

# Multimodal LOS

## “Point” Level of Service Project

### Final Report

August 2001



Dr. Linda B. Crider  
Jodi Burden, Feng Han  
Department of Urban & Regional Planning  
PO Box 115706  
University of Florida  
Gainesville, Florida 32611-5706  
(352) 392-8192 FAX (352) 846-0404  
In Conjunction With  
Sprinkle Consulting, Inc. Lutz, Florida  
Kittelson & Associates, Inc. Fort Lauderdale, Florida

## ACKNOWLEDGEMENTS

I wish to acknowledge the hard work and expert guidance of our “Point LOS” team who gave of their time through conference calls, draft report reviews, numerous meetings to hash out all aspects of bike, ped, and transit “point” measures, evaluate bus stops along an RTS route, and finally decide on a conceptual framework for each of these modes at the “point” level. I wish to thank **Angela Perez** of the Gainesville Regional Transit System for hours of “on board” surveys that she collected and analyzed for this project;

**Feng Han and Jodi Burden**, graduate students who worked tirelessly on the literature review, report drafts, videography of sites and transit photos; **Dwight Kingsbury and Theo Petritsch** of the FDOT Bicycle Pedestrian Program for their expert advice; **Bruce Landis and Sprinkle Consulting Inc.** for their expertise as our prime consultants on the bicycle and pedestrian point measures and conceptual frameworks; **John Karachepone and Kittelson & Associates** for their expertise as our prime consultants on the transit measures and conceptual frameworks; **Doug McCloud** of the FDOT Systems Planning Office for his vision; and finally, **Martin Guttenplan**, our fearless leader and project manager of the multimodal Level of Service research projects for the Florida Department of Transportation. It has been my pleasure and good fortune to have guided this project as part of a greater effort that the State of Florida Department of Transportation has embarked upon to recognize the mobility needs of all people.

This report is respectfully submitted, August 28, 2001 by **Dr. Linda Crider**,  
Department of Urban and Regional Planning, University of Florida, Gainesville, Florida



Martin Guttenplan “stands” with the Final “Conceptual Models” after hours of debate



The “point LOS team hard at work

# TABLE OF CONTENT

	<b>Page</b>
<b>Executive Summary</b>	1
<b>Introduction</b>	4
<b>Literature Review</b>	8
<b>Conceptual Framework Development</b>	28
-- Transit Infrastructure Survey	28
-- Transit Conceptual Framework (Kittelson & Associates)	32
-- Bicycling Conceptual Framework (SCI)	43
-- Pedestrian Conceptual Framework (SCI)	47
<b>Evaluative Methodology for Frameworks</b>	50
<b>Site Characteristics for Evaluation</b>	55
<b>Appendix</b>	
A. Pedestrian Point LOS Evaluation Form	58
B. (Sample) Intersection Rating Form	59

## EXECUTIVE SUMMARY

**The purpose of this research** was to extend the multimodal LOS research effort addressing specific measures that affect the user at the “points” in their journey. For the transit user, this relates to the actual **bus stop**, the point where they embark or disembark on their journey. For the bicyclist and pedestrian, this is the point of transition, from segment to segment or to destination, and generally relates to a crossing point either midblock or at an **intersection**.

**Techniques for identifying measures** - Through examination of measures identified in an extensive literature review and use of a panel of experts to review and select appropriate measures, the “conceptual frameworks” for point LOS for transit, bike and ped modes were identified. Further, a transit infrastructure (amenities) use survey was distributed to 500 bus riders in Alachua county (RTS system) and analyzed for their weighting of importance of various transit infrastructure.

Note: The steering committee “panel of experts” meetings were rich and often heated debates resulted in a complete thrashing out of each measure for its applicability and appropriateness. Usually the compromise was to include the measure as a “placeholder” for further assessment.



## CONCEPTUAL FRAMEWORKS

**Transit mode** including the primary service measure at the point level is frequency; a secondary measure includes accessibility to the pedestrian, passenger loading, and a comfort convenience measure (transit infrastructure of the bus stop).

**Bicycle through movement** – While there are three movements to model for intersection performance, we chose to look first at the through movement. This is described by factors included in the combination of **conflicts, exposure, and delay** experienced by the bicyclist. Conflicts include turning movements and may be modified by the g/C ratio and percent of truck volume. Exposure combines crossing distance (width plus 2X intersection radii) possibly modified by pavement condition, presence of exclusive motor vehicle right turn lane (outside lane geometry) and clearance interval (modified by loop detection for cyclists). Delay for signalized intersections is a factor of control delay (g/C ratio modified by outside lane width/configuration); for signalized intersections crossing

delay may be influenced by through movement MV volume from far side cross street plus approach traffic of the near side cross street, plus RT and LTo.

**Pedestrian through (side street crossing) movement** - Similar to the bicyclist movements, the pedestrian measures incorporate **conflicts, exposure, and delay** factors to determine the functioning of the intersection for the pedestrian. Conflicts (turning movements), exposure (crossing width/intersection radii, presence and type of crosswalk, presence of curb and/or sidewalk at waiting or landing area plus median type) are the factors for both signalized and unsignalized intersections. For Delay, signalized intersection measures are a function of cycle length with ped signal, facility g/C without ped signal; for unsignalized intersections crossing delay is a function of Tfs (cross street volume), turning movement of near side cross street and major streets “platooning” .



**Evaluation Methodologies** - Several techniques for analysis and model calibration were explored. They include for bike and ped mode, an actual “cross for science” participation study to assess ped and bicyclists comfort level in crossing various selected intersections, a “from the curb” scoring/analysis of intersection crossing factors, a videotape analysis of selected intersections, or a combination of several of these. This study will only recommend various techniques. FDOT will have to decide the efficacy and appropriateness of each. For the transit model, surveys of the point measures by both operators (transit agency) and user groups (bus riders) was suggested. Further the concept of video analysis of bus passengers at transit stops might prove useful. The final report also includes a listing of various “Site Characteristics” for all three modes (transit, bike and ped) to be used in any type of model validation for Point LOS.

**Implications of the Point LOS measures** – Aside from the obvious use of the point measures to combine with segment analysis in determining multimodal levels of service, there are implications for design features to be recommended or even required. Many of these are even currently in practice such as narrowing turning radii, straight through bike lanes with exclusive rt MV lanes, bus stop headway reductions and benches/shelters, real time GPS informational signage at bus stops and transfer centers, etc. It is the hope that from this research effort will come the validation for use of these various measures, their importance in quantifying the comfort/convenience/safety to the user of various modes, and the format for making transportation system decisions on a larger scale that will effect policy and planning, design, and evaluation.

**Making it “user friendly”** - In looking at the usefulness of the application of all our Level of Service measures, it is critical that not only are they research based, accurate, in line with HCM methodologies, and purposeful, but they are presented in such a way as to BE USED by various transportation planners, consultants, engineers and those making critical decisions at the local and regional level. Therefore every attempt should be made to present the models and their application in as “user friendly” a way as possible, including the use of visuals to depict concepts and actually SHOW what we are talking about.( Here is a LOS A roadway or intersection from the bicyclist perspective.)

Note: This was a request made at the recent state bicycle/pedestrian coordinators meeting following the LOS presentation. I believe it is valid and quite necessary.



# INTRODUCTION

The Florida Department of Transportation has embarked on an ambitious and significant project to establish "level of service" measures for modes of transportation including transit, bicycles and pedestrians in addition to the traditional LOS standards for motor vehicles. As part of this initiative, a number of studies are looking at the elements for each of these measures as they relate to quality for the user at a number of different levels: Point Level of Service for intersections or specific point locations (such as bus stops and pedestrian crossings), segment (along a roadway between points or intersections), facility (series of segments and intersections), corridor (consisting of parallel facilities), and areawide Level of Service for an entire area or community.

## PURPOSE

The purpose of this "Point LOS" research is to extend the "segment LOS" research to address specific quality measures that affect the user at specific points in their journey. For the transit user, this relates to the actual features of the bus stop, the point where they embark or disembark on their transit journey. For the bicyclist and pedestrian, this is the point of transition, from segment to segment or to destination, and generally relates to a crossing point either midblock or at an intersection.

A separate research initiative at the University of South Florida's CUTR is currently looking at the midblock characteristics for level of service. This research incorporates their findings into an overall Point Level of Service addressing bus stops, intersections and destination bicycle parking.

## IMPORTANCE

Martin Guttenplan, FDOT's Multimodal LOS research project manager expressed the importance of this part of the project research; "Ironically, the point or intersection level is the critical link for the pedestrian. The primary barrier to walking is crossing an intersection" or crossing the street midblock if the intersection is a significant distance from the destination or is hostile to the pedestrian. "Previously it would have been extremely difficult to quantify the conditions at the point level for non-motorized users. However, with the development of FDOT's Multimodal Level of Service segment techniques, it is possible to expand the process to encompass intersections.

"The importance of this point level assessment lies in its impact on the entire trip for the pedestrian, bicyclist, or transit user. It is literally a "critical point." By defining those characteristics of intersections and bus stops as determined from the user's perspective, we can incorporate such design standards and recommendations into multimodal facility planning, thereby enhancing the quality of the environment for many varied users.

## **METHODS OF STUDY**

This type of “Point LOS” analysis has not been formalized in Florida to date. Review of literature for point level analysis and identified measures was conducted to assist in the development of the Florida point level analysis. In addition, the work done by CUTR at the University of South Florida for assessing midblock crossing difficulty was taken into consideration.

A team of experts in the area of transit and bicycle/pedestrian level of service measures was involved in establishing measures and recommending the assessment techniques proposed.

Consultants were surveyed to determine the LOS point level measures. Identified characteristics of bus stops and intersection type and design were matched with specific site locations in the Gainesville area. These sites provided on-site evaluation by the expert team. The techniques for point level transit assessment were tested through an on-board transit survey in Gainesville, Florida. This research did not employ an active participant "cross for science" element as was done in the segment bicycle and pedestrian models calibration. Future research effort would be required for that type of model development and calibration.

From the survey feedback and on-site analysis technique responses "performance measures" were determined to incorporate into the overall multimodal LOS model process for use by local government agencies and MPO staff. The results of this research project provided the conceptual framework for "what if" analysis at the planning level to determine the effect of proposed improvements for intersections and bus stops.

## **ELEMENTS FOR THE VARIOUS MODES**

- A. For pedestrians and bicyclists the point level analysis is INTERSECTIONS.
- B. For transit users, the point level analysis is BUS STOPS.
- C. Also included is a description of measures related to BICYCLE PARKING as it effects the level of service for bicyclists at destination points.





## POTENTIAL MEASURES/CHARACTERISTICS FOR POINT ELEMENTS FOUND IN THE LITERATURE REVIEW

### A. INTERSECTIONS

1. Crossing distance (width)
  - ❖ Use of bulb-outs, refuge triangles and islands, raised medians (type, width)
2. Design of street corner, enough “storage” for pedestrians
  - ❖ Curb ramp design (ADA)
  - ❖ Curb radii
  - ❖ Gutters and ramp free of debris and/or standing water
3. Gap (volume and speed of motorized traffic)
4. Crosswalks
  - ❖ Marked vs. unmarked
  - ❖ width
  - ❖ Type of marking - parallel, high emphasis stripes, colored
  - ❖ Textured paving (brick or stamped brick, concrete inlay, etc)
  - ❖ Stop line setback
5. Vehicle movements
  - ❖ Right Turn on Red
  - ❖ Exclusive turn phase and turn lanes (right and left)
6. Lighting
7. Encroachment (red light running, vehicle stop bar setback)
8. Traffic signal alternatives/phasing (vs. non-signalized)
  - ❖ Pedestrian signalization
  - ❖ Timing (delay)
  - ❖ Prioritization ( “hot response” )
  - ❖ Automated feedback
9. Presence of sidewalk at the intersection
10. Traffic calming to slow speeds at approach to intersection



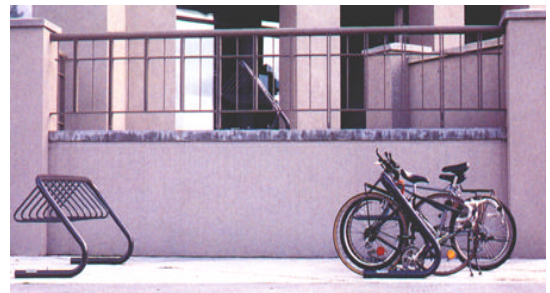
## B. BUS STOPS

1. Frequency of service
2. Information signage, Advanced Traveler Information System (ATIS)
3. Shelter structure, trees, shade
4. Bench
5. Places for people to lean
6. Lighting
7. Security (CPTED design, crime statistics correlated to land use)
8. Platform or paved waiting area connected to loading area
9. Sidewalk connection to waiting area
10. Location relative to destinations for boarding or disembarking
11. Bicycle racks on buses or racks at site
12. Landscaping
13. Telephones
14. Waste receptacles
15. Newspaper boxes
16. Map of surrounding area
17. Vending machines
18. Load factor on bus (availability of seats and/or standing room)
19. Features for disabled (platforms, ramps or elevators)
20. Surrounding retail and civic activities (cafe, art exhibit, etc.)



C. BICYCLE PARKING is a “destination point” factor for the service level to the bicyclist. Included are some of the considerations. Three basic types include: employee/long-term parking, short-term parking, and parking associated with transit facilities.

1. Proximity and distance to destination entrance (convenience)
2. Identifiability (easy to find/signage)
3. Security and efficiency of rack or locker design
4. Sufficient space for number of bikes
5. Covered from the weather
6. Lighting
7. Security of area
8. Landscaping
9. Cost or fee (meters or coin lockers)



# LITERATURE REVIEW

## Annotated Bibliography

*\*Note: Concurrent Level of Service projects (areawide, segment and midblock) have been reviewed as well as the following resources.*

### **1. JHK & Associates, Center for Applied Research Inc. and RTKL Associates Inc. 1987. "Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas - NCHRP Report 294B," Transportation Research Board, National Research Council.**

This report includes criteria for site evaluations of pedestrian facilities. A definition of each criterion is given followed by a paragraph of commentary, explaining the approach to the definitions and indicating, to the extent possible, the meaning of "excellent, good, fair, poor" or "none, low, moderate, sever". Most of the definitions are descriptive rather than quantitative. An effort was made to develop quantitative definitions earlier in the project, and these proved not to be practical in most cases, for reasons explained in the report. Some of the factors the report evaluated included:

- o Level of use by pedestrians
  - The method of evaluating level of use would vary, depending on the situation type. In some cases, effectiveness would be determined by the degree to which pedestrians use the intended facilities, as opposed to an alternate facility. This situation would exist, for example, with an over/underpass intended for pedestrian use. An evaluation scale could be devised that considered the percentage of pedestrians using the preferred facility that could have used it.
- o Accessibility
- o Continuity of path laterally (across the roadway)
  - This represents the degree of difficulty encountered in crossing the highway, which is usually the most significant barrier along the pedestrian route. The scale for lateral continuity must respond to all the design and operational elements that impact on a pedestrian being able to safely and conveniently cross the street. Each element would have to be examined in its own right first, and then a composite scale developed. In the initial stages of the project, an attempt was made to develop a scale for individual design and operational elements (e.g. crosswalks, signalization, channelization), but it quickly became evident that this would be impractical. In the end, the design and operational elements impacting lateral continuity became a checklist for the evaluator to be reminded of in developing the overall rating for this criterion. A descriptive definition of the scale is given.
- o Pedestrian delay
- o Level of pedestrian hazard
- o Degree of conflict with vehicles

- o Clarity of directional information for pedestrians
- o Directness of pedestrian path
- o Clarity of information provided for drivers
- o Aesthetics and environmental quality
- o Security
- o Overall friendliness of pedestrian environment

**2. Jaskiewicz, Frank. 1996. "Pedestrian Level of Service Based Upon Trip Quality", Glatting, Jackson, Keaher, Arglin, Lopez, Rinehart, Inc.**

Treatment at pedestrian crossings - Special treatment at pedestrian crossings, such as bulb-outs and textured paving, can encourage motorists to drive with caution by increasing their awareness that pedestrians might be present. Raised crosswalks and speed bumps are often not desirable because they frustrate and anger motorists and hence increase the likelihood that they will drive unintelligently.

**3. "Case Study 16 - A Study of Bicycle and Pedestrian Programs in European Countries," 1992. US Department of Transportation - FHWA**

The 10 km Hague demonstration project features intersection priority signals for cyclists and driver-alerting pavement texture changes in front of intersections. Road signs advise both cyclists and drivers of approaching intersections, and instruct the driver to yield to cycle traffic. Traffic and safety islands are also set up on the medians to allow phased left turns by both cars and cyclists. At most places where cars cross the cycleways, neck-downs and gentle ramps were built, using cobblestones and special markings alerting drivers to the presence of cyclists.

**4. Bailey, Charles, Reid Ewing, William Hellman, Charles Baker. 1998. "Mobility Friendly Design Standards for Middletown, Delaware", Proceeding of 1998 National Planning Council. AICP Press.**

References geometric design criteria for lower design speeds, tighter horizontal curve radii, minimize long target sections and introducing curves as a means to reduce speed.

Intersection design T and 4-way intersections at 90° degree angles with minimum 60° angle permitted on local streets. The article supports roundabouts as preferred intersection design to stop signs. Discusses ordinances for bicycle parking provisions at public, commercial and employment shelters and benches encouraged for transit stops; including sidewalk "pad"/sidewalks and stops adjacent to signalized intersection for access to ped crosswalks. If too far from intersection, a safe means of crossing the street must be provided in proximity to bus stops. Stops are required to be lighted and bus stops should have markers with display of schedule.

**5. "Guide for the Planning, Design and Operation of Pedestrian Facilities - DRAFT", August 2000. Ty Lin Bascor Int'l and SCI.**

At-grade crossings provide the pedestrian with the most direct route across a roadway and comprise the vast majority of roadway pedestrian crossings. Street corners are where concentrations of pedestrians wait for an opportunity to cross. The design of a street corner can effectively reduce the distance of a pedestrian crossing. This paper discusses issues surrounding curb ramp design, curb radii, crosswalk design, crossing islands, vehicle turning movements, street lighting and more.

**6. "Bicycle and Pedestrian Facilities Planning and Design Guidelines", December 1995. DEP. North Central Texas Council of Governments.**

Discusses the Pedestrian Environmental Factor, which quantifies the relative convenience, safety and level of effort of walking perceived by pedestrians. It is done by evaluating the following four factors:

1. Ease of street crossings;
2. Sidewalk continuity;
3. Street layout; and
4. Topography

Most key intersections in a high scoring zone would possess some or all of the following pedestrian friendly characteristics:

- o crosswalks are present and clearly marked;
- o medians have a refuge island;
- o right turn lanes are separated from through traffic by a refuge island;
- o signalization is timed to accommodate a complete pedestrian crossing;
- o there are frequent controlled intersections;
- o if grade separated, pedestrian pathways provide safe effective linkages; and
- o traffic volumes are low.

The paper also discusses bicycle terminal facilities and notes that in general, any bicycle parking device should be installed in accordance with manufacturer's specifications with regard to spacing, anchoring and installation procedures. Other standard elements include security, convenience, identifiability, and cost.

**7. *The Transit Infrastructure for Transit Handbook*, Transit Cooperative Research Program Report 46. 1999. TRB. National Academy Press.**

The waiting environment includes access to the station or stop, circulation within the area and movement into and out of the train or bus, the waiting space, and the transit infrastructure in these areas:

- o Seating or places for people to lean (some people prefer to lean even when a place to sit is available);
- o Shelter from the weather;
- o Lighting of the shelter and adjacent areas;

- o Information systems (ranging from basic signs, maps and schedules to electronic, updateable information about actual vehicle arrival times);
- o Telephones and waste receptacles;
- o Special features for people with disabilities;
- o Retail and other civic activities and uses (such as a place to get a cup of coffee and buy a newspaper or libraries, art exhibits, etc.).

The paper also discusses other ideas to increase efficiency and safety of transit service such as using bus waiting areas which "bump out" sidewalks so that buses do not have to pull into the curb and waiting areas are increased in size. Other examples of transit infrastructure that may improve transit efficiency are the alignment of the waiting area with vehicle floor, fare purchase mechanisms, and the arrangement of transit infrastructure at the stop and the configurations of the waiting area to allow queuing and easy boarding. To increase safety the paper suggests including: adequate lighting at and around bus stops; telephones at or near stops; location of stops near active land uses; and a map of the surrounding area.

**8. JHK & Associates. "The Suburban Pedestrian Crossing Dilemma - A Paper Based on NCHRP Reports 294A and 294B," National Cooperative Highway Research Program, TRB and the National Research Council.**

The transportation engineer is continually faced with the dilemma of how to allow for convenient and safe pedestrian crossings while maintaining traffic capacity. This paper focuses on the important role that medians, pedestrian refuge islands, and spot lighting play in maintaining pedestrian mobility and safety. The AASHTO Green Book states that "a median is a highly desirable element on all arterials carrying four or more lanes." Medians greatly simplify the pedestrian's task of crossing the street while at the same time provide positive benefits for traffic movement. The heavier the traffic volume, the more important a median becomes in facilitating street crossings. Pedestrian refuge islands should be considered where there is a concentration of pedestrian crossing activity and a full median cannot be provided.

**9. "Pedestrian Safety in California: A State Plan," 1994. Emergency Medical Services Authority. State of California - Health and Welfare Agency.**

This paper discusses a number of design measures that may be utilized to improve pedestrian safety. Included are discussions on curb extenders (or "chokers"), curb radii, traffic circles, crosswalk design, signalization and lighting.

**10. *Customer Transit Infrastructure Manual*. Herbert • Halback, Inc. LYNX.**

This manual contains a description of transit facilities, and design elements to be considered including: signage, specialty paving, benches, rails, shelters, maps & schedules, bicycle storage, lighting, landscaping and others.

**11. CUTR. *Making Crosswalks Safer for Pedestrians: Application of a Multidisciplinary Approach to Improve Pedestrian Safety at Crosswalks in St. Petersburg, Florida.* Florida Department of Transportation.**

The research objectives for this study included implementing a multidisciplinary program consisting of engineering, education and enforcement components to improve pedestrian safety at crosswalks and evaluating the effectiveness of the program. Researchers conducted a community assessment that included identifying pedestrian safety issues, analyzing pedestrian crash records, conducting an audit to identify crosswalks with pedestrian safety problems, selecting intersections and crosswalks for interventions, and collecting baseline observational data.

**12. Sarkar, Sheila, Ron Van Houten and John Moffat. 1999. "Using License Manuals to Increase Awareness About Pedestrian Hazards at Intersections - Missed Opportunity for Educating Drivers," Transportation Research Record 1674. TRB.**

Thirty-four percent of pedestrian injuries and 18% of pedestrian deaths occur at intersections. This paper discusses turning movements of vehicles and conflicts with pedestrians. It also discusses right turn on red policies and recommendations.

**13. Bowman, Brian, John Fruin and Charlie Zegeer. 1989. *Planning Design and Maintenance of Pedestrian Facilities.* FHWA. USDOT.**

Chapter Six of this manual deals with crosswalks, curb ramps and refuge islands. It discusses issues and crash rates surrounding marked vs. unmarked crosswalks. It makes recommendations on what type of locations crosswalks should be marked and gives a summary of the advantages, disadvantages and implementation considerations for unmarked, marked and midblock crossings. In addition the manual discusses sight distances, stop line provisions, crosswalk width and length and bus stop concerns. The manual points out that far side bus stop operations has been determined as resulting in fewer bus stop related accidents. The manual also discusses considerations for elderly and handicapped.

**14. Ewing, Reid. 1996. *Pedestrian and Transit Friendly Design.* Florida Department of Transportation.**

The variables that most increase the likelihood of a bus stop being chosen are a bus shelter, a bench, trees or an overhang for shade, a vertical curb at the stop and trees along the street leading to the stop.

**15. Eldritch, Michael. 1989. "Bad Turns," *Traffic Safety.* National Safety Council.**

This article discusses right-turn-on-red (RTOR) vehicle movements. Compared to states that had not begun permitting RTOR movements, states that did experienced 20% more crashes involving right turns at signalized intersections. Where rtor is allowed, the chief

violation is failing to make a full stop. At 29 such intersections studied, more than half (56.9%) of the motorists observed failed to stop.

**16. U.S. Department of Transportation. 1992. "Walking Through The Years ... Pedestrian Safety for the Older (65+) Adult". National Highway Traffic Safety Administration, Federal Highway Administration.**

We have learned that the majority of accidents involving older adults occur at intersections - both with and without crossing aids. Intersection accident is the first major risk area for the older pedestrian. (P.2)

Intersections are particularly difficult for the older pedestrian. TURNING VEHICLES at intersections are responsible for a number of pedestrian accidents. Turning vehicles have three major pedestrian hazards at intersections: 1) Left-turning vehicles, 2) First stepping off the curb, 3) Cars exiting the intersection. The highest risk to a pedestrian occurs when all three of these factors come together. (P.3-4)

NON-TURNING VEHICLES also account for a variety of pedestrian accidents at intersections. 1) Visual screens, 2) Signal "faith". The problem is that the pedestrian relies completely on the signal and, without looking for cars, starts to cross the street as soon as the light turns green or the pedestrian light says WALK. 3) Signal timing. (P.4-5)

**17. U.S. Department of Transportation. 1992. "Walk Alert - Pedestrian Safety for Older Adults".**

It's up to the pedestrian to be alert and on the defensive. There are several recommendations: 1) When crossing streets at intersections, follow the easy-to-remember rules, 2) Walk to edge of parked car to see traffic, 3) Watch for cars backing up.

**18. Chellman, Chrester E. and P.E. 1989. "A discussion of street geometry and design criteria for traditional neighborhood development" . White Mountain Survey, Inc.**

The greater the curb radius, the greater the length of the crosswalk needed to cross the street at that point. Despite the affect of discouraging crossing by some pedestrians altogether, greater crossing times mean pedestrians will be in vehicular areas (the street) for longer periods of time which, of course, is unsafe. It is recognized that curb radii may be smaller due to lower operating speeds, and the street and development standards of many municipalities allow curb radii of 10 feet to 15 feet. Encroachments in the oncoming lane can be tolerated where drivers of the trucks are made to wait, and at signalized intersections stop lines can be set back to provide additional turning room. (P.5)



**19. City of Bellevue, Washington. "Pedestrian corridor and major public open space design guidelines" . Don Miles Associates/PPS.**

Street crossings: Intention is to ensure that crossings of major streets provide for pedestrian safety, enhancement of the corridor, and adequate traffic flow. It is accomplished by establishing highly visible, very distinctive on-grade crossings with special paving, lighting, planting, and other pedestrian features. The principle addressed is safe crossing of traffic. (P. 12)

**20. Transportation Research Board, National Research Council. 1984. "Pedestrian and bicycle facilities" . Washington, D.C.**

The purpose of this study was to develop and evaluate innovative pedestrian sign and signal alternatives. (P.110)

In the majority of pedestrian accidents at signalized intersections, the pedestrian had violated the signal message. (P.111)

These alternatives include new sign and signal devices, modifications of existing devices, supplemental devices to enhance the function of the signal, and promotion of improved understanding and respect of the signals. (P.111)

Selection of pedestrian clearance alternatives: 1) pedestrian signal explanation sign, 2)

DON' T START signal indication, 3) steady DON' T WALK signal

Selection of alternatives to indicate potential conflicts with turning vehicles: 1) Motorist yield sign, 2) Pedestrian signal explanation sign, 3) pedestrian warning sign, 4) WALK WITH CARE signal indication, 5) flashing WALK indication. (P.112 – P.114)

**21. National Bicycling and Walking Study. 1993. "The effects of environmental design on the amount and type of bicycling and walking" . US Department of Transportation, Federal Highway Administration.**

Often the width of the street, the geometry of the intersection, and the timing of the traffic signals are designed only for the needs of vehicles, not pedestrians. (P.18)

Another consideration is the radius of the intersection corner. Traffic engineers often prefer wide radii that make it easier for vehicles to turn. However, the larger the radius, the more inconvenient and dangerous it become for pedestrians. (P.18)

There are many changes that can be made to facilitate pedestrian crossing. Crosswalks can be widened and corner radii reduced to 1-5 feet, with the maximum of 25 feet. The actual width of a street also can be reduced through widening sidewalks, by installing a center median, or through "neckdowns." "Neckdowns" (also called "bulges," "bulbs," or "chokers" ) jut out from sidewalks into streets in extensions that line up with parking lanes. (P.18-P.19)

Three basic types of bicycle parking are needed: employee/long-term parking, short-term parking, and parking associated with transit facilities.

- o Parking for employees should be dictated as a ratio of required motor vehicle parking spaces. Bicycle parking should be accessible from driveways or ramps designed to accommodate bicycle travel.
- o Provision for short-term parking needs should be required for all downtown business and all public buildings. Parking should be located in both public parking garages and at the perimeter of public spaces.
- o Transit facility parking should be highly secure and similar in many respects to long-term parking.
- o Many cities have incorporated bicycle parking requirements into zoning ordinance provisions. These ordinances require provision of bicycle parking as a percentage of required motor vehicle parking spaces or in a ratio to building square-footage or number of employees. (P.32-P.33)

**22. Wallwork, Michael J., P.E. and Theodore A. Petritsch. "*Designing Pedestrian Friendly Intersections*". Document from FDOT.**

"Intersections comprise about two percent of the urban roadway network. Yet, forty percent of pedestrian crashes occur there. Because of the high risk to pedestrians at intersections, particularly for the young, the elderly, and the physically/visually challenged... Yet, by making intersections safer for pedestrians we also make them safer and more efficient for drivers." (P.13)

"To design pedestrian-friendly intersections, the following guidelines should be followed:

- o Channelize intersections.
- o Minimize pedestrian crossing distances.
- o Use small turning radii.
- o Conflicts should occur at right angles.
- o Conflicts are clearly visible.
- o Conflicts should occur at low speeds.
- o Eliminate conflicts where possible.
- o Provide positive guidance for vehicles and pedestrians.
- o Provide audible/tactile pushbuttons at signalized intersections.
- o Provide curb cut ramps and pushbuttons at each end of every crosswalk.
- o Provide "storage" for pedestrians on corners.
- o Provide adequate crossing time for design pedestrians to cross the road.
- o Locate bus stops on the far side of intersections.
- o Replace cross intersections with Tee-intersections or staggered Tee-intersections." (P.14)

"Channelizing an intersection to provide channelized right-turn slip lanes and medians with pedestrian refuges will separate vehicle/vehicle and vehicle/pedestrian conflicts. Pedestrian crossing distances are minimized. Also a pedestrian crossing a slip lane only has to cross the path of vehicles turning right." (P.14-P.15)

"Proper channelization of an intersection will reduce the area of conflict, reduce vehicle wander and better define areas where conflicts occur." (P.15)

"Because of slip lanes and median pedestrian refuges the distance pedestrians must cross at one time are reduced. Right-turn slip lanes allow for better driver/pedestrian site lines and lower vehicle speeds." (P.16)

"Bulb-outs reduce the pedestrian crossing distances. This technique is gaining wider acceptance throughout the State as cities upgrade their downtown area to improve pedestrian facilities." (P.16)

"Use small turning radii. Large radius corners are dangerous as they increase pedestrian crossing distances." (P.17)

"Conflicts should occur at or near right angles. This provides pedestrians with the best opportunity to see approaching vehicles and to be seen by the drivers of those vehicles." (P.17)

"Design intersections to ensure maximum visibility of potential conflicts. Sight lines must be kept clear of signal controller boxes, strain poles, fences or other obstructions which could hide a pedestrian or block his or the driver's vision. Intersections should be well lit so pedestrians waiting to cross the road can be clearly seen." (P.18-19)

"Suggested radii are 25 feet for major roads, 10 to 15 feet for local streets. Where there are significant trunk movements a right-turn slip lane is recommended." (P.19)

"A lower left-turn speed is achieved by using a 50 foot radius and by extending median noses to within two feet of the projection of the intersecting curb line." (P. 19-20)

Other consideration include:

Access to intersection -- to ensure they can make use of the intersection facilities sidewalks must be installed along both sides of all streets and roads leading to tie intersection", and lighting and roundabouts. (P.22-23)

### **23. "Bike/Pedestrian of MTPO 2020 Transportation Plan (Alachua County - L. Dixon)**

During development of the 2020 Transportation Plan for Alachua County, several measures of pedestrian & bicycle performance were listed as ways of determining level of service to the cyclist & pedestrian. They included:

Performance Measures:

- o Crossing and conflicts
- o Crossing width
- o Ped signal delay

- o Reduced turn conflict implementation (No turn on red, restricted left and right turn to only arrow signal please)
- o Speed of 35 m.p.h. or less
- o Drive ways and sidestreets < 22/mile (segment)

Transit infrastructure:

- o Medians
- o Pedestrian lighting
- o Shade trees

**24. Calthorpe, Peter. 1993. "Next American Metropolis: Ecology, Community and the American Dream" .**

Pedestrian and Transit Friendly Design

Public Transportation Office, Florida Department of Transportation, 1996

This handbook provides a recommended practice for pedestrian and transit friendly design. A checklist of features associated with pedestrian and transit friendly design is provided divided into essential, highly desirable and nice additions. The following elements are related to the development of criteria for multimodal transportation districts:

Block Length

Block length and the number of intersections is essential for walkability. Recommended block lengths of 300' or less are desirable, 400' -500' is acceptable, greater than 600' is undesirable and requires mid-block crossing.

Safe Crossings/Turning Radii

Safe crossings are recommended once every 600 feet. Maximum corner radii are recommended to provide a clear pedestrian safe way.

Appropriate Buffering from Traffic

Guidelines are provided for appropriate buffering for pedestrians in relationship to vehicular speeds.

Comfortable and Safe Places to Wait

Guidelines for shelter and lack of barriers for pedestrian access to stops.

**25. "Pedestrian Environment, The 1000 Friends of Oregon" . 1993**

This document discusses research related to the effectiveness of the pedestrian environment to contributing to multimodal potential. Four factors were compiled to form a pedestrian environment factor: (1) ease of crossing, (2) sidewalk continuity, (3) sidewalk connectivity, and (4) topography.

**26. Burden, Dan and et.al. 1999. "Street Design Guidelines for Healthy Neighborhoods" . Center for livable Communities.**

This handbook provides a recommended practice for the design of roadways in livable communities. The handbook emphasizes roadways but also recognizes the importance of pedestrians and transit in livable neighborhoods. A classification of streets is proposed which matches the desired functionality and role of the roadways within the livable communities design philosophy. Factors considered in the classification include: maximum width, design speed, corner radii, curvature, medians, street length, vehicle volumes, walkways, bike lanes, trees, one-way or two-way traffic and parking.

**27. Local Government Commission, 2000. "Streets and Sidewalks, People and Cars: The Citizens Guide to Traffic Calming" . Center for livable Cities. Listed in "Multimodal Areawide Level of Service Measures" .**

The Document is a practical guide to traffic calming and is a resource of various traffic calming treatments. A table is provided that relates various traffic calming treatments to vehicle volume, vehicle speed, noise, vehicle conflicts, traffic diversion, pedestrian safety, bicycle safety, emergency vehicle access, estimated costs, timeline for construction, and appropriateness of use for arterials or residential roadways.

**28. Project for Public Space. 1998. "Transit-Friendly Streets: Design and Traffic Management Strategies to Support Livable Communities" . Listed in "Multimodal Areawide Level of Service Measures" .**

This research report uses a variety of case studies to illustrate the application of transit friendly design principles to streets. The emphasis of the research is more of a synthesis of transit infrastructure and strategies than evaluation scheme. The transit corridors were with evaluated qualitatively and major design configurations and elements were summarized and compared.

**29. Houten, Ron Van and Bruce Blasch, J.E. Louis Malenfant. 2001. "A Comparision of the Recognition Distance of Several Types of Pedestrian Signals with Low Vision Pedestrians". Transportation Research Board.**

Although approximately 80-85% of the legally blind population has some residual vision, little research has examined the relative conspicuity of various types of visual pedestrian signals with this group of pedestrians. This research compared the relative conspicuity of an incandescent WALK sign, a white LED WALK sign, a blue LED WALK sign, and white and blue LED WALK signs that included an animated 'eyes' display with legally blind participants who had some vision. All WALK signals were equated for brightness using a N.I.S.T. certified illuminance meter. Participants had to discriminate whether the test stimulus was a blue/ white WALK sign or a blue/ white DON'T WALK sign. Test stimuli were presented in randomized blocks of trials and recognition distances were

determined by having participants approach the test stimuli until they could identify them. Results indicated that there were no significant differences between the incandescent and LED signals without the animated eyes or between the blue and white LED signals. However, Tukey's method showed a significant contrast between the signals with the animated eyes display and signals without this display ( $F = 149.88$ ,  $P$  - value  $< .0001$ ). Participants could identify the WALK signal 62 percent further away when it also contained the animated 'eyes' display. These results show that the addition of an animated 'eyes' display to the WALK sign could significantly improve the use of visual pedestrian signals by a large segment of persons with visual impairment.

**30. Houten, Ron Van and J.E. Louis Malenfant. 2001. "The Scanning 'eyes' Symbol as Part of the WALK Signal: An Examination Across a Several Intersection Geometries and Timing Parameters". Transportation Research Board.**

This series of studies examined the use of animated eyes as part of the WALK signal. In the first experiment the conflicts were examined before and after the animated eyes were introduced at two intersections with one way traffic on both streets, four intersections with two way traffic on both streets, and two intersections with one way traffic on one street and two way traffic on the other. Conflicts were reduced at crosswalks on all eight streets with significant reductions on 7 of the 8 streets. The second experiment examined whether it was better to have the eyes look in both directions, eyes scanning back and forth with equal dwell times in each direction, or only in the direction of the threat, unequal dwell times with the eyes looking longer in the direction of the threat, at crosswalks on one-way streets. The results of this study showed that looking one way was no more effective than looking both ways. The effect of varying the percentage of the time that the eyes message was repeated during the WALK interval on looking behavior and conflicts was examined in the second experiment, and third experiment. The results of this study show that having the eyes on during the entire WALK interval was no more effective than having the eyes alternately on for 3.5 seconds and off for 3.5 seconds, but having the eyes alternately on for 3.5 seconds and off for 7 seconds was somewhat less effective.

**31. McCoy, Patrick T. and Geza Pesti, Patrick S. Byrd, Virendra A. Singh. 2001. "Guidelines for Opposing Left-Turn Lane-line Widths". Transportation Research Board.**

Vehicles turning left at intersections from opposing left-turn lanes often restrict each other's sight distance. Previous research has developed guidelines for offsetting opposing left-turn lanes in order to provide adequate sight distances. Implementation of these guidelines at existing intersections typically involves reconstructing the left-turn lanes. However, increasing the width of the lane lines between left-turn lanes and the adjacent through lanes has also been found to be a way of improving the sight distance between opposing left-turn lanes. Utilizing the relationship found between lane line width and available sight distance, guidelines for designing the width of left-turn lane lines to provide the required sight distance for opposing left-turn vehicles are presented.

**32. Reid, Jonathan D. and Parsons Brinckerhoff, Joseph E. Hummer. 2001. "Travel Time Comparisons between Seven Unconventional Arterial Intersection Designs". Transportation Research Board.**

Signalized intersections on suburban arterials are increasingly congested during peak periods with few inexpensive improvement options available. Much of the vehicle delay incurred at conventional intersections is a result of left turn demand. Unconventional intersection designs attempt to reduce intersection delay and travel times by rerouting left turns away from the main intersection. This paper compares seven unconventional designs the quadrant roadway, median u-turn, superstreet, bowtie, jughandle, split intersection and continuous flow intersection designs that could apply to a wide range of standard, four-leg intersections. Previous comparisons of intersection delay and travel time between conventional designs and these unconventional designs have been piecemeal and have largely used hypothetical volumes. The purpose of this research was to conduct fair travel time comparisons of conventional and unconventional designs using data from existing intersections.

The researchers conducted simulation experiments using turning movement data from seven existing intersections of varying sizes. The researchers used optimum cycle lengths for each design, and held a number of factors constant to keep the comparisons fair. The researchers examined off-peak, peak, and peak-plus-15-percent volume levels. The results from the simulations showed that at each intersection, one or more unconventional design had lower total travel times than the conventional design. While most of the unconventional designs showed improvement in one or more scenarios, the quadrant roadway and the median u-turn designs consistently produced the lowest travel times. When considering the design of high-volume intersections like those tested, engineers should seriously consider quadrant roadway and median u-turn designs where rights-of-way are available.

**33. Falzarano, Stacey and Richard Hazlett, Thomas Adler. 2001. " Quantifying the Value of Transit Station and Access Improvement for Chicago's Rapid Transit System". Transportation Research Board.**

The goal of the Congestion Management and Air Quality (CMAQ) program is to improve air quality by reducing auto use and highway congestion. Rapid transit station and pedestrian system improvements are important to Chicago's strategy to meet this goal for its CMAQ funding. The effects of improving transit service by traditional means are generally well understood and are represented in conventional travel forecasting models. Much less understood are how more general improvements in transit stations and transit access affect transit ridership and, ultimately, air quality.

This paper describes work to quantify the effects of potential changes to the Chicago rapid transit system's stations and pedestrian access and to measure the impacts of these changes on rapid transit system ridership, revenue, and auto emissions. The study was based on an in-depth computer-based survey of a sample of people who either currently

use rapid transit or who make trips that could reasonably be served. Preference information was collected using hybrid conjoint methods.

The study found that a modernized station provides an equivalent benefit of approximately \$0.23 to \$0.37/trip. Perceived benefits of individual components such as landscaping, security, improved mezzanines and better weather protection were found to vary in value from \$0.02 to \$0.05/trip. Enclosed walkways for downtown stations have an overall value of about \$0.11/trip but this value increases during inclement weather.

Estimated increases in transit ridership and reductions in auto emissions suggest that station modernization and pedestrian programs can be an important component of a regional transportation program such as CMAQ.

**34. Flannery, Aimee. 2001. "Geometric Design and Safety Aspects of Roundabouts". Transportation Research Board.**

This paper presents the findings of a three-year study conducted at The Pennsylvania State University for the Federal Highway Administration on the subject of roundabouts in terms of safety and operational performance, and geometric characteristics. This paper is focused on geometric characteristics that influence the safety and operational performance of roundabouts. Accident data (including driver testimonials) were reviewed along with videotapes developed at several roundabouts located in the States of Maryland, Florida, and Nevada. Several conclusions were drawn including the need to improve geometric design on approaches to rural roundabouts to reduce loss of control accidents; the need for adequate right of way to properly deflect vehicles around the center island; and the need for guidance regarding operating volume to capacity ratios. The findings from this study will assist planners, designers, and engineers to avoid unnecessary safety hazards and operational failures.

**35. Krygsman, Stephan and Martin Dijst. 2001. "Multimodal Trips in the Netherlands: Conceptual Clarification, Micro-level Individual Attributes and Residential Context". Transportation Research Board.**

Multimodal Passenger Transportation has received renewed attention in industrialized countries as a more sustainable and environmentally sensitive alternative to the uncontrolled growth in car travel. As a result there has been a diverse range of policy and planning guidelines supporting, promoting and evaluating seamless multimodal travel alternatives. Few attempts, however, have been made at quantifying the space-time implications of multimodal transportation on the travel behavior and activity patterns of individuals. This research is concerned with an analysis of multimodal trips in the Netherlands to provide insight into the specific travel behavioral and socio-demographic characteristics of multimodal transportation users in the Netherlands.

A conceptual overview of multimodal transportation is provided followed by a literature review that discusses some important research themes. This conceptual overview is



quantified with travel data from the Dutch National Travel Survey (1998). Based on the data conclusions are drawn regarding most frequently occurring mode chain combinations, number of trips, trip duration and mean trip and stage distance. Attention is also paid to each mode's unique distance decay function for the different stages in a multimodal trip. Based on the analysis results, a schematic framework of the typical multimodal trip characteristics is provided.

In the final instance the individual level attributes that influence multimodal transportation is explored with multivariate analysis. The results indicate some very distinct person characteristics associated with multimodal transportation.

**36. MacDonald, Alison, January 1989. "Transportation: Options for the Future Issues related to Older Driver and Pedestrian Safety." National Advisory Council on Aging**

This paper discusses the issues surrounding elderly drivers and pedestrians. Street crossings are particularly hazardous for seniors. The time allotted for crossing at intersections with walk signals is based on a norm for younger people and often is not long enough for elderly people. Elderly people tend to have more difficulty than younger people judging the speed of oncoming traffic. Recommend longer walk signals at controlled intersections, curb ramps to make entering and exiting the street easier, barriers to prevent people from crossing where it is not safe, and relocating the stop line to a point further from the crosswalk.

**37. Smith, S. A., K. S. Opiela and L. L. Impett, 1987. "Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas" . Transportation Research Board.**

This manual discusses in part the methodology and criteria that they used to evaluate sites. The issues they discussed included: level of use by pedestrians, continuity of path laterally (across the roadway), pedestrian delay, degree of conflict with vehicles, clarity of directional information for pedestrians, aesthetics and environmental quality, security and overall "friendliness" of pedestrian environment. Each issue has a set of criteria that they used to evaluate pedestrian facilities.

**38. Khasnabis, S., C.V. Zegeer and M.J. Cynecki. "Effects of Pedestrian Signals on Safety, Operations and Pedestrian Behavior: Literature Review," *Transportation Research Record*. Number 847, 1982.**

Some of the researchers found no significant reduction in the proportion of unsafe acts before and after the installation of pedestrian signals. Based on their evidence, those authors concluded that pedestrian signals are not an effective method for reducing pedestrian accidents.

Others found evidence to the contrary. Mortimer compared the compliance rates of pedestrian crossings at intersections with and without pedestrian signals.

1. Better signal compliance was found at intersections with pedestrian signals than at those without them;
2. Fewer illegal starts and more successful crossings were made at intersections with pedestrian signals than at those without pedestrian signals;
3. Hazard-index values calculated for intersections with pedestrian signals were slightly lower than those calculated for intersections without pedestrian signals;
4. Potentially serious pedestrian-vehicle conflicts were reduced substantially at intersections with pedestrian signals; and
5. The use of pedestrian crossings was instrumental in improving compliance and in providing more information to pedestrians, which resulted in more comfortable crossings and fewer crossing hazards.

The higher violation rates at scramble-timed intersections (i.e., where an exclusive pedestrian phase exists with diagonal crossings permitted) is indicative of the higher pedestrian delay generally associated with these locations.

Williams makes the general conclusion that pedestrians tend to accept natural gaps in traffic rather than wait for the signal to provide a protected crossing interval.

Pedestrian signals should generally be set with the minimum clearance interval and the WALK interval should not be less than some minimum period.

Kyle's study showed that a dynamic pedestrian signal tended to reduce the number of illegal pedestrian movements in the intersection area.

A study showed that a significant number of pedestrians were cleared from the crosswalk that had the dynamic signal, and the author recommended that this type of pedestrian control would be appropriate for intersections where the pedestrian interval is short or the crosswalk distance are relatively long.

The authors found that the presence of an amber phase generally resulted in better pedestrian compliance. Furthermore, in the absence of an amber phase, pedestrians tended to walk against the red. Based on this finding, the authors recommended the installation of an amber phase (clearance interval) for pedestrian signals.

The results of this study point out the general misunderstanding of the flashing WALK (or flashing man) indication as a warning to pedestrians to watch for turning vehicles.

The study indicates that unsafe behavior is associated with intersections that experience high frequencies of pedestrian accidents.

1. Evidence is not sufficient to conclude that a steady clearance is better than a flashing clearance.
2. The DON'T START message offers little or no improvement over the current DON'T WALK message.
3. A flashing WALK is not an effective means of warning pedestrians about turning vehicles.

**39. FHWA. *Urban Intersection Improvements for Pedestrians Safety*. FHWA Report No. FHWA-RD77-146. U.S. Government Printing Offices, Washington, DC 1977.**

This report summarizes the research completed in the third phase of a three-phase project. This phase was directed at identifying and evaluating alternatives to full signalization at school-pedestrian crossings. These school-pedestrian crossings are located at the intersection of a high-volume arterial street and a low-volume residential street where adequate gaps do not exist to allow pedestrians to cross the arterial street safely without an unreasonable time delay. These locations would not otherwise warrant full signalization.

This study was divided into three sections:

- o Identify alternative school-pedestrian crossing designs at intersections.
- o Evaluate five alternative school-pedestrian crossing designs using controlled field experiments.
- o Recommend the safest and most effective design for a school-pedestrian crossing based on the evaluation of the five alternatives.

The identification of alternative school-pedestrian crossings was divided into three tasks. Task one was to obtain information on school-pedestrian crossing designs currently being used. Task two was a survey of traffic engineers and safety experts to obtain information on what was currently being used for school-pedestrian crossing designs, their concerns regarding school-pedestrian crossing devices at intersections, and ideas on possible alternative school-pedestrian crossing designs to be evaluated. Task three was a meeting of the project advisory committee made up of twelve Federal, State, and local traffic engineers to develop guidelines to be used in the evaluation and to select the five school-pedestrian crossing designs to be field tested. The five school-pedestrian crossing designs selected were:

- o Sign and Stop Sign
- o Flashing Yellow Signal and Flashing Red Beacon
- o Flashing Green Signal and Stop Sign
- o Signal and Stop Sign
- o Crossing Guard

Based on the analysis, the following general advantage and disadvantages of the five school-pedestrian crossing designs compared to full signalization were:

Advantages:

- o Increased pedestrian compliance to the pedestrian signal.
- o Reduction in the stop time per vehicle on the major street approach.
- o Reduction in installation costs.

Disadvantages:

- o Reduction in both pedestrians' and drivers' understanding of how the traffic control devices operate.
- o Increase in vehicle angle conflicts, but non-significantly.

Based on the comparison among the five school-pedestrian crossing designs, the crossing guard, signal and stop sign, and flashing green signal and stop sign were judged to have operating characteristics more desirable than those measured at the fully signalized control site.

**40. Liggett, Robin and Anastasia Loukaitou-Sideris, Hiroyuki Iseki. 2001. "The Bus Stop - Environment Connection. Do Characteristics of the Built Environment Correlate with Bus Stop Crime?" . Transportation Research Board.**

The author found that crime rates were higher for bus stops near alleys, multi-family housing, liquor stores and check cashing establishments, vacant buildings, and graffiti and litter. In contrast, good visibility of the bus stop from its surroundings and the existence of bus shelters contributed to lower crime rates.

The most important predictor of crime is the location. The presence of undesirable facilities and litter result in higher crime rates, while visibility and large numbers of pedestrians lead to lower crime rates. The presence or absence of certain characteristics at the microenvironment of the bus stop can impact crime. The appropriate design and layout of the physical environment can reduce opportunities for criminal actions.

**41. Gray, Judith. "TCRP A-15A Passenger Service Time Data Update" . Kittelson & Associates, Inc. Portland, Oregon.**

This is a presentation that includes definitions about Passenger Service Time and Dwell time and summarize research methodology. The key findings are:

- o Default values in the TCQSM and HCM underestimate passenger boarding and alighting times by approximately 35% and 85%, respectively.
- o Low floor buses consistently have shorter boarding and front door alighting times compared to high floor buses.
- o Data regarding impacts of automated fare collection are scarce.
- o Agency experience indicates that increased passenger service time caused by automated fare collection have not required schedule changes for bus service.

**42. Garder, Per, Lars Leden, and Urho Pulkkinen. 1998. "Measuring the Safety Effect of Raised Bicycle Crossings Using a New Research Methodology" . Transportation Research Record, no.1636.**

- o Bicyclists have a higher risk of injury along "conventional" bicycle paths(along collector roads and arterials) where junctions are delineated by painted white rectangles than they have if sharing the roadway with automobile traffic. [ A recent comprehensive analysis of "all" available studies indicates, on average, a 1 percent increase in the number of injured bicyclists as a result of constructing bicycle paths through intersections.]
- o Bicycle paths can be made reasonably safe if all bicycle crossings are raised and painted a bright color.

- o Low vehicle speeds are essential in complicated environments if bicyclists' safety is to be high.
- o The speed of bicyclists must also be kept relatively low in complicated environments.

**43. Virkler, Mark R. 1998. "Scramble and Crosswalk Signal Timing" .  
Transportation Research Record, no.1636.**

The results of the field study indicate that, for crossings with relatively high volumes, pedestrian platoon size has a measurable effect on the expected time for the platoon to enter the intersection and platoon crossing time.

**44. Beckwith, Dana M. and Katharine M. Hunter-Zaworski. 1998. "Passive Pedestrian Detection at Unsignalized Crossings" . Transportation Research Record, no.1636.**

It is anticipated that the safety of unsignalized pedestrian crossings can be facilitated by using passive pedestrian detection systems. The infrared and Doppler radar sensors that passed the preliminary testing discussed in this report have shown encouraging initial secondary test results. With further analysis of these sensors applied to various crossing applications, it is anticipated that they will help in providing safe crossings.

**LIST OF ADDITIONAL RESOURCES**

Malenfant, J.E.L., R. Van Houten, R.V. Hall, and G. Cahoon. "The Use of Public Posting, Prompting and Public Enforcement Procedures to Increase Driver Yielding and Pedestrian Signaling at Marked Crosswalks," *Journal of Police Science and Administration*. Volume 13, 1985

Van Houten, R. "The Effects of Advance Stop Lines and Sign Prompts on Pedestrian Safety in a Crosswalk on a Multilane Highway," *Journal of Applied Behavior Analysis*. Volume 21, 1988.

Don Mills Associates/PPS. 1981. "Pedestrian Corridors and Major Public Open Space: Design Guidelines" . City of Bellevue, Washington. (APA)

Levinson, Herbert S. 1986. "Streets for People and Transit," *Transportation Quarterly*, Volume 40, No 4. (APA)

Untermann, Ruckard K. 1984. "Accommodating the Pedestrian - Adapting Towns and Neighborhoods for Walking and Bicycling," Von Nostrand Reinhold Company.

Chellman, Chester E. 1989. "A Discussion of Street Geometry and Design Criteria for Traditional Neighborhood Development," Ossipee, NH: White Mountain Survey Co. Inc.

Multimodal Transportation: Development of a Performance-Based Planning Process (publication pending).

Development of a Computer Model for Multimodal, Multicriteria Transportation Investment Analysis (publication pending).

Sacramento California. 1990. "Transit Oriented Development Design Guideline" . Listed in "Multimodal Areawide Level of Service Measures" .

Ewing, Reid. 1997. "Transportation and Land Use Innovations: When You Can't Pave Your Way Out of Congestion" . Listed in "Multimodal Areawide Level of Service Measures" .

# CONCEPTUAL FRAMEWORK DEVELOPMENT



## TRANSIT INFRASTRUCTURE SURVEY

### Background

A bus stop amenity survey of RTS riders (Regional Transit System, City of Gainesville, Florida) was conducted April 19- April 23, 2001. The purpose of this survey was to gauge rider preferences for transit infrastructure in bus stop waiting areas. All 18 RTS fixed routes were targeted in order to ensure that the full spectrum of RTS riders was represented. The dates, times, and routes surveyed are summarized as follow:

April 19, 2001/ 10:00am-2:00pm	Routes 9, 12, 20, 35 (Student Routes)
April 20, 2001/ 10:00am-6:00pm	Routes 2, 6, 10, 11, 15, 24, 43 (Eastside & Sante Fe)
April 21, 2001/ 12:30pm-5:30pm	Routes 1, 5, 7, 75 (Mall, Butler Plaza shopping)
April 23, 2001/ 10:00am-12:00am	Routes 13,14,8 (Campus, Neighborhoods)

### Survey Purpose and Instrument Design

The survey instrument consisted of three sections, and was administered as an on-board survey. The first section asked riders to rate the importance of nine different bus stop transit infrastructure on a scale from 1 to 5, 1 being the least important and 5 being the most important. An “other” category was also provided to allow for respondents to enter in an amenity that was not listed. The second section asked riders to list the amenity(s) that they considered to be the most important to them. The final section asked riders how often they had used transit in the previous week.

### Survey Response

Surveys completed 500

**1. Rank these transit infrastructure on a scale of 1 to 5 being the most important:**

**1-a. Presence of a Shelter**

Out of the 500 surveys, 499 respondents answered this question.

The average value of this response was 4.1

**1-b. Presence of a Bench**

Out of the 500 surveys, 500 respondents answered this question.

The average value of this response was 4.2

**1-c. Informational Signage**

Out of the 500 surveys, 498 respondents answered this question.

The average value of this response was 4.0

**1-d. Adequacy of Waiting Area**

Out of the 500 surveys, 500 respondents answered this question.

The average value of this response was 3.5

**1-e. Lighting**

Out of the 500 surveys, 498 respondents answered this question.

The average value of this response was 3.6

**1-f. Bicycle Parking**

Out of the 500 surveys, 496 respondents answered this question.

The average value of this response was 2.6

**1-g. Trash receptacles**

Out of the 500 surveys, 499 respondents answered this question.

The average value of this response was 3.4

**1-h. Telephone**

Out of the 500 surveys, 498 respondents answered this question.

The average value of this response was 3.0

**1-i. Vending Machine**

Out of the 500 surveys, 496 respondents answered this question.

The average value of this response was 2.3

**1-j. Other responses (1= Newspaper; 2= Cleanliness of stops; 3= Queues at busy hubs; 4= Real-time bus information; 5= Water fountains; 6= Clocks).**

Out of the 500 surveys, 11 respondents answered this question.

5 respondents felt that there should be newspapers (1).

1 respondent was interested in the cleanliness of stops (2).

1 respondent felt there should be queues at busier hubs (3).

2 respondents were interested in real-time bus info at stops (4).

1 respondent would like to have water fountains at stops (5).

1 respondent would like to have clocks at the stops (6).

**1-k Other (Rating)**

Response 1 (Newspaper) was rated as 4.3 (3 of the 5 were rated).

Responses 2 & 3 (Cleanliness of stops & Queues at busy hubs) were not rated.

Response 4 (Real-time bus information) was rated as 4.0.

Response 5 (Water fountains) was rated as 4.0.

Response 6 (Clocks) was rated as 4.0.



**1. Which of these transit infrastructure is most important to you?**

- a. Shelter = 191 responses
- b. Bench = 160 responses
- c. Info. Signs = 99 responses
- d. Size of waiting area = 34 responses
- e. Lighting = 47 responses
- f. Bike parking = 5 responses
- g. Trash cans = 7 responses
- h. Telephone = 18 responses
- i. Vending machines = 12 responses
- j. Newspaper = 1 response

\*No Answer = 47 surveys

\*\* Total will be higher than 500 due to multiple responses.

**2. How many times in the last week have you taken transit?**

Once = 22 responses (4.4%)

2-4 Times = 107 responses (21.4%)

5 or more = 371 responses (74.2%)

▪ **Conclusions**

Several things were learned from this survey. Based on the rating scale, the presence of a shelter received the highest score, followed by the presence of a bench, information signs, lighting, adequacy of waiting area, trash receptacles, telephones, bicycle parking, and lastly vending machines. Based on the question about importance, the presence of the shelter received the most votes, followed by the presence of a bench, information signs, lighting, adequacy of waiting area, telephone, vending machines, trash cans, bicycle parking, and lastly, newspapers. Almost 75% of the riders surveyed ride RTS 5 or more times a week. About 22% of the respondents ride 2-4 times per week, and about 5% ride only once per week.



## Bus Stop Amenity Survey

**We are interested in your opinion about bus stop waiting areas. Please rank on a scale of 1 (least important) to 5 (most important) the following things:**

	<i>(circle one)</i>				
	<u>Least Important</u>				<u>Most Important</u>
a) Presence of a Shelter	1	2	3	4	5
b) Presence of a Bench	1	2	3	4	5
c) Informational signage (schedules and destinations)	1	2	3	4	5
d) Adequacy of waiting area (Is there enough space?)	1	2	3	4	5
e) Lighting	1	2	3	4	5
f) Bicycle Parking	1	2	3	4	5
g) Trash receptacles	1	2	3	4	5
h) Telephone	1	2	3	4	5
i) Vending machine	1	2	3	4	5
j) Other <i>(please specify)</i> : _____	1	2	3	4	5
_____					
_____					

Which of these is the most important to you if you are waiting at a bus stop? \_\_\_\_\_  
(a, b, c, etc)

How many times in the last week have you taken transit? *(check one)*

- Once                      2-4 times                      5 or more times

*The Multimodal Level of Service Project*  
*Florida Traffic and Bicycle Safety Education Program - University of Florida*  
**PO Box 115706, Gainesville, FL 32611 - 392**

## TRANSIT CONCEPTUAL FRAMEWORK

### Considerations For FDOT Transit “Point” Quality Of Service Assessment

(Authors: John Karachepone and Alan Danaher, Kittelson & Associates, Inc.,  
Transportation Planning/Traffic Engineering, 110 E. Broward Boulevard, Suite 2410, Ft.  
Lauderdale, FL)

The Transit Capacity and Quality of Service Manual (TCQSM) is the nationally accepted source for transit capacity and quality of service principles, practices and procedures. This document forms the basis for all transit-related measures of quality of service used in Florida. Transit quality of service concepts excerpted from the TCQSM and the transit chapters of HCM 2000 are first presented here. Some options for consideration for transit stop (point) quality of service evaluation are then discussed and finally, a conceptual framework “model” that can be tested through research in a future project, is presented.

### Transit Quality Of Service Concepts

#### DEFINITIONS

Quality of service related to transit reflects the passenger’s perception of transit performance. It measures both the availability of transit service and its comfort and convenience. Quality of service depends to a great extent on the operating decisions made by a transit system, especially decisions on where transit service should be provided, how often and how long transit service should be provided, and what kind of service should be provided.

The following definitions of transit performance measures, transit quality of service, service measures, and levels of service are provided in the TCQSM:

- **Transit Performance Measure.** A quantitative or qualitative factor used to evaluate a particular aspect of transit service.
- **Transit Quality of Service.** The overall measured or perceived performance of transit service from the *passenger’s* point of view.
- **Transit Service Measure.** A quantitative performance measure that best describes a particular aspect of transit service *and* represents the passenger’s point of view. Also known as a *measure of effectiveness*.
- **Levels of Service.** Six designated ranges of values for a particular service measure, graded from “A” (best) to “F” (worst) based on a transit passenger’s perception of a particular aspect of transit service.

The primary differences between performance measures and service measures are the following:

1. Service measures must represent the passenger’s point of view, while performance measures can reflect any number of points of view.
2. In order to be useful to users, service measures should be relatively easy to

measure and interpret. It is recognized, however, that system-wide measures will of necessity be more complex than transit stop or route segment measures.

3. Level of service (LOS) grades are developed only for service measures. However, transit operators are free to develop LOS grades for other performance measures, if those measures would be more appropriate for particular applications.

The TCQSM divides quality of service measures into two main categories: “availability” and “comfort and convenience”. The availability measures address the spatial and temporal availability of transit service. If transit is located too far from a potential user or if it does not run at the times a user requires the service, that user would not consider transit service to be available and thus the quality of service would be poor. Assuming, however, that transit service is available, the quality measures can be used to evaluate a user’s perception of the comfort and convenience of their transit experience.

The TCQSM provides for analysis of different elements of transit. The three elements considered are the transit stop, the transit route segment, and the transit system. Combining the two performance measure categories ( “availability” and “comfort and convenience” ) with the three transit elements produces the matrix shown in Table 1. Service measures are denoted in CAPITAL LETTERS and have corresponding levels of service in the TCQSM. Other performance measures shown are discussed, but do not have levels of service associated with them.

**Table 1: Transit Quality of Service Framework in TCQSM**

Category	Service & Performance Measures		
	Transit Stop	Route Segment	System
Availability	FREQUENCY accessibility passenger loads	HOURS OF SERVICE accessibility	SERVICE COVERAGE % person-minutes served indexes
Comfort and Convenience	PASSENGER LOADS amenities reliability	RELIABILITY travel speed transit/auto travel time	TRANSIT/AUTO TRAVEL TIME travel time safety

Source: TCQSM, TCRP 1999

Some measures appear in more than one cell of the table, but only one service measure is assigned to each cell, representing the performance measure that best represents the passenger’s point of view of availability or convenience for a particular transit element. In many cases, though, it may be helpful to combine the service measures into a kind of transit “report card” that compares several different aspects of transit service at once.

### “Point” Measures in the Transit Capacity and Quality of Service Manual

The transit quality of service framework (Table 1) in the Transit Capacity and Quality of Service Manual (TCQSM) identifies two service measures for transit stops, or “points”, one each related to availability and comfort and convenience:

- o Availability - service frequency.

- Comfort and convenience – passenger loading.

**Availability**

The spatial aspect of transit availability at a transit stop is a given, since the stop exists. During a typical hour-long analysis period, hours of service is also a given—either transit service exists or it does not. Therefore, *frequency* is chosen as the service measure for this category. The service frequency level of service thresholds for urban scheduled transit service are presented in Table 2.

Under availability, accessibility and passenger loading are identified in the framework as added performance measures. Although not so easy to quantify, transit stop *accessibility* by foot, bicycle, or automobile is also an important measure of transit availability, and persons with disabilities require special consideration. *Passenger loads* determine whether there is room on a transit vehicle for additional passengers to board, which is yet another aspect of transit availability.

**Table 2: Service Frequency LOS: Urban Scheduled Transit Service**

LOS	Headway (min)	Veh/h	Comments
A	<10	>6	Passengers don't need schedules
B	10-14	5-6	Frequent service, passengers consult schedules
C	15-20	3-4	Maximum desirable time to wait if bus/train missed
D	21-30	2	Service unattractive to choice riders
E	31-60	1	Service available during hour
F	>60	<1	Service unattractive to all riders

Source: TCQSM, TCRP 1999

**Comfort and Convenience at Transit Stops**

Whether or not one can find a seat on a transit vehicle is an important measure of transit quality. *Passenger loads*, the selected service measure in the TCQSM, also influences boarding and alighting times, which in turn affect total dwell time and the capacity of transit routes. The passenger loading level of service thresholds are presented in Table 3.

**Table 3: Passenger Loading LOS**

LOS	Bus		Rail		Comments
	M <sup>2</sup> /pass.	Pass/seat*	M <sup>2</sup> /pass.	Pass/seat*	
A	>1.20	0.00-0.50	>1.85	0.00-0.50	No passenger need sit next to another
B	0.80-1.19	0.51-0.75	1.30-1.85	0.51-0.75	Passengers can choose where to sit
C	0.60-0.79	0.76-1.00	0.95-1.29	0.76-1.00	All passengers can sit
D	0.50-0.59	1.01-1.25	0.50-0.94	1.01-2.00	Comfortable loading for design
E	0.40-0.49	1.26-1.50	0.30-0.49	2.01-3.00	Maximum schedule load
F	<0.40	>1.50	<0.30	>3.00	Crush loads

\*approximate

Source: TCQSM, TCRP 1999

Under comfort and convenience, amenities and reliability are identified as added performance measures. Amenities relate to features at the transit stop and on-board the vehicle to increase comfort and convenience, such as shelters, benches, informational signing, trash receptacles, vending machines, and air conditioning/heating on-board the transit vehicles. The kinds of *amenities* provided at transit stops is not a service measure in the TCQSM because it is so highly dependent on the daily boarding passenger volumes at a given stop: achieving better levels of service would require installing facilities that might not be justified economically. *Reliability* is an added measure of quality of service at a transit stop, but this measure also applies to a transit route and will tend to have consistent values for a series of stops along a route segment.

### Options For FDOT's "Point" Transit Qos Analysis

The transit route segment quality of service measure adopted by FDOT focuses on service availability. It considers both service frequency and hours of service, and then is modified to reflect a pedestrian accessibility factor (addressing pedestrian quality of service, the presence of any "obstruction" between an adjacent sidewalk and bus stop, and pedestrian crossing difficulty along the street that the bus route operates). At the segment level, FDOT has chosen service availability as the prime determinant of transit quality of service. Thus a specific comfort and convenience measure was not identified, though the TCQSM identifies reliability as a second service measure for transit route segments. Pedestrian accessibility was identified as a component of the service measure, even though it is only identified as a performance measure for transit segments in the TCQSM.

A building block approach to go from "point" analysis, to segment and corridor analysis, and finally to system analysis may have some benefits from an

understandability viewpoint. As such it would seem that a “point” quality of service measure for transit should be a subset of the segment measure. The most logical “point” measure under this structure would be to weigh service frequency with the pedestrian accessibility factor under the same construct as for the segment analysis, discounting hours of service that is a segment service measure in both FDOT’s procedure as well as the transit quality of service framework in the TCQSM.

All of the performance measures identified and listed in the TCQSM for the transit stop (table) were considered for inclusion in FDOT’s transit point quality of service assessment procedure as follows:

### The Primary Measure – Service Frequency

The TCQSM identifies service frequency as the service measure for service availability at a transit stop. Additionally, FDOT has adopted service frequency as the primary component of transit level of service at the route segment level. The adoption of service frequency as a level of service component at the Point level (transit stop) is consistent with national practice as documented in the TCQSM and with FDOT practice. Level of service thresholds for service frequency is available in the TCQSM and is presented in Table 2.

### Consideration of Pedestrian Accessibility

Access to transit is most commonly accomplished as a pedestrian. The quality of pedestrian access to a transit stop is therefore a major factor in transit user perception of quality of transit service. The importance of pedestrian access was also recognized in FDOT’s route segment quality of service procedure. Pedestrian access to transit stops can be described by four separate factors:



1. The presence of a sidewalk at the transit stop.
2. Obstacles between the nearest sidewalk, the waiting area and the boarding/alighting area.
3. Ease of crossing the street.
4. Pedestrian connectivity to origins and destinations.

### ***Presence of a Sidewalk at the Transit Stop***

The presence of a sidewalk at the transit stop provides transit riders a pedestrian route for access to transit. The absence of a sidewalk degrades transit quality of service.

### ***Obstacles Between the Nearest Sidewalk, Waiting and Boarding/Alighting Area***

Under the most favorable conditions, a transit stop would be provided with ADA accessible conditions between the nearest sidewalk, the waiting area and the boarding/alighting point. In other cases, the requirements of ADA access may not be strictly met, but access may be “functional”. “Functional” access implies that most persons (including those with disabilities) would be comfortable in the access provided to the transit stop but all requirements for ADA access may not be present. A non-functional pedestrian access is one where there is some obstacle between the sidewalk and waiting area or between the waiting area and the boarding/alighting area. Such an obstacle could be a drainage swale with no paved connection to bridge across it, or a fence or wall. Access to the transit stop would be less than satisfactory to most transit users. A non-functional pedestrian access would be unacceptable for children, elderly and for persons with disabilities.

### ***Ease of Crossing the Street***

The measure of pedestrian accessibility should reflect an aspect of accessibility important to all passengers boarding or alighting at a transit stop — the ease of crossing the street with transit service. Passengers boarding or alighting at a bus stop may need to cross the arterial street at some point during their round trip, their ease of crossing the street is therefore an important factor. Traffic volumes partially influence the degree of difficulty of crossing streets, but the width of the street and the type of pedestrian crossing control provided also play a role. The proposed FDOT pedestrian crossing LOS measure (Mid-block and Point) is expected to account for the ease of crossing streets.

### ***Origin/Destination Connectivity***

In a residential area, most passengers will arrive at transit stops from side streets, rather than from along the arterial itself. In other areas transit user destinations can be along cross-streets or at locations perpendicular to the arterial street with the transit service. The availability of pedestrian connections between the origin/destination of transit users and the transit boarding/alighting point is an important factor in the transit point quality of service assessment procedure. One way of assessing pedestrian connections to origins and destinations would be to check for the presence of sidewalks on cross streets within one-eighth of a mile from the transit stop.



## Consideration of Passenger Loading

It is proposed that a passenger loading measure be incorporated into the “point” analysis procedure, to be consistent with the transit quality of service framework in the TCQSM. There are two options in how this could be accomplished:

1. Evaluate passenger loading separate from the modified service frequency measure, thus having two service measures. The passenger loading level of service thresholds in the TCQSM would be applied.
2. Develop a passenger loading adjustment factor to be applied to the service frequency measure, thus having a single measure. The most logical passenger loading adjustment factor to be applied would be the load factor, with different factors identified for bus vs. rail. Again the load factor level of service thresholds in the TCQSM would be applied.

The effects of loading on transit availability could be incorporated into a single service measure by reducing the transit vehicle arrival frequency to reflect any transit vehicles that are regularly full when they reach a particular stop. As an example, if three buses an hour serve a stop but you can only get on two of them, then the effective service frequency is two buses per hour.

An alternative way would be to calculate available seats per hour (at the transit stop) as the service measure.

## Consideration of Transit Infrastructure at Stops

Provision of infrastructure at transit stops (serving as passenger amenities) could be treated as a transit performance measure, with a weighing system developed based on the type and extent of infrastructure to be provided. The primary infrastructure of benefit to the transit passenger at a transit stop, in our opinion, include a shelter, bench, route information, adequate passenger landing area at the stop, and lighting; with a trash receptacle, telephone, bicycle racks, vending machines, and landscaping of lesser importance. Specific weights for different types of infrastructure could be developed based on their importance. It should be noted that the kinds of infrastructure provided at transit stops are usually a matter of agency policy and is usually related to the number of boarding passengers that would benefit from a particular type of infrastructure.

## Consideration of Reliability

Reliability is the service measure identified for the Route Segment element of transit quality of service in the Comfort and Convenience category in the TCQSM. This is because reliability, as a service measure, tends not to vary greatly between adjacent stops. Reliability is measured and described as a percentage of “On-Time Performance” for fixed-route scheduled transit service with headways greater than 10 minutes and by “Headway Adherence” as measured by the coefficient of variation for fixed-route

scheduled bus service with headways equal to or less than 10 minutes. On-time performance evaluation at a given transit stop will require adequate sampling to provide a statistically valid sample at that transit stop. This requirement is also true for consideration of passenger loading. Coefficient of variation is a statistical measure that is difficult to visualize.

### **Conceptual Framework for FDOT Transit Point Quality of Service Measure**

Based on the considerations discussed previously, the conceptual framework for a transit “point” quality of service assessment procedure could be as follows:

Transit Stop QOS = Primary function of service frequency; and secondarily a function of passenger loading, pedestrian access conditions, infrastructure (commensurate with need and number of boarding passengers), and reliability.

At this time, it is recommended that reliability is not included in the planning level analysis, due to the high level of data collection required to obtain a statistically significant sample of transit vehicle arrival times or headways to conduct a meaningful assessment. The list of components to the point quality of service measure for transit stops at a planning level of analysis would then be as follows:

1. Service Frequency (primary service measure)  
Number of transit vehicles per hour serving the transit stop
2. Pedestrian Accessibility
  - a. Facility crossing ability/LOS  
LOS score A through F based on pedestrian mid-block or intersection crossing LOS assessment
  - b. Presence of sidewalk at the transit stop
  - c. Connection between nearest sidewalk and waiting and boarding area  
ADA accessible, functional connection OR non-functional
  - d. Origin/destination connectivity  
Good, fair or poor.
3. Passenger Loading (will the user get a seat on the transit vehicle OR be able to board it?).  
Can all boarding passengers board the transit vehicle and find seats OR  
All passengers can board the transit vehicle but some may have to stand OR  
Some or all riders must wait for next transit vehicle.
4. Amenities/Infrastructure
  - a. Special Bus-Stop Information (Information signage)  
Relevant as part of the service measure regardless of number of boarding passengers.
  - b. Presence of Shelter

- Relevant as part of the service measure if there are more than 50 boarding passengers per day.
- c. Presence of Bench  
Relevant as part of the service measure if there are more than 25 passengers per day.
- d. Adequately Sized Waiting Area  
Relevant as part of the service measure if there are more than 10 passengers per peak hour.
- e. Lighting  
Relevant as part of the service measure if span of service is greater than 12 hours per day.

The average number of boarding passengers during the analysis time period should be reported. Similarly the span of service provided at the transit stop should be reported.

An example of a worksheet that can be used at any transit stop to gather information required to evaluate transit “point” quality of service is provided in Table 4. A possible quality of service assessment procedure for transit stops based on the information collected above is presented in Table 5. The reader is cautioned that the impact of each of the factors is estimated at this time and should be tested through research. Survey techniques that could serve to test/calibrate the impact of each factor include a transit operator survey, a transit user/patron survey, a stated preference survey, and a review of video logs.

Stated preference surveys, if used, must be interpreted with caution since they are not “user” surveys and may incorporate the influence of factors that do not affect actual behavior. Persons with limited familiarity with transit, when asked about transit user issues, may use cues contained in the context of the question to decide how to state their preferences. The first time many individuals (if they are not transit patrons) have considered or heard about transit issues could be when the survey question is asked and they could respond in a way that may not reflect actual behavior.

Note: At the May 17, 2001 Multimodal Level of Service Steering Team meeting, there was a lot of discussion as to the merits of including transit stop infrastructure as part of the FDOT transit “point” service measure or as a separate performance measure. There is certainly the option of developing a weighed average of the different special infrastructure items at a transit stop and assessing this as a separate measure pending a final decision on how infrastructure is to be addressed in the transit “point” quality of service assessment.



**Table 4: Example of a Worksheet that Can be Used for Bus Stop Data Collection for Quality of Service**

**Point Quality of Service**

**Evaluation of Bus Stops  
Conceptual Planning Level Analysis**

Bus Stop Location:  
 Nearest cross-street/intersection:  
 Direction of travel: NB, SB, EB or WB Route Direction of travel  
 Hour of Observation: (Afternoon peak hour, mid-day peak hour, etc.)

Bus Routes serving Bus Stop:

Service Frequency: Buses per hour

Passenger Loading:

Observations	All boarding passengers can find seats	All passengers can board	Some or all riders must wait for next bus.
Sample 1			
Sample 2			
Sample 3			
Sample 4			
Sample 5			
Sample 6			
Total			

Number of boarding passengers:

Observations	
Sample 1	
Sample 2	
Sample 3	
Sample 4	
Sample 5	
Sample 6	
Average/hour	

Bus Stop Access:

1 Facility crossing LOS	A through F
2 Presence of Sidewalk at the Bus Stop	Yes or No
3 Obstacles between nearest sidewalk and waiting and boarding area	ADA accessible, Functional, Not-functional
4 Origin/destination connectivity (Presence of sidewalks on cross-streets within 1/8 mile of Bus stop)	Good, Fair or Poor

Infrastructure:

Bus Route Information Signage: Real-time schedules, Bus route and schedule/map, Bus Routes identified, sign only

**Table 5: Example of Transit Point Quality of Service Identification**

**Point Quality of Service**

**Evaluation of Transit Stops  
Conceptual Planning Level Analysis**

**Passenger Loading Impact**

Service frequency will decrease by the number of buses that could not be boarded (if any/some riders must wait for next bus).  
 If all boarding passengers can find a seat to sit on, then adjustment = 1.0  
 If some boarding passengers must stand, then adjustment = 0.90

**Bus Stop Pedestrian Access Adjustments**

Facility crossing LOS		Adjustment for sidewalk at the Bus Stop		Adjustment for origin/destination pedestrian connectivity
LOS A	1.15	Yes	1.05	
LOS B	1.10	No	0.90	
LOS C	1.05			Good 1.10
LOS D	1.00	Adjustment for obstacles to loading area		Fair 1.00
LOS E	0.85	ADA accessible	1.10	Poor 0.85
LOS F	0.55	Functional	1.00	
		Not-Functional	0.85	

**Impact of Infrastructure**

Special Bus Route Information Signage				
Real-time		Yes = 1.10		
Route/Schedule Map		Yes = 1.05		
Route No. Identified		Yes = 1.00	No = 0.95	
Presence of Shelter		Yes = 1.10	No = 0.9	Applicable only if boarding passengers equal to or > 50 per day
Presence of Bench		Yes = 1.05	No = 0.9	Applicable only if boarding passengers equal to or > 25 per day
Adequately sized waiting area		Yes = 1.00	No = 0.9	Applicable only if boarding pass. equal to or > 10 per peak hr.
Lighting		Yes = 1.00	No = 0.9	Applicable only if span of service is 12 or more hours

**After above adjustments, service frequency will be compared to TCQSM thresholds (Table 2) to determine LOS at Transit Stop**

**BICYCLING CONCEPTUAL FRAMEWORK** (Author: Bruce Landis, Sprinkle Consulting, Inc., Tampa, Florida)

Intersections are among the most complex features of the transportation system; in many cases, they represent the most formidable portion of bicyclists' and pedestrians' travel route. The accurate modeling of these transportation features will enable transportation planners and engineers to assess actual travel conditions, hence the performance of a roadway facility, and will also provide insight as to how to design intersections that better, and more safety, accommodate bicyclists and pedestrians.

**BICYCLING CONDITIONS – THE CONCEPTUAL FRAMEWORK FOR MODELING**

Similar to modeling intersections' performance in accommodating motor vehicles, it is anticipated that there are three distinct movements for each intersection approach that must be simulated. These movements are:

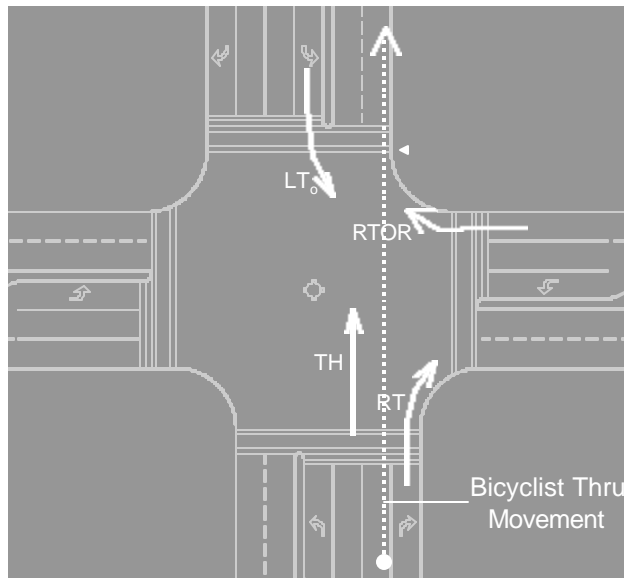
- The left turn movement(s) - including the “upstream” approach weave, and the “downstream” restorative weave
- The through movement
- The right turn movement

These movements, for each of the intersection' s approaches, combine to provide a true picture of an intersection' s performance, or level of service, to bicyclists. The through movement is considered the first candidate movement to be modeled; the approach is outlined in the following sections.

**Modeling the *Through* Bicycle Movement**

The bicyclist' s movement through an intersection, hence the intersection' s level of service to the bicyclist, can be described by the conflicts, exposure and delay experienced by the bicyclist. Referring to Figure 1 below, as the bicyclist travels along the primary facility and through an intersection, he experiences *conflicts* with various motor vehicle turning movements, their number, volume, and speed of which is believed to affect his perception of safety and comfort. The intersection' s g/C ratio may also modify the level of these conflicts experienced by the bicyclist.

The bicyclist' s *exposure* to conflicts with motor vehicle traffic is also believed to affect his level of service. For example, the amount of open intersection crossing distance and, in the case of a signalized intersection, the clearance interval could likely be the factors that describe the bicyclist' s *exposure* to motor vehicle traffic conflicts. It is likely that the impact of these factors, conflicts and exposure, on the bicyclist' s perception is affected by the geometry of outside lane. Thus, there may be several cases for the various approach geometries. Finally, the intersection control *delay* experienced by the bicyclist is considered a principal aspect of the intersection' s level of service. It may be affected by outside lane geometry.



**FIGURE 1.** Potential motor vehicle-bicyclist conflicts of the bicycle thru movement at a signalized intersection

Outlined below is believed to be these three principal aspects, and their *primary* factors, of a signalized intersection's level of service to a bicyclist's through movement.

**Conflicts:**

RT (Right Turns) - modified by the approach geometry and the facility's (major street's) operating speed and curb radius

TH (Through movement)

LT<sub>o</sub> (opposing Left Turn; in the case of a signalized intersection, this factor may be modified by signal phase – permitted and/or protected plus sneakers)

RTOR (right turn on red from side street) or RT<sub>s</sub> (side street Right Turns, in the case of an unsignalized intersection)

Note: The g/C ratio (green to cycle length ratio for signalized intersections) may modify the above conflict factors as may truck volume percentages

**Exposure:**

Crossing Distance (cross-street width plus two times the intersection radii) – possibly modified by pavement condition

Presence of Exclusive Motor Vehicle RT lane (modified by type of outside lane approach geometry)

Clearance Interval (possibly modified by loop detection for bicyclists)

**Delay:**

For signalized intersections:

Control delay – similar to that for motor vehicles, it is a function of the facility's  $g/C$ ; however, it may be modified by a function of outside lane width and/or configuration.

For unsignalized intersections:

Crossing delay – In this case it is assumed that the facility is the major street as defined in the *Highway Capacity Manual*, thus there should be minimal delay for the through movement in unsignalized conditions. However, as bicyclists are frequently undetected by motorists, there may in fact be some delay experienced by bicyclists. If this is the case, it is anticipated that this delay would be a function of  $T_{fs}$  (through movement volume from the far side cross-street) plus  $LT_s + TH_s + RT_s$  (the approach traffic of the near side cross-street – see Figure 2) plus  $RT_o$  and  $LT_o$ .

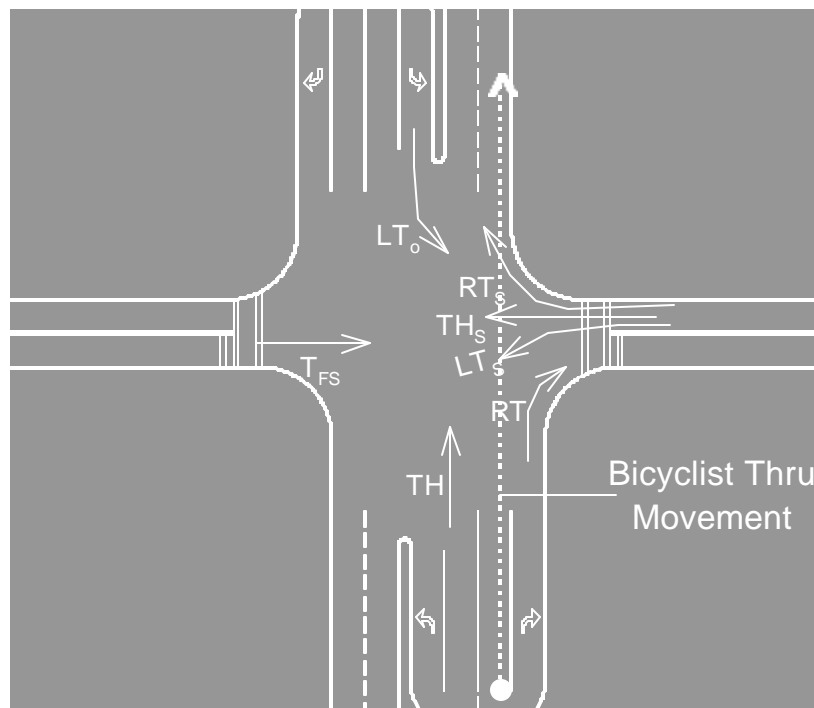


FIGURE 2. Potential motor vehicle-bicyclist conflicts for bicycle thru movement at an *un-signalized* intersection

The following “process of evaluation” outlines the anticipated approach to modeling what is believed to be the least complex intersection movement by bicyclists – that of the through movement. Modeling this movement first is recommended not only for its relative simplicity, but also because for an individual *roadway facility*, it would be the more important of the intersection movements factoring into the *facility's* level of service. Furthermore, the calibration of this movement's LOS model would serve as a baseline for the development of the other movements' LOS. This “process of evaluation” is anticipated to result in a statistically-reliable model for the *operational* level of service analysis. (See next section: Evaluative Methodology, for bicycle through movement, P49)



<b>Statistics of Bicyclist Observed Crossing Intersections</b>			
<b>No.</b>	<b>Intersections</b>	<b>On Roads</b>	<b>On Sidewalks or Crosswalks</b>
1	39th Ave. & 43rd St.	2	
2	34th St. & 16th Ave.		2
3	34th St. & SW 2nd Ave.		3
4	Univ. Ave. & 13th St.	1	7
5	Univ. Ave. & NW 17 St.	2	3
6	Stadium Rd. & North South Dr.	3	1
7	Museum Rd. & North South Dr.	8	2
8	Museum Rd. & 13th St.	9	5
9	SW 13 th St. & SW 16 Ave.		
	<b>TOTAL</b>	<b>25</b>	<b>23</b>

Nine Intersections in Gainesville Florida were videotaped for bicycle & pedestrian LOS analysis by the team of experts. The chart above indicates of the bicyclists observed crossing the intersection, the number crossing in the roadway vs. the number utilizing sidewalks, curb cuts & crosswalks.



**PEDESTRIAN CONCEPTUAL FRAMEWORK** (Author: Bruce Landis, Sprinkle Consulting, Inc., Tampa, Florida)

**CONCEPTUAL FRAMEWORK FOR MODELING THE THROUGH (SIDE STREET CROSSING) PEDESTRIAN MOVEMENT**

Similar to modeling intersections' performance in accommodating motor vehicles, it is anticipated that there are two general pedestrian movements for each intersection approach that must be simulated. These movements are:

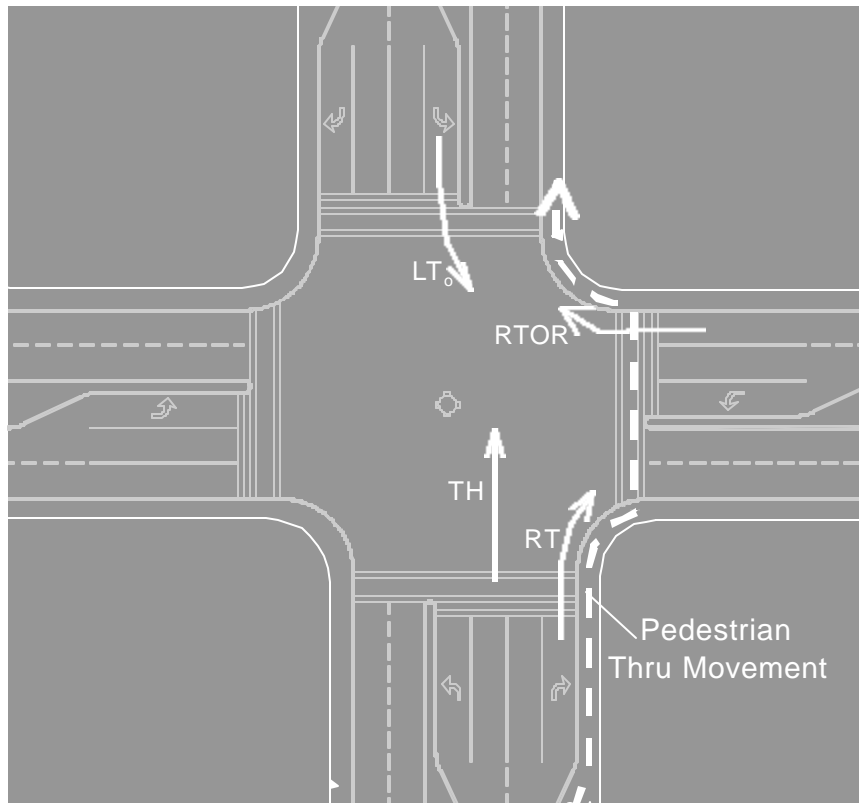
- The side street crossing movement
- The major street crossing movement

These movements, for each of the intersection' s approaches, combine to provide a true picture of an intersection' s performance, or level of service, to pedestrians.

**Modeling the *Through* Pedestrian Movement**

The pedestrian' s movement through an intersection, hence the intersection' s level of service to the pedestrian, can be described by the conflicts, exposure and delay experienced by the pedestrian. Referring to Figure 1 below, as the pedestrian walks along the primary facility and travels through an intersection, he experiences *conflicts* with various motor vehicle turning movements, the number, volume, and speed of which is believed to affect the pedestrian' s perception of safety and comfort. Likewise, the pedestrian' s *exposure* to conflicts with motor vehicle traffic is believed to affect his level of service. For example, the unprotected crossing distance and the presence of a crosswalk (and potentially it' s marking style) could likely be the factors that describe the pedestrian' s exposure to motor vehicle traffic conflicts. Finally, the intersection crossing *delay* experienced by the pedestrian is considered a principal aspect of the intersection' s level of service to the pedestrian. Outlined below is believed to be these three principal aspects, and their *primary* factors, of a signalized intersection' s level of service to a pedestrian' s through movement.





*FIGURE 1. Potential motor vehicle-pedestrian conflicts for pedestrian thru movement at a signalized intersection*

**Conflicts:**

RT (Right Turns) - modified by the facility's (major street's) operating speed and curb radius and heavy vehicles (i.e., trucks - combination vehicles, in particular)

TH (Through movement) - modified by a function of the cross-walk's setback from the traffic stream

LT<sub>o</sub> (opposing Left Turn; in the case of a signalized intersection, this factor would be modified by signal phase – permitted and/or protected plus sneakers)

RTOR (right turn on red from side street) or RT<sub>s</sub> (side street Right Turns, in the case of an unsignalized intersection – see Figure 2). Possibly modified by the percentage of heavy vehicles (for the opposing pedestrian direction).

**Exposure:**

Crossing Distance (cross-street width plus a portion of the intersection radii)

Presence of Crosswalk - modified by type of markings

Presence of Curb and/or Sidewalk (at waiting/landing areas)

Median Type

**Delay:**

For signalized intersections:

Pedestrian's crossing delay - a function of cycle length for crossings *with* a pedestrian signal; a function of the facility's  $g/C$  for crossings *without* a pedestrian signal.

For unsignalized intersections:

Pedestrian's crossing delay - a function of  $T_{fs}$  (through movement volume from the far side cross-street) plus  $LT_s + TH_s + RT_s$  (the approach traffic of the near side cross-street - see Figure 2). The pedestrian's delay may possibly be modified by the facility's (major street's) platooning plus ( $RT$  and  $LT_o$ )

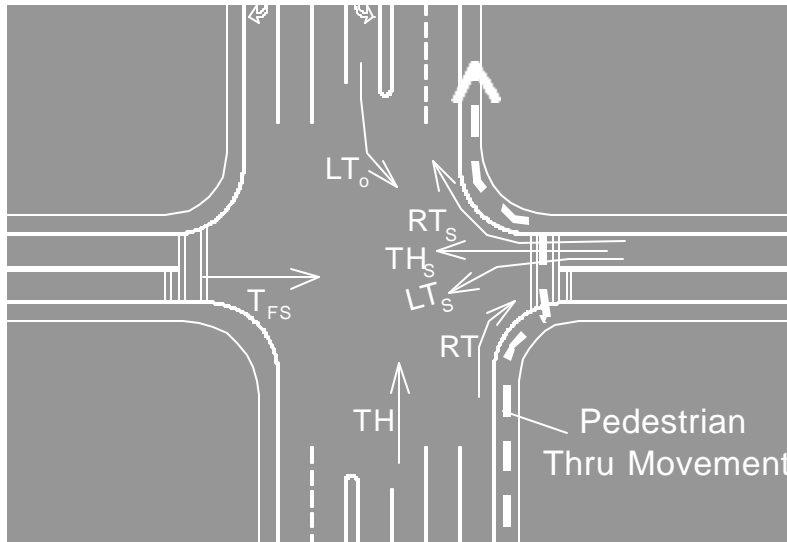


FIGURE 2. Potential motor vehicle-pedestrian conflicts for pedestrian thru movement at an *un-signalized* minor street intersection

The following “process of evaluation” outlines the anticipated approach to modeling the side street-crossing maneuver. Modeling this movement first is recommended because for an individual *roadway facility*, it would be the more important of the intersection movements factoring into the *facility's* level of service. Furthermore, the calibration of this movement's LOS model would serve as a baseline for the development of the other movement's LOS. This “process of evaluation” is anticipated to result in a statistically reliable model for the *operational* level of service analysis. (See next section for model development tasks for pedestrian intersection crossing, P50)

## EVALUATIVE METHODOLOGY FOR FRAMEWORK

The Point LOS steering committee discussed a number of evaluative methodologies to be considered in formalizing the “conceptual framework” for the transit, pedestrian, and bicycle (through movement) point level of service. The Steering Committee also raised concerns over the variability of the traffic conditions during an intersection cycle. It could pose problems for an actual crossing analysis. Dr. Chu recommended a cycle length evaluation period by the participants much as was done with the midblock crossing project.

Regarding transit, Alan Danaher provided background on the TCQSM and future editions. The document will not be recommending that transit stop “amenities” be included as the service measure at the point level and that frequency would continue to be the service measure, with “transit amenities or infrastructure” and load factor being performance measures. It was agreed upon that the term “amenities” be replaced by “infrastructure” . Though consensus wasn’ t reached, the majority of participants felt that infrastructure (transit amenities) should be part of the performance measure for transit at the point level.

### PEDESTRIAN AND BICYCLE “POINT LOS” AT INTERSECTIONS

The optimal technique for pedestrian and bicycle through movements would involve the model calibration method previously used with segment analysis for both the bicycle and pedestrian LOS models. These type “bike or walk for science” methods employed a group of volunteer participants who actually walked (or bicycle) a course laid out with various measurable attributes, allowing for the calibration of a model depicting quality or level of service to the user. To replicate this technique, a similar procedure would be used, soliciting volunteer participants to rate comfort level of intersection crossing by pedestrians and bicyclists. (See detailed outline at end of this section.)

There are alternative methods for evaluation. While they may not be suitable for calibration of operational level, these alternatives are suitable for intersection LOS models at the planning level. They may also work for a generalized level.



A second method for evaluating intersections (both signalized and unsignalized) would involve the use of a rating scale\* of various measures affecting the intersection (included in the conflicts, exposure,&delay formulaes) that would be used by a group of volunteers. These volunteers would observe from various corners of a series of intersections and rate the “performance” of the intersection as it relates to pedestrian crossing or bicycle through movement. (This is similar to the technique used by CUTR in the “mid-block pedestrian LOS evaluation research). (\*See draft Intersection Rating Form for Pedestrians)

A third method employs the above rating technique but the observer watches a videotape of the various types of intersections as pedestrians or bicyclists are negotiating through it. and then rates the intersection accordingly. (An example of this technique was used by the Point LOS steering committee for 7 intersections in Gainesville, Fla. during the confirmation of the selected measures for evaluation.)

Finally, the second and third methods could be combined where the participant group (some transportation “experts” and some lay citizens) would first observe selected intersections and then return to a room to watch videotaping of all the various intersections to be rated. That way a “frame of reference” is established among the participants and the actual “feel” of the intersection with certain amounts of traffic volumes, speeds, turning movements etc. can be experienced before watching the series of intersections videotaped for the purpose of evaluation.

The author feels that the first method would be preferable for more accuracy in model calibration. However, it may not be possible to carry out this methodology because of various constraints on the use of human subjects (concern for safety and liability). In that event, the other methods could be employed and yield significant information relating to the purpose of the research, to assess the level of service from the users perspective at the point (intersection crossing) level.

(See list of site characteristics in the next section for both signalized and non-signalized intersections to be evaluated for Pedestrian and Bicycle LOS.)

### **TRANSIT “POINT” LOS – EVALUATION OF THE TRANSIT STOP (INCLUDING TRANSFERS)**

As part of this research, an “on board survey” was developed and tested to rate the importance of various bus stop transit infrastructure (see previous section on transit conceptual framework). This survey form coupled with questions relating to the other service measures (frequency, passenger loading, and accessibility) forms the basis for an evaluative methodology regarding transit stops.

Two survey groups would be involved in testing the “conceptual framework” outlined in previous sections: the transit agency (operators) and the bus riders (users). Additionally, focus sessions with a type of “visual preference” rating scale could also

be employed for both these groups to test the “weighting” of various factors or measures identified at the point level.

(See list of site characteristics of bus stops in the next section for the transit Point LOS evaluation)

## **ANTICIPATED MODEL DEVELOPMENT TASKS FOR BICYCLE THROUGH MOVEMENT**

1. Convene Expert / Advisory Committee for the model calibration study kick-off meeting; refine initial (conceptual) LOS methodologies (left turn – including the “upstream” approach weave, and the “downstream” restorative weave, through, and right turn movements) and data format from previous research (Point LOS Study). Create and/or refine the long list of potential study (calibration) sites (roadway facilities) for calibrating the through (and ultimately, all of the) movement(s). The sites shall be representative of Florida metropolitan roadway facilities. The final course location is anticipated to be within the Orlando metropolitan area.

2. Design the data collection *procedure* to obtain real-time response/observations for the model calibration. Test (using internal research staff) the *procedure*. Convene the Expert / Advisory Committee for review and comments to the *procedure*. Refine and retest the *procedure*.

3. Develop the data collection *course*. The Course is anticipated to include a connected series of roadway facilities ranging from two to six lanes with intersections with facilities ranging from two to six lanes as well. The roadway facilities should each have a consistent cross-section. It is expected that the intersection approach geometry may have a significant impact on the effect of the conflicts & exposure perceptions as well as the actual delay experienced by bicyclists. Accordingly, the following approach geometries (for the outside approach lane) should be represented in the course:

Standard approach (combined thru and right turn) lane

Standard (thru) lane with right turn storage lane (for motor vehicle traffic)

Approach lane with a bicycle lane

Approach lane with bike lane and right turn storage lane for motor vehicle traffic

4. Plan the volunteer participant event. The plan shall include final event location selection, promotion, participant registration, and event logistics planning. Site visits (three anticipated) and an event pilot run is anticipated. Coordination of the state bicycle/pedestrian coordinators’ annual meeting will be accomplished to ensure that an adequate number of course proctors will be available.

5. Perform data collection of intersection conditions within the event course. Evaluate data to ensure adequacy of data ranges. Convene Expert / Advisory Committee for final

review and refinement of the data collection course design and event planning and logistics. Refine course and event logistics as needed.

6. Stage the data collection / observation event and perform simultaneous turning movement counts and elevated video documentation for signal phase (i.e., intersection delay) matching with individual participants.

7. Compile the observations and conduct data reductions. Evaluate for, and determine statistical outliers. Test for statistically-different population groups. Conduct Pearson Correlation analysis; conduct stepwise regressions to create Model.

8. Analyze initial results; conduct factor sensitivity testing; convene Expert / Advisory Committee for review and refinement of *Model*.

9. Recommend any additional testing, calibration techniques, or data collection programs; Produce final documentation (format: TRB paper); Present results to State Bicycle Coordinators and to District LOS Coordinators.

Note:

It is anticipated that there will be a maximum of six Expert / Advisory Committee meetings, and that they will be held in either the Tampa or Orlando metropolitan areas.



### **ANTICIPATED MODEL DEVELOPMENT TASKS FOR PEDESTRIAN INTERSECTION CROSSING**

1. Convene Expert / Advisory Committee for the model calibration study kick-off meeting; refine initial (conceptual) LOS methodologies and data format from previous research (Point LOS Study). Create and/or refine the long list of potential study (calibration) sites (roadway facilities) for calibrating the side street crossing through (and ultimately, the other) movement. The sites shall be representative of Florida metropolitan roadway facilities. The final course location is anticipated to be within the Ft. Lauderdale metropolitan area.



2. Design the data collection *procedure* to obtain real-time response/observations for the model calibration. Test (using internal research staff) the *procedure*. Convene the Expert / Advisory Committee for review and comments to the *procedure*. Refine and retest the *procedure*.

3. Develop the data collection *course*. The Course is anticipated to include a connected series of roadway facilities ranging from two to six lanes with intersections with facilities ranging from two to six lanes as well. The roadway facilities should each have a consistent *roadside* cross-section.

4. Plan the volunteer participant event. The plan shall include final event location selection, promotion, participant registration, and event logistics planning. Site visits (three anticipated) and an event pilot run is anticipated. Coordination of the state bicycle/pedestrian coordinators' annual meeting will be accomplished to ensure that an adequate number of course proctors will be available.

5. Perform data collection of intersection conditions within the event course. Evaluate data to ensure adequacy of data ranges. Convene Expert / Advisory Committee for final review and refinement of the data collection course design and event planning and logistics. Refine course and event logistics as needed.

6. Stage the data collection / observation event and perform simultaneous intersection turning movement counts and elevated video documentation for signal phase (i.e., intersection delay) matching with individual participants.

7. Compile the observations and conduct data reductions. Evaluate for, and determine statistical outliers. Test for statistically-different population groups. Conduct Pearson Correlation analysis; conduct stepwise regressions to create Model.

8. Analyze initial results; conduct factor sensitivity testing; convene Expert / Advisory Committee for review and refinement of the *Model*.

9. Recommend any additional testing, calibration techniques, or data collection programs; Produce final documentation (format: TRB paper); Present results to State Bicycle Coordinators and to District LOS Coordinators.

It is anticipated that there will be a maximum of six Expert / Advisory Committee meetings, and that they will be held in either the Tampa or Ft. Lauderdale metropolitan areas.

## SITE CHARACTERISTICS FOR EVALUATION

In order to validate the “conceptual framework” discussed in the previous section for each of the 3 modes (Transit, Bike and Ped), for “Point Level of Service”, the following are characteristics of the varying types of sites (Bus Stops and Intersections) that could be selected to try out the models.

### TRANSIT SITE CHARACTERISTICS FOR “POINT LOS”

- I. Sites with varying bus service frequency ranges per hour  
(TCQSM Categories)            1            2            3-4            5-6            > 6
  
- II. Stops with multiple routes (to incorporate transfer sites)
  - 1 route
  - 2-3 routes
  - > 3 routes
  
- III. Different pedestrian access scenarios
  - Facility Crossing – Level of Service A through F
  - Sidewalks adjacent to stop and without sidewalks
  - Origin/Destination Connectivity (within 1/8 mile) - Good, Fair, Poor
  - Obstacles/ADA Accessible (meets all ADA standards)
    - Functional (not ADA, but some degree of access)
    - Non-functional (obstacles)
  
- IV. Range of amenities/infrastructure
  - Bus stop signage
  - Bench and shelter
  - Signals and shelter
  - Trash receptacles etc. (See survey form on page 28)
  
- V. Additional information needed for such site includes:
  - a. Bus span of service
  - b. Number of boarding passengers

## **PEDESTRIAN SITE CHARACTERISTICS FOR “POINT LOS” – TYPES OF INTERSECTIONS TO VALIDATE PEDESTRIAN LOS**

### **I. Non signalized and signalized intersections**

For all of following:

2 X 2

2 X 4

2 X 6

4 X 4 (Signalized only)

4 X 6 (Signalized only)

6 X 6 (Signalized only)

### **II. Non signalized -**

- 2 way stop
- All way stop

### **III. Range of turning volumes**

### **IV. Different crosswalk types**

- High emphasis/zebra
- Parallel
- None
- Special pattern (brick, etc)

### **V. Sidewalk/curb vs. no sidewalk**

### **VI. Median treatments**

- Landscaped
- Concrete
- Paint
- None

## **BICYCLE SITE CHARACTERISTICS FOR “POINT LOS” – BICYCLE THROUGH MOVEMENTS OF INTERSECTIONS**

### **I. Types of intersections**

2 X 2

2 X 4

2 X 6

4 X 4

4 X 6

6 X 6

II. With bicycle facilities (Bike lanes, especially straight thru route excluding right turn lane for cars)

III. Without bicycle facilities

IV. With various approach geometries (5 geometric approaches)

V. Various truck volumes

VI. Various turning movement volumes

VII. Sidewalks

VIII. Curb cuts

IX. Various signal detection

Appendix A.

# Pedestrian Point Level of Service Evaluation Form

## Conflicts

Right turn volume: \_\_\_\_\_  
\_\_\_\_\_

turning vehicles' average speed

Through movement volume: \_\_\_\_\_

crosswalk setback from traffic stream \_\_\_\_\_

Opposing left turn volume: \_\_\_\_\_

signal phase \_\_\_\_\_

Right turn on red (side street) volume: \_\_\_\_\_ ( \_\_\_\_\_ % heavy vehicles)

## Exposure

Crossing distance:

Cross street width: \_\_\_\_\_

Intersection radii: \_\_\_\_\_

Is there a crosswalk present?  Yes  No

If so, list type of marking: \_\_\_\_\_

Median present?  Yes  No types: \_\_\_\_\_ width: \_\_\_\_\_

Is there a sidewalk present?  Yes  No

Is there a curb with landing or waiting areas?  Yes  No

Comments: \_\_\_\_\_

## Delay

### Signalized Intersections

Is there a pedestrian signal?  Yes  No

If yes, cycle length: \_\_\_\_\_

If no, g/c ratio \_\_\_\_\_

### Unsignalized Intersections

Through movement volume from for side cross-street

LTs + THs + RTs (approach traffic of near side cross street

Major street "platooning plus (RT & LT0)

Figure 1 - Signalized

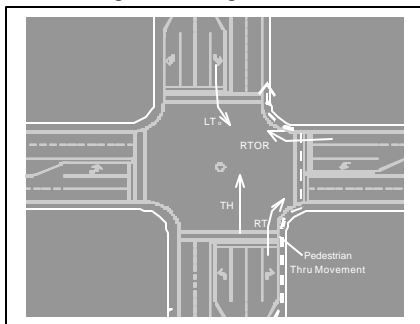
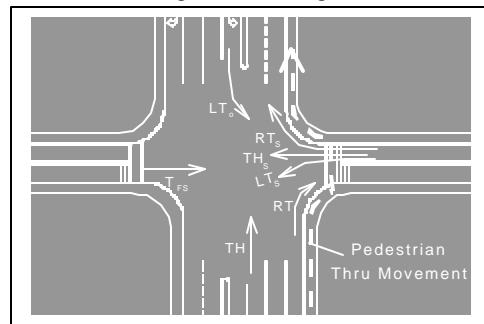


Figure 2 - Unsignalized



( "Point LOS" project, University of Florida, DURP, L. Crider & B. Landis, Aug. 2001)

Appendix B.

## Intersection Rating Form for Pedestrian Crossing (Sample)

Intersection Name/Location: \_\_\_\_\_

**Rate the intersection on a scale of 1-5 (1 being worst, 5 being best)**

<b>Intersection Measures</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>Comments</b>
<b>Average speed</b>	Over 45 mph	40-45 mph	30-35 mph	20-25 mph	10-15 mph	
<b>Volume ADT</b>	>				<	
<b>Crossing Width</b>	Super Wide $\geq 84'$	Wide 60-83'	Average 40-59'	Narrow 24-39'	Super Narrow 10-23'	
<b>Crosswalk Type</b>						
<b>Median Type</b>	None	Right Turn Lane (Pork Chop)	Pavement Stripe 4-8'	Concrete	10'+ Landscaped	
<b>Cycle Length</b>						
<b>Ped Signal</b>	None/Broken	Delay too long	Average delay, some peds wait	Very little delay	No delay, ped sensitive (auto response)	
<b>Corner Radius</b>						
<b>Turn Movements (RTOR,RT,LT0)</b>	High volume of continuous RTOR movements	RT & LT0 turning movements	Average turning movements #/hr.	Very few turning movements #/hr.	No turns allowed on ped phase	
<b>Truck Volume</b>	Very High Over 5%	High $>2\%$ $<5\%$	Average 2%	Low 0.5% - 2%	Less than 0.5%	
<b>Bike/Ped Conflicts</b>	Chaotic $>25/hr.$	Many 25/hr.	Some 10-24/hr.	Few $<10/hr.$	None	
<b>Landscaping/Amenities</b>	No shade, Lighting or waiting area	Some shade, lighting, small waiting area	Adequate waiting area	Lighting or shade	Lighting and shade, large waiting area	

Comments: \_\_\_\_\_

DRAFT May, 2001  
UF- Dept. of URP