Bicycle / Pedestrian
Design Treatments & Criteria:
At Grade and Separated Pedestrian Crossings &
On-Street Bicycle Lane Configurations

Prepared for:
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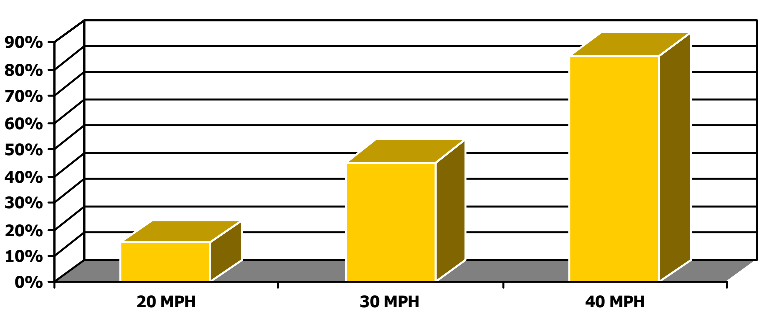
A. INTRODUCTION

The Hillsborough County Metropolitan Planning Organization (MPO) considers the safety of its citizens paramount. Figure No. 1 demonstrates the danger pedestrians [and bicyclists] face as traffic speeds increase.

In response to these safety concerns and the need to provide more efficient use of existing roadway rights-of-way, the MPO strives to provide an environment that encourages balance between conventional (single occupant private vehicles and other transportation modes) and non-conventional (walking, bicycling and transit patronage) modes of transportation

The MPO, using engineering consultant resources, has developed guidelines for overall safe pedestrian crossing treatments for at-grade, overpass and underpass crossings; and developed of a policy and guidelines for institutionalizing the inclusion of bicycle lanes during the resurfacing of local government roadways. This report details the results of these investigations and provides matrices and background documentation that should encourage transportation professionals to consider the implementation of appropriate pedestrian crossings and bicycle lanes on existing roadways.

Figure No. 1
Probability of Pedestrian Fatality with Increasing Vehicle Speed



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B. PEDESTRIAN CROSSING GUIDELINES

1. Methodology

The consultant conducted an international literature review of pedestrian crossing treatments currently in practice. (see Appendix "B") These treatments have been adopted by State and local governments or have been implemented on experimental bases requiring further review. Considering the applications of these treatments and their effectiveness in enhancing pedestrian/motorist interaction, matrices have been developed, demonstrating suitable pedestrian treatments for various roadway configurations.

Land use, facilities, and traffic characteristics such as the number of pedestrians and vehicles have been considered in the development of these matrices.

2. Study Analysis

a. Pedestrian Grade Separated Crossings:

The effectiveness of grade separated crossings depends on the user's perception of accessibility and ease of crossing. Often times it is perceived to be more efficient to cross at grade than to use an overpass. Users weigh the perceived safety benefits against effort and time issues. To maximize the use of grade separated crossings, they should be located in the normal or expected path of major pedestrian movements. Guidance design (bushes, fences, medians) is sometimes needed to funnel pedestrians along a path directing them to the structure. The basic types of such crossings are noted below.

i) Pedestrian Overpasses/Bridges

Typically designed for non-motorized users over roadways with stairs or ramps provided. Depending on topography, the road may be depressed and the bridge is at ground level.

ii) Skywalks/Skyways

Connecting buildings at mid-block usually at the second or third level.

iii) Pedestrian Tunnels/Underpasses

Stairs or ramps lead down to a below-grade passageway. Depending on topography, the road may be elevated and the underpass is at ground level.

iv) Below-Grade Pedestrian Networks

These consist of extensive underground walkways usually accessible from downtown buildings and often subway stations. "Underground Cities" can be developed with shops, restaurants, offices and in limited capacities – residences.

Underpasses and overpasses normally require about a 10 and 20 feet of vertical clearance respectively. Also, underpasses may create some security problems as well as topographical or water table problems. Overpasses are very expensive to build and require side and top fencing to prevent throwing of objects.

Determining the need for a grade separated crossing can be facilitated by the adoption of warrants or criteria for their installation. Appendix "G" provides qualitative and quantitative analysis and criteria associated with the decision requirements to install pedestrian overpasses or underpasses.

b. Pedestrian At Grade Crossings

Land use plays a crucial role in the opportunities and propensity of pedestrians to cross streets at specific points. Corridors with scattered land use such as in rural locations make it difficult to predict where pedestrians will cross. Conversely, concentrated urban environments provide logical crossing points where expectation is high for pedestrians to cross (shopping areas, schools, parks, and government institutions to name a few). Transit stops in terms of locations and transfer points as well as traffic signal spacing play a role in providing a degree of comfort, appropriate walking distances, and security to pedestrians (patrons).

Our research has revealed that there are no clear industry-wide warrants or criteria for the installation of uncontrolled and mid-block crossings. However, we note below some guidelines that have been developed.

i) *Guidelines for installing crosswalks at uncontrolled and mid-block crossings.* (Source: C.V. Zegeer, Chapel Hill, as presented in the Institute of Transportation Engineer's compilation: *"Alternative Treatments for At-Grade Pedestrian Crossings"*, (2001). This guideline is shown in Appendix "A"; it provides for quick analysis on an "Install / Do Not Install" approach for crosswalks based on traffic volume, pedestrian volume, speed limit, roadway configuration, and other characteristics.

ii) *Guidelines for the installation of Marked Crosswalks Used in San Luis Obispo, California, as presented in the Institute of Transportation Engineer's compilation: "Alternative Treatments for At-Grade Pedestrian Crossings", (2001).* Notwithstanding other details associated with their local design, the basic guidelines for installation are as follows.

- Pedestrian volume: 40 or more per hour during peak hour pedestrian use, or 30 groupings of two or more pedestrians for a continuous 2-hour period twice/day; and
- The 85th percentile approach speed is below 40 mph; and
- The roadway has fewer than three travel lanes per direction; and
- The location has (or will be installed) adequate street lighting; and

- There is unrestricted visibility for specific distances, for example, at a 35 mph design speed, the minimum sight distance would be 250 feet; and
- For residential streets, an ADT of 2,700 or more is required; and
- No controlled crosswalk (signal or "Stop" sign) is within 656 feet of the proposed location.

iii) *Installation Criteria: Crosswalks at Uncontrolled Locations as presented in the City of St. Petersburg, Florida "CITY TRAILS Bicycle Pedestrian Master Plan", (2003).* Crosswalks must meet the following five criteria for the installation of a marked crosswalk.

- High pedestrian locations: more than 24 pedestrians per hour during peak periods (should exceed 24 for at least two hours per day) or regular use by children, seniors or persons with reduced mobility). Numbers of crossing by vulnerable pedestrians should exceed 12 crossings a day.
- Two way traffic counts of over 300 vehicles per hour during times when most pedestrians are present and /or pedestrian-motor vehicle conflicts (Pedestrian motor vehicle conflicts are defined as: 1. instances when the driver of a vehicle has to engage in abrupt braking, has to swerve to avoid striking a pedestrian, or if a pedestrian has to take sudden evasive action to avoid being struck. This type of conflict has been shown to be highly correlated with crash frequency (Lord, 1996). 2. The pedestrian being rapped ["trapped"] in the roadway with vehicles passing ahead and behind him/her for a period greater than 15 seconds), or a history of events at an unmarked crosswalk plotted using GIS software and analyzed using PBCAT crash typing tools).
- Locations where the next crossing is more than 300 feet away.
- The stopping distance for vehicles traveling at mean or mode vehicle speed should be no greater than 234 feet. This distance should be calculated using the signal timing formula. This corresponds to a mean or mode speed of 40

mph with no grade. Crosswalks should not be installed at uncontrolled locations if the stopping distance for vehicles traveling at the mean or mode speed is greater than 234 ft. If the stopping distance for vehicles traveling the mode speed is greater than 234 ft, a crosswalk should not be installed unless the stopping distance for vehicles traveling at the mode speed can be reduced through traffic calming measures or speed enforcement.

- The 85th percentile speed should not exceed 45 mph.

It is clear that each jurisdiction takes a local approach to managing the installation of uncontrolled crosswalks. However, in general terms, the principles are very similar: pedestrian volumes, traffic volumes, sight distance, roadway configuration, and vehicle speeds are common elements. It appears that the San Luis Obispo, California and the City of St. Petersburg, Florida criteria are somewhat less restrictive.

3. Proposed Warrant/Criteria Model

There is a downside to using pedestrian volume as a way to measure pedestrian activity. For example when a location is near a logical demand based on land use such as the proximity of schools, places of employment, transit routes, and parks to name a few, yet the crossing is hazardous and therefore avoided.

The MPO's *Pedestrian Demand Assessment* methodology predicts the greatest potential for pedestrian activity and is more realistic than using pedestrian volume for the development of pedestrian crossing warrant/criteria charts.

Taking best practices from the research and the MPO Pedestrian Plan, enhanced pedestrian at-grade crossings are recommended under these conditions:

- Latent demand score of 4 or greater or if the corridor is identified as a Pedestrian Improvement Corridor in the Comprehensive Pedestrian Plan.

- The next nearest controlled crossing (traffic signal or "stop" sign) is more than 300 feet away.
- The 85th percentile approach speed should not exceed 45 mph.
- The roadway has no more than four travel lanes per direction with a median for pedestrian refuge
- The location has or will have adequate street lighting.
- There is unrestricted visibility for specific distances (for example, at a 35 mph design speed, the minimum sight distance would be 250 feet).

Table No.1 provides criteria for Overpass/Underpass considerations.

4. <u>Innovative Pedestrian Solutions</u>

Several "communication" methods enhancing the crossing safety of pedestrians and bicyclists are available. These have been successfully used in other communities. A short list is noted below supplemented by a more detailed list in Appendices "D", "E", and "F".

- In-Pavement Lighting
- Raised medians with staggered pedestrian approaches
- Raised intersections
- Raised crosswalks
- Curb extensions (reduced crossing exposure)
- Count-down pedestrian signals
- In-Street "Yield to Pedestrian Signs"
- "Yield" Pavement Markings w/ "Yield" Signs

Table No. 1
Pedestrian Overpasses and Underpasses
Warrants/Criteria

OVERPASSES	QUALITATIVE CONSIDERATIONS	CRITERIA – Overpasses/Underpasses
	High Volume of pedestrian and vehicle traffic, virtual lack of gaps for pedestrians, crime concerns that dissuade pedestrians from using a crossing point.	• The at-grade latent demand score for pedestrian traffic is 7 or greater • Greater than 10,000 vehicles in same 4 hour period or ADT > 35,000 for speeds over 40 mph in urban areas. If not met, the vehicle volume should be > 7,500 in 4 hours or ADT > 25,000. • Maintain 600 feet between safe (signal, controlled grade crossing, O/P U/P) crossings. • Barrier to discourage at-grade crossing at O/P U/P location. • Topographical changes should be minimal to keep costs down. • Land use may dictate the need for grade separation. • Funding should be in place prior to construction commitment. • Formal Benefit/Cost analysis should be applied.
	Across roads with high speeds even if gaps are more available, particularly near schools, sporting or entertainment centers.	
	The connection of two activity centers where highways separate them; it is preferred to cross at the second floor level.	
	Bridges should be at least 10 feet wide, open and well lit with minimal use of stairs or ramps.	
	Engage commercial kiosks to minimize crime.	
	Highly desirable when used in conjunction with a multi-use trail. In this case, stairs/ramps will most likely be used as this effort is minimal relative to the overall trail use.	
	ADA standards must be met.	
UNDERPASSES	Tunnels must be well lit with vandal resistant walls (artwork or glazing is best).	
	Best to have each end visible by altering the elevation accordingly.	
	Commercial kiosks, entertainment complexes or other activity centers should be encouraged, particularly for long tunnels.	
	Drainage issues must be considered to provide a dry environment for its users.	
	ADA standards must be met.	

Source: Florida Pedestrian Planning and Design Handbook, April 1999 – Modified for Pedestrian Latent Demand Score

C. BICYCLE LANE RESTRIPING GUIDELINES

1. Methodology

This study includes the development of a policy that provides for the safe inclusion of bicycle lanes as part of the normal resurfacing process. To effectively develop guidelines suitable for transportation practitioners to use on a day-to-day basis, a thorough review of the existing national and state acceptable roadway lane widths was conducted.

A series of matrices have been developed articulating acceptable roadway lane widths that would provide space for designated or undesignated bicycle lanes. It should be pointed out that land use, facilities, traffic characteristics and roadway configurations were also considered in the development of these matrices.

To further assist the practitioner in quantifying the costs of implementing bicycle lanes on resurfacing projects, estimates of per mile costs of the various restriping configurations have been made. These cost estimates (2004 rates) include restriping by grinding and re-painting; and milling, resurfacing and re-painting methods.

(It should be pointed out that agencies such as the Florida Department of Transportation (FDOT), City of Tampa, and the Hillsborough County Public Works Department have specific programs that consider and implement bicycle lanes where feasible.)

2. Study Analysis

a. Current Minimum Travel Lane Widths

Several documents have been published by various authorities providing, among other things, standard minimum travel lane widths. Table No. 2 summarizes these features.

Table No. 2
Summary of Minimum Standards
Travel Lane Widths

Standard	Roadway Type (Minimum Lane Width in Feet) *				
	Major Arterials	Minor Arterials	Collectors	Local	Bike lanes
Manual of Uniform Minimum Standards for Design, Construction and Maintenance for Streets and Highways – "Florida Greenbook"(May 2002)	11	11	11	10	4/5
Plans Preparation Manual, Volume I (Jan.2003)	11	11	11	N/A	4/5
Plans Preparation Manual, (Transportation Design for Livable Communities - 2003)	10	10	10	10	4/5
American Association of State Highway and Transportation Officials, Policy on Geometric Design of Highways and Streets (2001)	11	11	10	10	4/5
Manual of Uniform Traffic Control Devices (2003)	N/A	N/A	N/A	N/A	N/A
Hillsborough County – Transportation Technical Manual (2003)	12	12	10	10	4/5
Florida Intersection Design Guide (2002)	12	11	11	10	4/5

* Minimum from charts and respective notes such as design speeds under 40 mph, truck volume 10% or less, and interrupted flow conditions. See appendices for detailed charts.

Clearly, a variety of minimum lane widths have been adopted by these authorities. Further, it is obvious that the use and purpose of the specific bicycle lane installation (balancing the needs of through traffic) and its resultant travel lane alterations will assist the practitioner in deciding on an ultimate overall lane configuration

3. <u>Proposed Criteria for Determination of Minimum Acceptable Travel Lane Widths</u>

In determining appropriate travel lane and bicycle lane design treatments, it is generally accepted that six factors are most often cited.

a. <u>Traffic Volume:</u>

Higher motor vehicle traffic volumes represent a greater risk to bicyclists resulting in less comfortable driving experiences. Based on the typical minimum lane width in the appendices and engineering experience, the traffic volumes have been sub-divided into three groups:

- Under 2,000 (Average Annual Daily Traffic) AADT
- 2,000 to 10,000 AADT
- 10,000 to 20,000 AADT
- Over 20,000 AADT.

b. <u>Speed Limit:</u>

The posted speed limit and more importantly the roadway's operating speed, plays an important role on risk and comfort. The speed profile has been grouped as follows.

- 25 mph or lower
- 30, 35, or 40 mph
- 45 mph
- 50 mph and over.

c. <u>Traffic Mix:</u>

The degree of concentration of large vehicles can also increase the risk and reduce comfort level of bicyclists. Accordingly, if the quantity of large vehicles approaches and/or exceeds 10% of AADT, in most cases, minimum travel lane widths should be increased to the next level.

d. <u>On-Street Parking:</u>

The presence of on-street parallel parking increases the need for separation between the bicyclist and through traffic. Where space for bike lanes can be accommodated, the designated bike lane must be at least 5.0 feet wide. Further, it may be necessary to increase the width of a travel lane adjacent to a bike lane. This increase is particularly necessary with increasing speeds and traffic volume.

e. Sight Distance:

Care should be taken to ensure that adequate sight distance between the motorist and the bicyclist exists.

f. Number of Intersections:

Generally, the number and frequency of intersections should be taken into account when considering bike treatments. Transitional issues such as relating to right turning vehicles and congestion at signalized intersections may increase risk and discomfort levels.

Considering each of these factors and the minimum travel lane widths as noted in Table No. 2 and detailed in the appendices, tables have been developed to assist practitioners in determining the appropriate bicycle treatments. Tables Number 3, 4, and 5 provide minimum travel lane widths and their companion Tables Numbered. 3a, 4a, and 5a, indicate the relative remaining roadway treatments.

Table No.3
Minimum Travel Lane Widths
Urban Section w/o On-street Parking

	Average Annual Daily Traffic Volume			
	< 2,000	2,000-10,000	10,000-20,000	>20,000
Speed Limit (mph)	Min. Travel Lane (ft)	Min. Travel Lane (ft)	Min. Travel Lane (ft)	Min. Travel Lane (ft)
25 and lower	10	10	11	11
30-40	10	11	11	12
45	11	11	12	12
50 and over	12	12	12	12

For Resurfacing, Restoration, and Rehabilitation (RRR) projects, a minimum of 10 feet (11 feet if trucks 10% or more) may be used for all traffic volumes and all design speeds; for multi-lane use 11 foot lane adjacent to portion in Table 3a. ***Note January 1, 2004 Plans Preparation Manual, Section 25.4.5 for details.***

Table No. 3a
Remaining Roadway Treatment
Urban Section w/o On-street Parking

Remaining Roadway (per direction)	Treatment
0 – 1.9 feet	Paint Line at Edge of Pavement (EOP) **
2.0 – 3.9 feet	Paint Line Left of EOP
4.0 or more +	Paint/Sign Designated Bike Lane

** Optional for **traffic calming purposes**, paint a continuous white line left of Edge of Pavement.
+ Not including gutter.

Note: "Bike Route" and/or "Share the Road" signs may be installed if such routes have been adopted and mapped by the local jurisdiction.

Table No. 4
Minimum Travel Lane Widths
Urban Section w/ On-street Parking

	Average Annual Daily Traffic Volume			
	< 2,000	2,000-10,000	10,000-20,000	>20,000
Speed Limit (mph)	Min. Travel Lane (ft)	Min. Travel Lane (ft)	Min. Travel Lane (ft)	Min. Travel Lane (ft)
25 and lower	10	10	11	12
30-40	10	11	12	12
45	11	12	12	12
50 and over	12	12	12	12

For RRR projects, a minimum of 10 feet (11 feet if trucks 10% or more) may be used for all traffic volumes and all design speeds; for multi-lane use 11 foot lane adjacent to portion in Table 4a. *Note January 1, 2004 Plans Preparation Manual, Section 25.4.5 for details.*

Table No. 4a
Remaining Roadway Treatment
Urban Section w/ On-street Parking

Remaining Roadway (per direction)	Treatment
0 – 1.9 feet	Do Not Paint Line (Wider outside lane results)
2.0 – 4.9 feet	Paint Line Left of Parking Stall (PS)
5.0 or more +	Paint/Sign Designated Bike Lane Lt of PS

+ Not including gutter.

Note: "Bike Route" and/or "Share the Road" signs may be installed if such routes have been adopted and mapped by the local jurisdiction.

Table No. 5
Minimum Travel Lane Widths
Rural Section

	Average Annual Daily Traffic Volume			
	< 2,000	2,000-10,000	10,000 – 20,000	>20,000
Speed Limit (mph)	Min. Travel Lane (ft)	Min. Travel Lane (ft)	Min. Travel Lane (ft)	Min. Travel Lane (ft)
25 and lower	10	10	11	11
30-40	10	11	11	12
45	11	12	12	12
50 and over	12	12	12	12

For RRR projects, please refer to *January 1, 2004 Plans Preparation Manual, Section 25.4.5 for details.*

Table No. 5a
Remaining Roadway Treatment
Rural Section

Remaining Roadway (per direction)	Treatment
0 – 1.9 feet	Paint Line at Edge of Pavement (EOP)**
2.0 – 3.9 feet	Paint Line Left of EOP
4.0 or more +	Paint/Sign Designated Bike Lane

** Optional for **traffic calming purposes**, paint a continuous white line left of Edge of Pavement.
+ Not including gutter.

Note: “Bike Route” and/or “Share the Road” signs may be installed if such routes have been adopted and mapped by the local jurisdiction.

D. CONCLUSION

The lack of specific implementation guidelines associated with providing designated or undesignated bicycle lanes during resurfacing projects while maintaining minimum travel lane widths often results in designers maintaining the status quo configuration. Similarly, the lack of specific pedestrian crossing criterion often results in designers not providing for mid-block or unsignalized intersection crossings.

This report concludes that after considering the various documented standards and guidelines in the transportation industry, that it is feasible to develop guidelines and criteria to establish clear opportunities for the installation of designated/undesignated bicycle lanes and pedestrian crossings respectively. In this regard, tables have been developed to assist the practitioner in providing suitable combinations of travel and bicycle lanes depending on operating speed, traffic volume, parking, and land use characteristics. Further, criteria have been identified to also assist the practitioner in formulating clear methods to decide on the implementation of pedestrian mid-block crossings.

These methods should be reviewed by end users and practitioners to ensure that these recommended policies and practices are appropriate and complement the existing policies and practices of their respective agencies.

The Hillsborough County Metropolitan Planning Organization considers the safety of its citizens paramount. Providing additional pedestrian crossing opportunities in association with innovative crossing treatments coupled with the provision of appropriate combinations of travel and bicycle lanes will go a long way to meeting this mission.

E. RECOMMENDATIONS

1. That the MPO endorse the proposed criteria associated with the installation of mid-block at-grade and grade separated pedestrian crossings as noted in this report;

2. That the MPO endorse the proposed matrices associated with the application of designated and undesignated bicycle lanes as shown in Table Nos. 3/3a, 4/4a, and 5/5a; and

3. That the MPO incorporate the criteria in the report into the update of the 2025 LRTP. In addition, direct staff to work with the applicable implementing agencies to formulate appropriate language, for addition to the local government's Comprehensive Plans and Technical Manuals, to institutionalize these guidelines for consideration during resurfacing and reconstruction projects throughout Hillsborough County.

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