, the net effect of pedestrian signals at midblock crossing difficulty is an empirical question and depends on the relative strengths of these elements.

Control Characteristics

Signal Cycle

Signal lights can have significant impacts on arterial traffic patterns at midblock locations. One important characteristic of signal lights is the cycle length.

<u>Measurement</u>. We plan to measure signal cycle with the full cycle length. The measurement will be limited to the two intersections of the block being evaluated. It will be by direction. For non-signalized intersections, the cycle length will be zero.

<u>Expected Effects and Form</u>. We expect to enter the variables linearly into the model. However, their signs are unknown at this point. While cycle length could have a significant effect on traffic platooning in a block, its net effect on crossing difficulty is not as clear. When the cycle lengths are relatively short, one may experience relatively frequent gaps resulting from platooning of traffic. While these gaps are relatively short, they are long enough for pedestrians to cross the block. When the cycle lengths are long, however, one is likely to experience gaps that are extremely long for a single pedestrian to cross the block but infrequent. As a result, longer cycle lengths may not increase the overall availability of gaps in the traffic stream.

Signal Spacing

In addition to signal cycle, the effect of platooning from traffic signals on the supply of traffic gaps also depends on the distances from signals for a given crossing point. The distance between the crossing point and traffic signals affects platooning because platooning disperses over time. According to Homburger et al. (1996, p. 4-8), where signalized intersections are spaced less than 0.25 miles apart and are well coordinated, platoons will move as a group with substantial gaps between them. In the absence of other nearby signals, platoons will tend to disperse within 0.25 miles downstream. With signal separations of 0.5 miles, platoons will definitely disperse.

<u>Measurement</u>. We plan to use the actual signal spacing of the roadway segment with the block being evaluated if it is no longer than half a mile and to use 0.5 miles otherwise.

<u>Expected Effects and Form</u>. We expect to enter this variable linearly into the model, given the lack of evidence otherwise. It is expected that it will show a positive coefficient because the longer the signal spacing, the more likely vehicle platoons disperse in midblock locations and fewer traffic gaps of safe duration.

Sampling and Data Collection

Overall Approach

Our conditional recommendation on the overall approach is to use field surveys with pretended pedestrians to collecting data on midblock crossing difficulty as perceived by pedestrians. As discussed in the last chapter, this approach involves pretended pedestrians reporting their perceived level of crossing difficulty based on their real-time observation of traffic and roadway conditions. This recommendation is based on two factors. One is that it has been used several times in research projects related to the Department's Multimodal Quality of Service Program. The other factor is that pedestrian perception will be based on observation of real-time conditions. Our main reservation about this overall approach is that it will require volunteers be recruited through a median campaign. Such volunteers are likely to provide responses that are systematically biased.

Our second choice would be to use in-house surveys with pretended pedestrians. As discussed in the last chapter, in-house surveys involve a sample of pretended pedestrians viewing the conditions of a site on a TV screen that have been pre-taped. The main concern over this overall approach is that participants viewing videos may perceive the operational conditions systematically differently from participants being in the field. This overall method has been successfully implemented in evaluating bicyclist level of service for riding along roadways.

The following sections discuss the details on how sites and pretended pedestrians will be selected and how data will be collected from them. This discussion assumes that field surveys with pretended pedestrians will be chosen as the overall approach to data collection.

Sampling

Our choice of using field surveys with pretended pedestrians means that we need to select our sites and participants separately. Holding other factors constant, the preferred sampling method is simple random sampling or at least some form of systematic sampling. This applies to both site and pedestrian selection.

Participants

For pedestrian selection, however, we propose not to select them through some form of systematic sampling. The reason is that there is a large amount of efforts involved on the part of participants. Instead, we propose to follow the approach that has been taken by Landis and associates (1997, 1999, and 2000). This approach relies on various forms of media to inform the general public about this research project and to ask for participation. Those with even a slight interest are asked to contact researchers for more information. At his point, anybody who is at least 13 years or old is welcome and we do not plan to set any other criteria for exclusion. We plan to target a total of 120 persons by the deadline for volunteering and 100 persons on the day of surveys for actual participation. However, we will not know exactly how many may actually show up until the actual survey.

Sites

For site selection, we plan to select them through some form of stratified sampling. At this point, we have a database of roadway facilities and a database of roadway blocks for both Hillsborough and Pinellas Counties. Each roadway facility is a roadway section with a distinct name. These two databases are extracted from the Roadway Characteristics Inventory database by District Seven of the Department. In addition, we have requested and obtained a list of signalized and un-signalized midblock crosswalks from the Hillsborough County Transportation Department, City of Tampa Public Works Department, City of Clearwater Public Works Department.

We plan to use four strata for selecting sites: one for un-signalized crosswalks, one for signalized crosswalks, one for roadway blocks with medians, and one for roadway blocks without medians. For the last two strata, we may randomly select roadway facilities first and then randomly select a single block from each of the selected facility with multiple blocks. When feasible, we will limit the sites to roadway facilities that are collectors or higher functional classification. When possible, we may also limit the sites in close proximity to the University of South Florida to make the survey logistics easier.

At this point, we plan to select a total of 30 sites. The exact distribution of these sites among the four strata is not determined yet. A reasonable distribution may be as follows: 5 with signalized crosswalks, 5 with un-signalized crosswalks, 10 with medians, and 10 without medians.

Sampling Errors

By using volunteers as the sample of participants, serious sampling errors are likely. Volunteers are likely to be more passionate about pedestrian issues. Consequently, policy-response bias is likely: They may believe that responding negatively might induce improvements in favor of pedestrians. We settled on such ad hoc approaches because we believe some form of data is better than nothing in order to move forward toward a truly multimodal planning process. However, the possibility of errors will be made known to any potential users of the models developed from this project.

Data Collection

Pre-survey Gathering

People who have agreed to participate will be asked to gather at a pre-selected location. This gathering serves four purposes. One is logistics. Each person who actually shows up will be given a participant ID wristband. Groups of participants will be formed. The size of each group will have to be determined at the time of this gathering. Each group will be assigned a group leader who will be given a group ID wristband. The group leader will not be a participant. Each group will also be given a set of sites to cover along with the site maps and taping equipment for each site. Each site will also be given an ID. The second purpose of the gathering is to give the participants a better understanding what we try to do in this project and how important their participation is to the project. The third purpose is to conduct a brief survey of personal attributes of the participants (see below for details). The last purpose is to work out the transportation logistics in terms of who is going to drive with whom and how.

Figure 4: Form for Collecting Crossing Difficulty

Participant ID:__________ Group ID:______________ Site ID:________________

Street Name: ____

Intersecting Streets: 1)____

2)____

We are going to ask you one question about how you perceive the level of difficulty with regard to your crossing this street at this point.

To answer this question, you simply need to mark one letter from A through F. A indicates that you have no difficulty in crossing the street. F indicates extreme difficulty.

Before you actually answer this question, please keep several things in mind:

- Provide your perception of crossing difficulty at this point of the midblock.
- Consider all aspects related to the crossing, including but not limited to the amount of time to cross, the availability of traffic gaps, and your safety.
- Do not consider any other sites that you have been asked to answer questions.
- Do not consider your views on how important it is to improve conditions for pedestrians.
- Do not consider what you might do on the other side of the street.

Without actually crossing it, how do you perceive the level of difficulty for you to cross this street at this point under current conditions? Please mark one and only one letter:

No Difficulty — Extreme Difficulty

A____(1) B____(2) C____(3) D____(4) E____(5) F____(6)

Thank you for your inputs.

Perceived Crossing Difficulty

It is extremely important that the data we collect on the perceived crossing difficulty are meaningful and not biased. One way to achieve that is to make sure that the participants understand what we are trying to measure. For that purpose, we plan to discuss during the pre-survey gathering several issues that the participants must understand before they complete the survey. These issues are:

- Please provide your perception of crossing difficulty at this crossing point.
- Please consider all aspects related to the crossing, including, but not limited to, the amount of time for you to wait and cross, the availability of traffic gaps, and your safety.
- Please do not take into account any other sites that you have been asked to answer questions.
- Please do not take into account your personal views on how important it is to improve conditions for pedestrians in an automobile-dominated transportation system.
- Please do not take into account what you might do on the other side.

Figure 4 shows a proposed form for the field survey of crossing difficulty. This form will be identified by the group ID, site ID, and participant ID. The group leader will complete the site ID and the group ID before giving the form to a participant.

Personal Characteristics

We will collect two personal attributes: personal age and crossing experience. The participants will only need to indicate yes or no on the question of crossing experience. They will need to select one out of 6 ranges on the question of personal age. Data on crossing experience will not be used in estimate the model.

This information may be collected at the gathering before the field survey of crossing difficulty. Figure 5 illustrates a simple form for this purpose. There are two advantages of collecting it before the field survey. Participants will only need to answer the questions once. The same information is only entered once from completed forms. One disadvantage is the need to identify individual participants in field surveys.

Figure 5: Form for Collecting Personal Characteristics

Participant ID:______________

Q1. Which of the following ranges does you age fall into? Please select one only:

13-24____(1) **25-34**____(2) **35-44**____(3) **45-54**____(4) **55-64**____(5) **65+**____(6)

Q2. Do you consider yourself as experienced with street crossing outside your neighborhood? Please mark yes or no:

Yes________(1) **No**________(0)

Traffic Characteristics

To avoid bias from measurement errors in variables, data on traffic conditions would need to be collected concurrently with the field survey of crossing difficulty. Assume that it will take five minutes for each participant to observe and answer the question on crossing difficulty. Data on these traffic conditions would need to be collected for the same five-minute period.

Since each group leader will work with several participants, there is the issue of whether these participants will answer the question during the same five-minute period. The advantage of doing it simultaneously is time saved. The disadvantage is lost variation in traffic conditions among these participants for this site. Given the small number of sites to be included in the project, we need as much variation in traffic conditions as possible. On the other hand, any other group of participants who also come to the same site is likely to experience a different set of traffic conditions.

Concurrent data on traffic volume and traffic speed at each site may be collected with the group leader video taping the cross sectional conditions where the participants stand. Assuming that the participants in the same group will answer the question simultaneously for a single site, the tapes will be identified with the site ID and a group ID.

Concurrent data on turning movements will require more than a single video camera. In addition to the group leader video taping the cross sectional conditions, at least two other people and cameras will be needed. One will tape the longitudinal conditions on one side of the street and the other will tape the conditions on the other side. Given that we are going to have 10 groups, we will need a total of 30 video cameras on the day for field surveys. Even with these two additional people, we may still miss some turning movements as a result of large-sized vehicles blocking the longitudinal view of cameras.

Roadway and Control Characteristics

Data for roadway and control characteristics are relatively easy to collect. We plan to collect these data before field surveys of crossing difficulty are carried out. A form like the one illustrated in Figure 6 might be used for this purpose. The table lists all variables for which data are to be collected, a definition of the variables, and the unit of measurement. The measured result for each variable will be recorded in the last column. We will need to make a mark at the cross section where data on facility conditions are collected so that the group leader can identify it on the day of field surveys.

One form is used for each site included in the study. The form identifies a particular site both in terms of an ID that is pre-determined once the sites are selected, in terms of the name of the street the particular site is located, and in terms of the names of the intersecting streets. We will separately determine whether each type of median treatment is present: raised, grassed, or painted medians. Raised and grassed medians are restrictive medians, while painted medians are non-restrictive. Painted medians include two-way-left-turn lanes. Refuge islands will be treated as restrictive medians.

Figure 6: Form for Collecting Roadway and Control Characteristics

Date:__________ Site ID:__________

Street Name:____________________

Intersecting Streets: 1)____________________

2)____________________

	Variables	Definition	Unit	Result
Roadway	Crossing distance – near side	Curb to center distance	Feet	
	Crossing distance – far side	Center to curb distance	Feet	
	Raised median	Width	Feet	
	Grassed median	Width	Feet	
	Refuge island	Width	Feet	
	Painted median	Width	Feet	
	Crosswalks	Whether a crosswalk is present: 1 if present; 0 otherwise	0 or 1	
	Pedestrian signals	Whether any pedestrian signal is present: 1 if present; 0 otherwise	0 or 1	
Control	Signal cycle – near side	Full cycle length – near side	Seconds	
	Signal cycle – far side	Full cycle length – far side	Seconds	
	Signal spacing	Block distance if both intersections are signalized; 1000 feet otherwise	Feet	

Pilot

We plan to conduct an informal pilot test of these data collection efforts, particularly the field survey of perceived crossing difficulty. The purpose is to make improvements to the procedures for data collections. A small number of people will be recruited at the USF campus and asked to provide their perception of the level of crossing difficulty to them for a few sites near the campus. In addition, both road and facility conditions will also be collected on these sites. Any lessons learned from this pilot will be considered for improving the initial procedures.

Calibration and Validation

Estimation

We will estimate the relationship between the reported rating on crossing difficulty and its determinants, using the ordinary least squares method. This approach to modeling this relationship will be consistent with that used in the other modules of the Department's Multimodal Quality of Service Program.

However, we plan to take into account the number of repeated responses from any individual participant in determining the significance of individual variables. As discussed in the last chapter, different perceptions from the same individual are typically not independent. Treating them as independent would under-estimate the standard errors of coefficients. As a result, variables that are not really significant at a given level of significance are claimed as significant. In addition, treating them as independent would over-estimate R^2.

Validation

Two of the three types of validation are recommended: one compares predicted crossing difficulty with actual perceptions and the other examines how reasonable are the responses of the preferred model to changes in key site characteristics. The third type of validation, examining the practical reasonableness of the predicted crossing difficulty and the corresponding level of service, may be carried out, depending on resource availability.

Application

Once a preferred model is obtained through the calibration and validation process, it may be used for applications in planning studies. We discuss four issues involved in this transition: integrating it into the multimodal quality of service program, converting the predicted crossing difficulty to level of service designations, implementing it into a simple spreadsheet template for scenario analysis, and adapting it to different levels of planning studies.

Integration into Multimodal Quality of Service Program

To integrate the pedestrian midblock crossing difficulty developed in this project into the Department's Multimodal Quality of Service Program, the methodology from this project could potentially be combined with those for the pedestrian level of service along a roadway segment and for crossing at intersections to determine the combined pedestrian level of service for an entire roadway segment. In addition, this combined pedestrian level of service at the segment-level can then be used as a direct input into the transit level of service methodology. The current measure for transit levels of service incorporates pedestrian crossing difficulty as a multiplicative factor (Karachepone, 2000). For example, the multiplicative factor would be 0.5 for a combined pedestrian level of service of F, 1 for D, etc.

Conversion to Level of Service Designations

Once a model is estimated, it can be used to estimate the crossing difficulty of any site for which data are available for the variables included in the model. In order to estimate the level of service for this site, however, one would need a conversion mechanism that translates the estimated crossing difficulty to one of the six levels of service. The key is to select a set of breakpoints as the six designations. Three alternative approaches were discussed in the previous chapter. To maintain consistency with the other modules, we plan to use the range-based approach for this conversion with the following breakpoints: 1.5, 2.5, 3.5, 4.5, and 5.5.

Level of Planning

The level of planning details affects how the preferred model will be used. It may be used to predict crossing difficulty for individual sites with only the key variables present. The key factors would be any variables in the model other than personal age and turning movements. These variables may be called the adjustment factors and would be set to their default values representing the idealized conditions. This level of application is most appropriate for detailed planning as in ART_PLAN.

It may be used to create tables that relate the key factors to pedestrian levels of service for midblock crossing. These tables could be part of ART_TAB, the spreadsheet template for generalized planning. As with the first application, the adjustment factors would all be set to their default values.

It may also be used to predict crossing difficulty for more detailed planning. For this purpose, all variables will take values that are specific to individual sites being evaluated, including the adjustment factors. In addition to including the adjustment factors, this level of application may also need to obtain data for the key variables that represent conditions when a particular site is most used by pedestrians.

Spreadsheet Model

Based on the recommended determinants and their likely effect on perceived midblock crossing difficulty, a simple spreadsheet is constructed to illustrate how different scenarios as defined by these determinants for a roadway segment would affect its predicted crossing difficulty and the corresponding level of service. The format of this spreadsheet model follows the one used in the PED_LOS. All determinants enter the functional relationship linearly for this illustrative spreadsheet. The coefficients are all hypothetical values. Figure 7 illustrates the spreadsheet.

Figure 7: Spreadsheet Model

Pedestrian Midblock Crossing Difficulty Sensititivity

Variable Category	Person	Traffic					Roadway						Control			Crossing	
Variable name	MA	NV	FV	NT	FT	SP	NW	FW	RM	NM	CW	PS	NC	FC	DS	Difficulty	
Definition	Age 16-65	Near Volume	Far Volume	Near Turns	Far Turns	Spd. Limit	Near Width	Far Width	Res. MedRes.	Non	Cross Walk	Ped. Signal	Near Cycle	Far Cycle	Signal Space	Value	LOS
Unit	(%)	(vph)	(vph)	(vph)	(vph)	(mph)	(ft)	(ft)	(ft)	(ft)	0/1	0/1	(sn)	(sn)	(ft)	1-6	A-F
Base Condtitions	0	6,000	6,000	0	0	35	24	24	0	0	0	0	60	60	200	**4.5**	**E**
Scenarios																	
Older population (MA)	25	6,000	6,000	0	0	35	24	24	0	0	0	0	60	60	200	**5.0**	**F**
Double volume	0	12,000	12,000	0	0	35	24	24	0	0	0	0	60	60	200	**5.1**	**F**
Turning movements	0	6,000	6,000	60	60	35	24	24	0	0	0	0	60	60	200	**4.6**	**E**
High speed (SP)	0	6,000	6,000	0	0	55	24	24	0	0	0	0	60	60	200	**4.7**	**E**
Double road width	0	6,000	6,000	0	0	35	48	48	0	0	0	0	60	60	200	**5.0**	**F**
Long cycle	0	6,000	6,000	0	0	35	24	24	0	0	0	0	120	120	200	**5.1**	**F**
Large signal spacing (DS)	0	6,000	6,000	0	0	35	24	24	0	0	0	0	60	60	400	**4.8**	**E**
Res. median present (RM)	0	6,000	6,000	0	0	35	24	24	6	0	0	0	60	60	200	**0.8**	**A**
Non res. Median (NM)	0	6,000	6,000	0	0	35	24	24	0	6	0	0	60	60	200	**2.0**	**C**
Crosswalk present (CW)	0	6,000	6,000	0	0	35	24	24	0	0	1	0	60	60	200	**3.2**	**D**
Pedestrian signal (PS)	0	6,000	6,000	0	0	35	24	24	0	0	0	1	60	60	200	**3.9**	**D**

MA = percentage of pedestrians 16-65
NV = near-side volume
FV = far-side volume
NT = near-side turning movements
FT = far-side turning movements
SP = midblock running speed
NW = near-side road width
FW = far-side road width
NC= near-side signal cycle
FC = far-side signal cycle

DS = spacing of traffic signals
RM = restrictive medians
NM = non-restrictive medians
CW = crosswalks
PS = pedestrian signals
vph = vehicles per hour
mph = miles per hour
ft = feet
sn = seconds
0/1 = 0 or 1

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