Statewide School Crossing Assessment

In Support of H.B. 493:
Enhanced Safety for School Crossings

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1.0 EXECUTIVE SUMMARY

This report summarizes findings from the Florida Department of Transportation (Department) to fulfill the requirements included in House Bill 493 (HB 493) passed during the 2017 Regular Session. The report includes detailed information on the viability and costs for the implementation of a specific, uniform system of high-visibility markings and signage for use on arterial and collector roads within 1-mile of all schools.

Florida has over 4,200 public and private schools. Based on results obtained from sampling over 400 school sites, the Department estimates that there are over 200,000 marked crosswalks on arterial and collector roadways within 1-mile of all public and private schools. Approximately one out of every three (37%) of these crosswalks are located on the state highway system, with the remaining two-thirds (63%) located on locally maintained arterial and collector roads (off the state highway system).

The majority of the Department's standards and manuals concerning signing and marking of crosswalks apply only to state highway system roadways and to those local jurisdictions that have voluntarily adopted Department standards for their roadways (e.g. FDOT Standard Plans or Traffic Engineering Manual). Some local agencies in Florida use the minimum federal Manual on Uniform Traffic Control Devices (MUTCD) or the American Association of State Highway and Transportation Officials (AASHTO) standards and have not adopted the more robust Department specific standards for items such as pavement marking patterns (use of special emphasis patterns where required) and/or materials (use of thermoplastic instead of retroreflective paint). Documentation on the existing condition of crosswalk markings within 1-mile of all schools has determined that approximately 69% of these crosswalks either have reduced visibility with the appearance of being partially worn (due to age and traffic volumes) or do not meet the existing Department standards already in place.

The FDOT Manual on Speed Zoning for Highways, Roads and Streets (SZM) is the singular source for Florida's school zone and school crossing requirements. The SZM mandates specific treatments for all crosswalks located within school zones or school areas for all public roads, regardless if they are on the state highway system or not. However, this requirement only applies to crosswalks that are within proximity to school areas and buildings and does not extend to all crosswalks expressed in HB 493.

When considering the viability and costs for implementation of a specific, uniform system of high-visibility markings and signage for use on arterial and collector roads within 1-mile of all schools, these factors pose a significant fiscal impact overall, but most notably for city and county agencies due to the large number of marked crosswalks on non-FDOT maintained roadways. As a point of reference, spending an average of $5,000 in enhancements for existing crosswalks on arterial and collector roads within 1-mile of all schools statewide, both on and off-system, is estimated to cost over $1.1 billion.

Given these factors, a tiered approach incorporating programmatic (statewide) options for a uniform system of crosswalk markings for schools has been developed for consideration. The tiered approach starts with opportunities, costs and challenges associated with meeting current state standards and expands to include experimental and policy-related enhancements under subsequent tiers, which may require longer-term investments and Federal approval.

2.0 INTRODUCTION

House Bill 493 *Enhanced Safety for School Crossings*, approved by Governor Rick Scott on June 14, 2017, requires the Florida Department of Transportation (FDOT) to develop and submit a report evaluating the viability and cost of a specific, uniform system of high-visibility markings and signage for use on arterial and collector roads within 1-mile of all schools to designate as "safe school crossings".

This report summarizes the activities conducted by FDOT to fulfill HB 493 requirements, including results of a detailed sampling of school sites statewide, documentation of national research findings for crosswalk treatments and information on viability and costs for implementation of a specific, uniform system of high-visibility markings and signage for use on arterial and collector roads within 1-mile of all schools.

3.0 STATEWIDE SCHOOL INVENTORY

Active school location data was obtained from the Florida Department of Education (FDOE) for the total number of active schools statewide, both public and private, from kindergarten through high school. This effort, known as the "Inventory Phase", was required to support the development of a statewide report on the opportunities and impacts associated with a uniform system of pavement markings for all crosswalks on arterial and collector roadways within 1-mile of all schools.

The total number of active school sites used for this analysis is 4,268 schools. The initial listing of all active schools originally exceeded 4,500 total school records prior to final review. During final review, sites such as adult education, juvenile detention centers and school district offices included on the initial list were filtered out. Additionally, a few school sites shown on the school choice listing included non-accredited private schools and pre-schools (pre-kindergarten), which were also removed from the final list of school sites used for this assignment.

Table 1 breaks down the final inventory of schools utilized as the basis for this report. ***Appendix A*** contains additional information on the active school site inventory, including a map of FDOT Districts.

FDOT District Region	Rural Area Schools	Urban Area Schools	Total Schools	% of Schools by District
D1	38	509	547	13%
D2	68	458	526	12%
D3	98	275	373	9%
D4	2	797	799	19%
D5	36	757	793	18%
D6	2	596	598	14%
D7	17	615	632	15%
Total	**261**	**4007**	**4268**	**100%**

Table 1: Statewide School Inventory breakdown (Public and Private Schools)

4.0 ESTIMATING CROSSWALKS WITHIN 1-MILE OF ALL SCHOOLS

Developing a program to achieve HB 493 requirements starts with accurately estimating the total number of crosswalks on arterials and collectors within 1-mile of all schools through conducting a statistical sampling. Using this method, the sample size calculated to achieve a 95% confidence level in the number of crosswalks within 1-mile of all schools was determined to be a minimum of 400 school sites.

408 school sites were sampled and the results were used as the bases for estimating statewide impacts including planning level quantities and costs related to developing a uniform system of high-visibility markings and signage for crosswalks on arterial and collector roads within 1-mile of all schools. Further information on the statistical sampling, including detailed methodologies and calculated results can be found in ***Appendix B***.

A major challenge in estimating the 'true' average number of crosswalks within 1-mile of a school is when schools are physically located in close proximity to other schools, as they are commonly found throughout the state. In this common scenario, the 1-mile radius for one school overlaps the 1-mile radius for a number of other schools, and therefore an indeterminate number of crosswalks would be shared by multiple schools. To effectively mitigate this challenge, FDOT developed a "cluster" approach for collecting and estimating the crosswalk data. School cluster boundaries were then refined by taking the bounding shape of the 1-mile radii for each school within the cluster. Aerial desktop reviews were then performed using a single outline boundary for each cluster without considering multiple overlaps, as illustrated in ***Figure 1***.

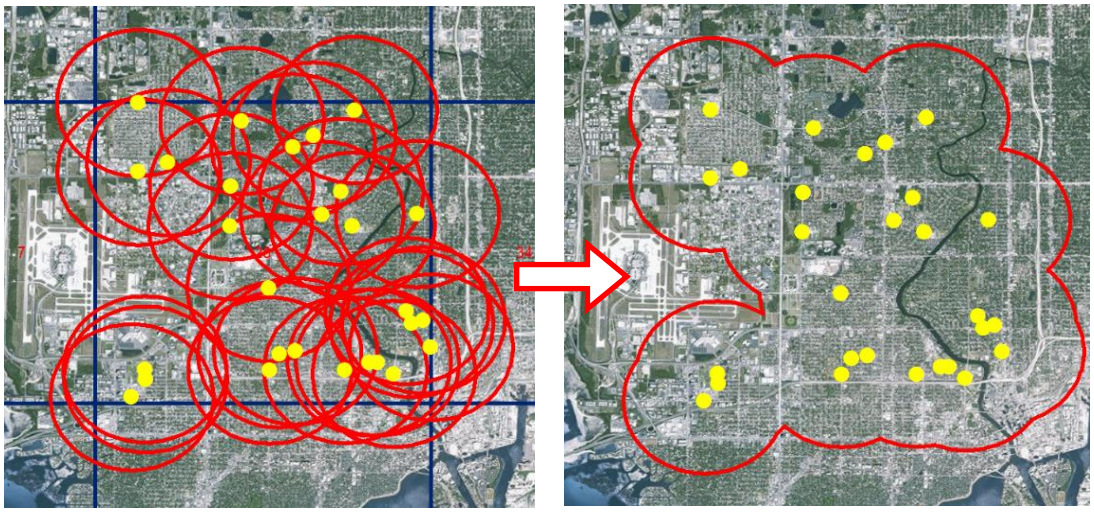

Figure 1: Cluster Boundary Example

A sufficient number of clusters from each district and from both urban and rural areas were selected to capture 408 school sites sampled to answer the question for the estimated number of crosswalks located on arterial and collector roads within 1-mile of all schools. The urban/rural split within the statewide inventory is approximately 17:1, which was used a basis to sample the proportionate number of rural and urban schools to further minimize the standard deviation resulting from this analysis. ***Table 2*** provides the proposed number of schools per district to be sampled via aerial mapping.

FDOT District Region	Rural Area Schools	Urban Area Schools	Total Schools Sampled
D1	5	52	57
D2	10	52	62
D3	14	45	59
D4	2	53	55
D5	5	52	57
D6	2	59	61
D7	3	54	57
Total	**41**	**367**	**408**

Table 2: School Sites Selected for Sampling, Statewide

4.1 Data Collection Results

The number of crosswalks on arterial and collector roads within 1-mile of a school site is between 50 and 55 crosswalks for urban schools and between 7 and 13 crosswalks for rural schools. This statement is made with a 95% confidence level and represents the average extrapolated for statewide use for estimating costs for all crosswalks located within 1-mile of schools. These numbers cannot be used to approximate the average number of crosswalks for an individual school. This is due to the common overlap of 1-mile radii for multiple school sites used in the analysis. ***Table 3*** provides a breakdown of the statistical sampling results.

School Type	Total Schools	Sampled Schools	Crosswalks for Sampled Schools	Average Crosswalks per School	Standard Deviation	Low Estimate*	High Estimate*
Urban	4,007	367	19,360	52.78	2.16	203,000	220,000
Rural	261	41	407	9.33	2.1	2,050	3,150
Total	***4,268***	***408***	***19,767***	*n/a*	*n/a*	***205,050***	***223,150***

Table 3: Summary of Statewide Crosswalk Estimates Within 1-Mile of Schools
*(*Low and High Estimates Obtained using the Standard Deviation)*

With a 95% confidence level, ***the total number of crosswalks on arterial and collector roads within 1-mile of all schools statewide is estimated to be approximately 214,000*** (±9,000), or between approximately 205,000 and 223,000 crosswalks. Additionally, the percentage of crosswalks located on the state highway system has been estimated to be approximately 37% of the total with the remaining crosswalks located on off-system (local) arterial and collector roadways. ***Table 4*** provides a summary of the probable breakdown for crosswalks by facility jurisdiction type.

Facility Type (Arterials & Collectors)	Percent of Crosswalks	Low Estimate*	High Estimate*
State Highway System	37%	76,000	82,500
Off-System (Local)	63%	129,000	140,500
Total	**100%**	**205,000**	**223,000**

Table 4: Summary of Statewide Crosswalk Estimates by Facility Jurisdiction

Quality control measures for the data collection included field verification for forty (40) school sites, or about 10% of the total sample size used to estimate the total crosswalks on arterial and collector roadways within 1-mile of all schools. In addition to verifying crosswalk locations during the field verification, additional crosswalk characteristics were documented including crosswalk pattern type, materials, signage, and photographs. Based on the field verification results, several notable crosswalk characteristics become evident with the condition and location of crosswalks sampled within 1-mile of schools. These characteristics include:

- The average number of lanes crossed by a pedestrian per marked crosswalk is approximately 3 lanes (2.94).
- Approximately 11% of crosswalks within 1-mile of schools are not located at intersections, but are classified as midblock crosswalks.
- Approximately 55% of crosswalks are marked using standard white paint, while 45% are marked using the more retroreflective white thermoplastic markings. Thermoplastic markings use plastic material installed on the road by a heating process that melts the material into the top layer of the asphalt.
- Approximately 69% of all crosswalks have 'moderate' to 'extremely worn' appearance in the pavement markings, where at least 50% of the pavement marking surface appears worn or faded due to traffic.

Detailed data collection results for each individual school (e.g. the cluster it belongs to, number of schools in the cluster, number of crosswalks associated with the cluster and average number of crosswalks for the schools in that cluster) have been included in ***Appendix B*** for further research.

5.0 CROSSWALK RESEARCH SUMMARY

Findings concerning standard marking and signing practices, published research, experimental applications and documented pedestrian safety or driver behavior benefits for various marked crosswalk treatments are included in this section. This research includes a review of standard state practices found nationally as well as experimental trials found both nationally and in international communities. ***Appendix C*** includes detailed information obtained from this research review.

Industry-based research on this topic is found from several accredited sources including major contributors such as the Federal Highway Administration (FHWA), state Departments of Transportation (DOTs), the Transportation Research Board (TRB) and University/College Research Centers. Nationally, most states have adopted the FHWA's Manual on Uniform Traffic Control Devices (MUTCD), with a few states developing their own version of the MUTCD with FHWA approval.

5.1 Manual on Uniform Traffic Control Devices (MUTCD)

A standard marked crosswalk has two (2) 12-inch wide parallel white lines spaced at a minimum width of 6-feet. This complies with the minimum standard set by the Manual for Uniform Traffic Control Devices (MUTCD) (1). The special emphasis pavement markings approved in the MUTCD consist of

two (2) 12-inch wide parallel white lines with 24-inch longitudinal 'bars' spaced a maximum of 5-feet apart in between the parallel lines.

Section 3B.18 of the MUTCD states that "when crosswalk lines are used, they shall consist of solid white lines that mark the crosswalk", as well as "for added visibility, the area of the crosswalk may be marked with… white longitudinal lines parallel to traffic flow" and "this type of marking may be used at locations where substantial numbers of pedestrian's cross without any other traffic control device, at locations where physical conditions are such that added visibility of the crosswalk is desired, or at places where a pedestrian crosswalk might not be expected".

FHWA has also developed recommendations for incorporating the findings from their 2009 study, of the relative daytime and nighttime visibility of three high visibility crosswalk marking patterns into the MUTCD. The recommendations, shown in ***Figure 2***, were endorsed on June 23, 2011 and directly affect Section 38.18 of the MUTCD.

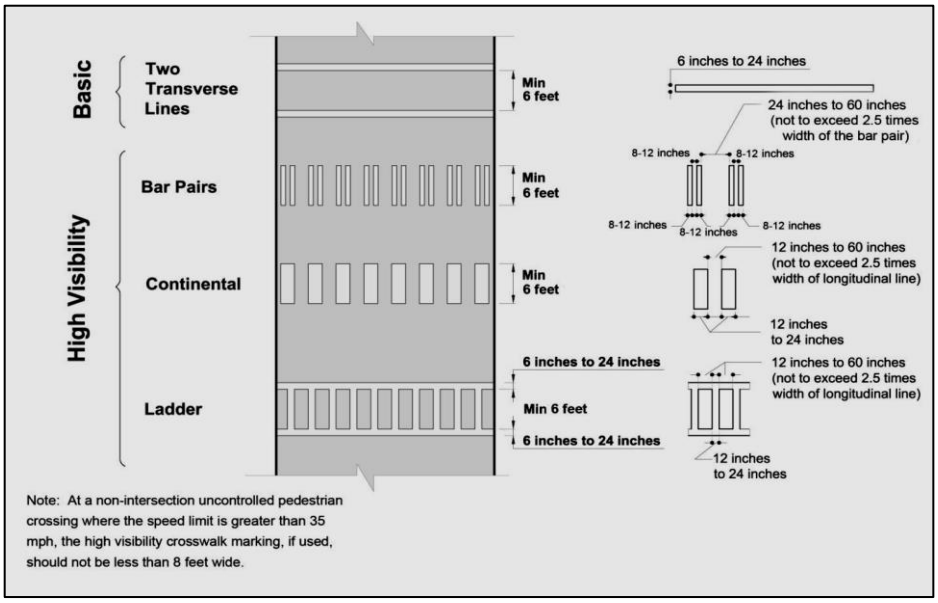

Figure 2: MUTCD Endorsed Crosswalk Markings

Section 2C.50 of the MUTCD refers to signage and considers the use of Pedestrian Crossing Signs (W11-2, or S1-1 for school crossings) as 'optional' to warn motorists in advance of or where the location of a pedestrian crossing has been marked. When used, these signs must be accompanied by a plaque mounted under the sign that reads 'AHEAD', 'NEXT xx MILE' or with a downward facing arrow indicating the location of the crossing, as shown in ***Figure 3***. Additionally, per Section 7B.07 of the MUTCD, all signs and supplemental plaques used in association with school warnings are to have a fluorescent yellow-green background with a black legend. This includes all S-series warning signs and associated plaques, also shown in ***Figure 3***.

Figure 3: Example of MUTCD Crosswalk Signs with Arrow Plaque
(Left: W11-2 Crosswalk; Right: S1-1 School Crossing)

Another optional treatment covered by the MUTCD is the use of the In-Street Pedestrian Sign (MUTCD R1-6a or c), shown in ***Figure 4***. According to Section 2B.12 of the MUTCD, "*…the In-Street Pedestrian Crossing sign shall be placed in the roadway at the crosswalk location on the center line, on a lane line, or on a median island." Although these signs are allowed under the current version of the MUTCD, ongoing research is being conducted in Florida to support expanding its use to allow placement on the right edge line or curb of the roadway known as the "Gateway" effect, as described further in Section 5.5 of this Report.*

Figure 4: MUTCD R1-6 In-Street Pedestrian Signs

5.2 Florida's Crosswalk Standards

Signing and marking standards specific to crosswalks on the state highway system in Florida can be found in several sources from the FDOT. Most counties and municipalities (local agencies) follow these standards when required for the roadways under their jurisdiction, but not all FDOT guidelines are adhered to for off-system roads, including when and where to mark crosswalks and the standards, specifications, and materials used for signing and marking those crosswalks.

Findings from national research suggests that FDOT's crosswalk standards are comparable with or more stringent than standards found in the MUTCD and in other states. This only applies to state

highway system roads and local roads where the local agencies have chosen to adopt FDOT crosswalk standards. The FDOT has clear standards or baseline pavement markings and signage requirements for marked crosswalks, depending on the documented need (level of pedestrian activity, vehicle speeds, site conditions, etc). Florida's crosswalk requirements and guidelines are summarized below with detailed information from these sources located in ***Appendix C***.

FDOT Design Manual (FDM) and Standard Plans

Rule 14-15.010, Florida Administrative Code (F.A.C.), adopts the MUTCD as the uniform system of traffic control devices for use on the streets and highways of the state as required by Section 316.0745, Florida Statutes. The MUTCD is therefore the minimum standard for signing and pavement marking on all roads in the State. Where Department manuals indicate criteria, which is more stringent than the MUTCD, FDOT criteria must be followed for State Roads (FDM, Section 230.3 Pavement Markings).

The standard for crosswalks located at intersections is set forth by Florida is through the FDOT's Standard Plans 711-001 (f.k.a. '*Standard Index* Drawing No. 17346), as shown in ***Figure 5***. Section 230.3.1 of the FDOT Standard Plans also requires the use of thermoplastic materials for all pavement markings, unless temporary applications with use of paint.

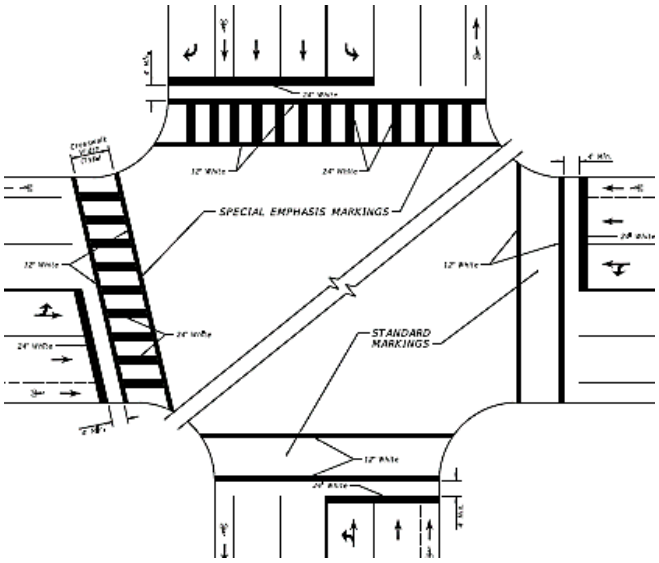

Figure 5: Florida's Design Standard for Intersection Crosswalks

The FDM Section 230 also provides standards required for midblock crosswalks, as shown in ***Figure 6.***

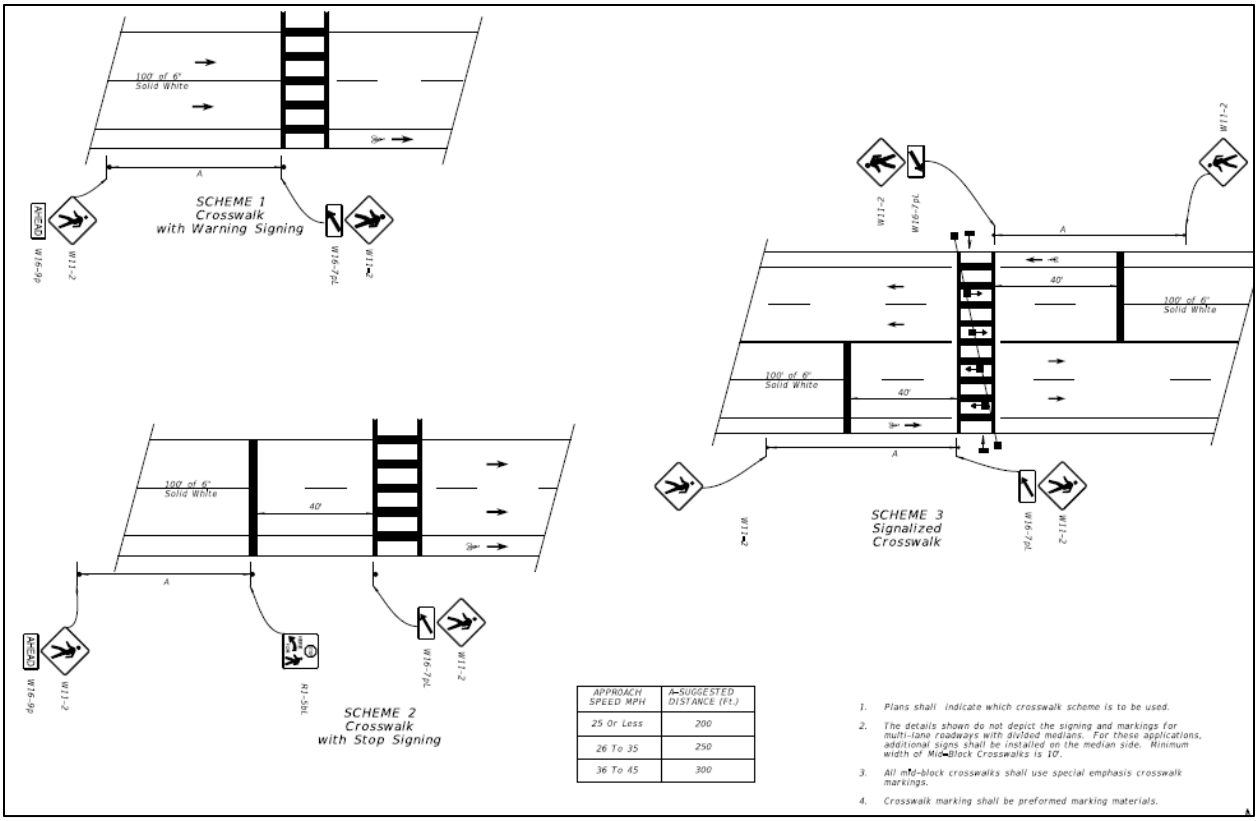

Figure 6: Florida's Design Standard for Midblock Crosswalks

FDOT Standard Specifications for Road and Bridge Construction

Section 700-1.2.4 of the January 2018 *FDOT Standard Specifications for Road and Bridge Construction* specifies that "Type IV yellow-green fluorescent sheeting is used for school S1-1, S3-1, S4-3, S4-5 and supplemental panels used with S1-1 signs. Do not mix signs having fluorescent yellow-green sheeting with signs having yellow retroreflective sheeting." Type IV is a proven and nationally recognized standard developed by the American Society for Testing and Materials (ASTM). Therefore, the materials for all school crossing signs in Florida are required to meet this national standard.

FDOT Traffic Engineering Manual (TEM)

The FDOT Traffic Engineering Manual (TEM), version dated November 2017, contains guidance and requirements for various Florida-specific traffic engineering topics including signing and marking treatments for crosswalks and pedestrian routes. The TEM requirements apply to all state roads and is encouraged but elective for use on local roads by the local agency.

Sections 3.6 through 3.8 of the TEM include specific treatments and devices for use when conditions are met, such as optional use of Rapid Rectangular Flashing Beacons (RRFBs), in-pavement lighting or a pedestrian signal control. *Section 3.8 Marked Pedestrian Crosswalks at Midblock and Uncontrolled Approach Locations* establishes criteria for the consistent installation and operation of marked pedestrian crosswalks at midblock and unsignalized intersections on the State Highway System.

FDOT Speed Zoning Manual for Roads, Highways and Streets (SZM)

The FDOT *Manual on Speed Zoning for Highways, Roads, and Streets in Florida* (SZM), Revision 7/2017 is adopted for use on all roadways in Florida through Rule 14-15.012, F.A.C. The newest edition of the SZM contains information concerning requirements for school areas, school crossings and school zones (Chapter 15). These requirements apply to all roads in Florida.

The SZM chapter for school zones and crossings include guidance for when reduced speed school zones are warranted and illustrates placement of signage and marking requirements at and in advance of school crossings that are within designated school zones or school areas.

Illustrations of signing and marking requirements for school crossings from Chapter 15 of the SZM are included in ***Appendix C***.

5.3 Safety and Behavior-Based Research

A location within the roadway established as a 'marked' crosswalk has many implications, including the potential for a statistically significant increase in pedestrian crash rates over unmarked crossing locations (Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations: FHWA-RD-01-075), given certain conditions. Additional considerations when deciding to mark a crosswalk location should also account for adequate crosswalk warning signage, need for traffic control devices, established walking paths or routes, level of community awareness and proper education for both the pedestrian and driver.

One of the most comprehensive research publications to date includes '*An Evaluation of Pedestrian-Related Roadway Measures: A Summary of Available Research',* published for FHWA (DTFH61-11-H-00024) in 2014. This publication provides a detailed summary of all major research publication results and findings over the last fifteen years. It indicates several studies that provide high emphasis markings increase driver awareness and quicker recognition of the crossing location.

Additional findings from these sources suggest that pedestrian refuge islands, raised crosswalks, and traffic control features such as pedestrian signals have the ability to increase safety by improving crosswalk conspicuity or slowing traffic speeds. Other more recently developed crosswalk treatments, such as 3-Dimensional (3D) pavement markings and special patterns for crosswalks have not been fully tested or studied thoroughly enough to evaluate safety and pedestrian/driver behavior effects, as well as maintenance requirements and costs. A summary of major research findings is included in ***Appendix C***.

5.4 Other State Standards

There are generally variations from state to state with the types of high visibility or special emphasis crosswalk treatments that are used; however, due to the recognized increased safety benefits from high emphasis marking patterns, most areas are beginning to make high emphasis crosswalks their

standard. Overall, Florida has adopted this approach when certain conditions are met and this appears similar with other states' standards for when to mark a crosswalk or when to use high emphasis crosswalk markings.

According to the 1996 California Traffic Design Standards, "*Whenever a marked pedestrian crosswalk has been established in a roadway contiguous to a school building or the grounds thereof, it shall be painted or marked in yellow…",* which is also noted in the 2015 CalTran Standard Crosswalk Drawings. Standard illustrations from both references are included in ***Appendix C***.

A few states and larger cities have developed additional standards for crosswalk markings that are noteworthy for this report. For example, in 2012, the City of Sacramento developed its own standard high visibility pattern for uncontrolled locations called the 'triple-four' pattern, which is shown in ***Figure 7***. The City has implemented this treatment citywide, involving three four-foot segments, two dashed lines on the outside with a clear space in the center to direct pedestrian traffic.

Figure 7: Example of "Triple Four" Crosswalk Pattern

The City of Portland, Oregon has used green colored pavement markings since at least 2013 to indicate bicycle crossings, with this combination cycle/pedestrian crossing shown in ***Figure 8*** located near downtown.

Figure 8: Example of Multi-Use Crosswalk in Portland, Oregon (2013)

Additionally, the 2015 edition of the Arlington County, Virginia Traffic Engineering and Operations (TE&O) Construction Standards provides a decision matrix for selecting crosswalk treatment options depending on roadway configuration, traffic volumes and posted speeds, which is similar to the FDOT TEM Section 3.8 overview of the crosswalk treatment decision process. Pedestrian crossing criteria at crosswalks for all 50 States (2016) can be found at the following internet link: (http://www.ncsl.org/research/transportation/pedestrian-crossing-50-state-summary.aspx).

5.5 Innovative Practices

In addition to standards used in other states, innovative practices and experimental treatments were also documented in support of this report. The term innovative practice refers to signing or marking of crosswalks using experimental materials, patterns or colors as well as non-standard practices found in other countries.

MUTCD Request to Experiment (RTE) Database

Several states are practicing innovative ideas for crosswalk treatments. In Florida, most recently in November of 2017, FHWA approved FDOT to experiment with the placement of In-Street Pedestrian Signs (MUTCD R1-6) in a 'Gateway' configuration at 24 marked crosswalk locations throughout Florida. This RTE is scheduled to begin in January 2018 and will last approximately 36 months. Results of this RTE will be used statewide and nationally to support the potential benefits toward driver yielding rates when using the R1-6 Gateway configuration. Detailed information on this RTE can be found in ***Appendix C.***

In other examples, California has also begun implementing its version of the high visibility 'triple four' crosswalk markings. It is a 4' x 4'x 4' pavement marking design that combines the bars and the continental styles. Also in school zones, California is using yellow crosswalks and stencils. A previous Ohio (ODOT) RTE utilized a new type of painted crosswalk where multicolored paint was used to create an optical illusion of a three-dimensional raised surface when viewed from the perspective of drivers. The early results of the study indicated slightly better vehicular yielding rates shortly after installation. After some time, drivers appeared used to the new crossing and crosswalk yielding rates were similar to other standard crosswalk patterns.

Chicago also conducted a traffic control measure evaluation where they experimented with the use of Yellow-Green pavement markings; however, the results did not indicate a significant reduction in speeds with the combination of yellow/green pavement markings for crosswalks, centerlines, stop lines, and school legends.

Several other RTE's are available from Florida and other states that are either still being conducted or have been included in the 2009 MUTCD as an optional practice. A complete list of active RTE's available from the MUTCD website is included in ***Appendix C*** for further reference.

Other Innovative Practices

In addition to MUTCD requests to experiment, innovative practices from other states and countries have been documented for inclusion in this report. Many states and other countries are also experimenting with alternate crosswalk patterns and markings. For example, Florida and other states are using inlaid thermoplastic materials and other similar products shown in ***Figure 9***. This type of material is currently approved for use in Florida under Standard Specification 528 and found on the FDOT Approved Products List (APL); however, these are only used for decorative applications since the inlaid material must not be retroreflective in accordance with official FHWA rulings. ***Figure 9*** (Photo Left) shows a manufacturer's design which it refers to as "safe schools" pattern, while photo right shows a multi-use trail crossing in Indianapolis, Indiana.

Figure 9: Decorative Inlaid Thermoplastic Designs

Based on limited testing throughout the country, these inlaid materials and colored patterned products have not been proven to provide any measurable safety benefits, with results indicating it may require further testing under experimental circumstances. Additionally, long-term wear and maintenance expenses are a major concern with in-laid materials. ***Appendix D*** provides additional information.

Internationally, a town in Iceland has created the country's first 3D pedestrian crossing after being inspired by similar projects in New Delhi, India and China. The scheme, shown in ***Figure 10***, is intended to slow down drivers speeding through the town, as stated in the recent Twitter article dated October 30, 2017. While these types of 3D patterns are new, there is a lack of verifiable research findings that indicate long-term safety benefits and maintenance requirements by using these innovative types of patterns.

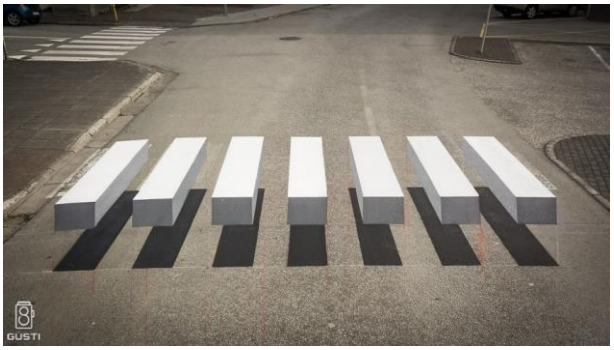

Figure 10: Experimental 3D Crosswalk Marking Pattern (Iceland)

The City of Tacoma, Washington, has also recently instituted an experimental program for new crosswalk markings to help with traffic calming measures. The colorful pattern, shown in ***Figure 11***, has been installed at several neighborhood crosswalks using temporary paint as a measure to initiate testing and community awareness. Results are currently unavailable as to the success or efficacy of this experiment.

Figure 11: Experimental Crosswalk Markings in Tacoma, WA.

In addition to experimenting with different crosswalk markings, some agencies are including policy measures to help improve pedestrian safety. As part of the WALKArlington pedestrian initiative, the Arlington County Board approved a new ordinance to designate certain crosswalks in the County where motorists who fail to yield the right of way to pedestrians can be fined from $100 to $500. The ordinance provided Arlington County Police a significant enforcement tool and was intended to make motorists more aware of their responsibility to yield the right of way to pedestrians at crosswalks.

To address unique needs for a high pedestrian traffic, mid-block crosswalk, the Ballston Mall in Arlington County uses a system consisting of Light Emitting Diode (LED) lights embedded in the pavement and a passive laser-based detection system. When a pedestrian enters through the laser beam, the flashing amber colored LED lights are activated for the appropriate direction of traffic. While in-pavement lighting is a standard allowable practice under the MUTCD, passive detection devices are still considered experimental. Florida is also currently experimenting with similar passive pedestrian technology applications that will enhance the optional treatments available for appropriate crosswalk locations.

In certain high pedestrian activity locations where the speed of traffic is greater than 30 mph, Arlington County has also employed the use of fluorescent yellow-green u-post inserts in addition to the crosswalk warning signs to increase sign visibility and further highlight the pedestrian crosswalk. This type of treatment is used only at unsignalized/mid-block crossings and is shown in ***Figure 12***.

Figure 12: Example of a Reflective Sign Post Treatment

6.0 OPPORTUNITIES AND RECOMMENDATIONS

Considering the number of crosswalk locations within 1-mile of all schools, developing a new uniform system of high-visibility markings and signage for crosswalks on arterial and collector roads within 1-mile of all schools could be a complex and costly effort. Options to meet requirements of HB 493 include improving existing crosswalk conditions to meet current FDOT standards to developing new experimental treatments specifically for school crosswalks. As a point of reference, spending an average of $5,000 in enhancements for existing crosswalks on arterial and collector roads within 1-mile of all schools statewide, both on and off-system, is estimated to cost over $1.1 billion.

Given these factors, a tiered approach incorporating programmatic (statewide) options for a uniform system of crosswalk markings for schools is presented in this report. The tiered approach starts with opportunities, costs and challenges associated with meeting current state standards and expands to include experimental and policy-related enhancements under subsequent tiers or 'levels', which may require longer-term investments. ***Appendix D*** provides additional details for the Tiered approach, including pro's and con's (opportunities and challenges) for three optional treatments for potential testing and case-study.

Tier 1: Refurbish Crosswalks to Meet Current Florida Standards

Implementing a high-visibility system of markings and signage for crosswalks on arterial and collector roads within 1-mile of all schools could begin with evaluating compliance with current standards, including a programmatic approach to re-marking and signing crosswalks to meet current FDOT standards. Based on field verification of existing crosswalks, a statistically significant portion of existing crosswalk markings (up to 69%) have the appearance of being moderately to extremely worn. This suggests that these crosswalks may not be adequately visible and could be of sufficient age they are no longer considered to meet current FDOT standards.

Florida, as compared to other states, also has robust crosswalk standards and guidelines to provide consistency for marking crosswalks and school crossings. However, these standards were not always found in the field. Reasons such as crosswalk age and maintenance of crosswalk features appear to be the two most common reasons for variability in crosswalk conditions. Therefore, improving the condition of

crosswalks to meet current standards is likely to provide a baseline improvement over existing conditions to safety and driver behavior throughout Florida (17).

The Tier I approach would seek to implement the following existing FDOT standards for on-system crosswalk locations:

1. Special Emphasis markings for all crosswalks at all signalized intersection approaches, all mid-block crossings and all crossings in school zones or school areas.
2. Upgrade all W11-2 and S1-1 signs using Type IV fluorescent yellow-green (FYG) sheeting for all school area crosswalks.

Using planning-level cost estimate projections, ***Table 5*** identifies potential costs associated with improving the condition of crosswalks to meet current FDOT standards. This assumes approximately 69% of all crosswalks within 1-mile of schools would receive new markings and signage upgrades to meet current FDOT standards. Tier I does not include evaluating changes to existing crosswalk standards at this time. As a result, enhancements under Tier I may be limited to crosswalks on the state highway system and off-system roads where the local agency uses current FDOT standards. To develop planning-level costs for Tier I, the most recent FDOT unit prices were used to estimate special emphasis markings and signage for a typical crosswalk crossing 3-lanes of traffic, which is the average crosswalk length obtained through the field verification exercise.

Facility Type (Arterials & Collectors)	Percent of Crosswalks	Tier I Crosswalk Locations*	Planning Level Costs (millions)
State Highway System	37%	55,000	$165 M
Off-System (Local)	63%	93,000	$279 M
Total	**100%**	**148,000**	**$444 M**

Table 5: Summary of Statewide Crosswalk Estimates by Facility Jurisdiction
*(*Median Value of Crosswalks without Standard Deviation)*

The likely implementation strategies for Tier I should account for roadway resurfacing cycles to achieve a balance between the desire for a uniform system and the projected statewide costs associated with this approach. If incorporated into already programmed roadway resurfacing projects, implementation costs are significantly less. However, implementation timeframe may be much longer. Additionally, these planning-level cost projections are based on FDOT standards for special emphasis markings and advanced warning signs, which some counties and municipalities may not be prepared to implement or may require assistance to achieve the desired results.

Tier II: Identify Opportunities for Enhancements to Current Standards and Practices

A number of counties and municipalities in Florida require minimum MUTCD compliance for crosswalk marking treatments on roadways within their jurisdictional control, which includes the use of standard

12-inch white parallel crosswalk lines and highway paint, rather than special emphasis patterns and thermoplastic markings as required by FDOT.

Using accepted research findings, the appearance and style of crosswalk pattern directly correlates to earlier driver recognition of the crosswalk area (17); therefore, an opportunity to enhance or create more uniformity for crosswalk markings would be to establish a required statewide standard for designated school crossings that must be followed by all jurisdictions in Florida. This recommendation has far-reaching implications that should be fully vetted with local agency partners to understand the impacts and challenges with instituting new statewide standards for school crosswalks on off-system roads. Potential examples for implementing Tier II opportunities include developing or clarifying specific standards for school crosswalks, including:

- ***Designate all marked crosswalks on arterial and collector roads within 1,000 feet of any school as a "school crossing".*** Currently, the state of Florida does not have such designation for crosswalks within a certain distance of schools. Selecting 1,000 feet as the threshold distance for designating a school crossing is consistent with how the Highway Safety Manual (HSM) uses the 1,000-feet threshold for such things as bus stops or alcohol sales establishments when calculating predicted crash frequencies.
- ***Develop specific signing and marking standards for crosswalks designated as school crossings.*** FDOT requires special emphasis markings and FYG sign sheeting for crosswalks near schools or within school zones, but does not clearly define how or when to designate these crossings. The SZM also has specific signing requirements for crosswalks within school areas and school zones, but does not require those standards when not within a school area or school zone.
- ***Develop required and optional treatments specifically for crosswalks designated as school crossings.*** Currently, FDOT and other states list their required and optional treatments for marked crosswalks in terms of site characteristics (i.e. traffic volumes, speeds, pedestrian volumes and other characteristics). Enhancing existing SZM or TEM sections to include specific treatments for school crossings could also help achieve uniformity.

The following FDOT documents, publications and/or programs have been identified as opportunities to include enhancements to existing standards:

FDOT Design Manual (FDM) and Standard Plans – Enhancing language within the FDM to clarify special emphasis crosswalks as the required standard, with allowances for the transverse 12" standard white lines where engineering judgement deems appropriate could offer opportunities to improve uniformity in crosswalk patterns. This approach is similar to other states that have adopted more stringent language for requiring high emphasis markings for crosswalks.

FDOT Traffic Engineering Manual (TEM) – Chapter 3 of the TEM includes specific guidance on selecting crosswalk controls and optional treatments. Detailed information on selecting optional treatments specifically for school-related crosswalks could enhance the application of these standards found in the TEM. Additional guidance on roadway types, speeds, traffic volumes and other characteristics could be added in the form of a decision matrix to enhance or clarify requirements and optional treatments, such

as when to use optional beacons and signage with school crosswalk locations. A similar example from Arlington County, VA is included in ***Appendix C***.

Speed Zoning Manual (SZM) – Chapter 15 of the SZM defines school areas, crossings and school zones in general terms. Language could be added to define a school crossing as any crosswalk within a specified distance from school grounds (i.e. 1,000 feet) as a designated school crossing, thus making it eligible for specific standards applied to these types of crosswalks in the future. The SZM holds requirements for all roadways, not just for the state highway system, which makes it a viable option for enhancements to school crossing requirements statewide.

As similar with the TEM, the SZM holds language for optional treatments that are left up to the decision maker to decide if they are appropriate to use under certain circumstances. Language to clarify the use of optional treatments for school crossings, such as the use of R1-6c In-Street school children signs for high student volumes as an example, could be instituted within the SZM to help provide additional uniformity with school crossings.

Safe Routes to School (SRTS) Program – As another example, FDOT's Safe Walking Routes to School (SRTS) Program, which is administered as a Federal-Aid grant program through the Fixing America's Surface Transportation (FAST) Act passed by Congress in 2016, provides funding for local agencies to add sidewalk and crosswalk enhancements to support safe walking routes for students. To qualify for funding under the SRTS program, sidewalk and crosswalk requests must be within 2-miles of a school and applications are submitted by the roadway maintaining agency with required detailed information on walking routes, school administered surveys of student walking patterns and verified cost estimates and concept plans.

However, the FDOT SRTS program does not currently contain specific requirements or recommendations for designating certain crosswalks as part of the safe walking route identification process as 'school crossings'. An opportunity to enhance the SRTS program may be available by requiring all crosswalks within the designated walking routes for each SRTS application to be identified as 'school crossings' and therefore meet any FDOT standards for such crossings. If standard school crossing treatments are developed for use on the state highway system, they can be implemented in coordination through the SRTS program and required for all crosswalks within the safe walking route through the application process. Since this is a federal grant program, additional discussions may be required to fully explore using the SRTS grant program as an opportunity to improve school crossing uniformity throughout Florida.

Statewide costs for undertaking Tier II enhancements have not been calculated for this report. These opportunities are recommended for further consideration in coordination with FDOT Districts and Florida's local agencies to fully understand the implications.

Tier III: Identify Innovative or Experimental Opportunities for School Crosswalk Enhancements

Based on the lack of robust industry research for supporting safety benefits of newer and more innovative crosswalk treatments, Tier III recommendations include opportunities for Florida to continue evaluating

additional experimental treatments and supporting research used to justify statewide enhancements in the future. These opportunities include:

Testing of New Experimental Crosswalk Patterns – The new pattern referred to in other states as the 'triple four' appears to have favorable initial results from other areas where this pattern has been used. FDOT could apply for a new RTE to try new crosswalk patterns at controlled environments to conduct testing and evaluation of this pattern in Florida. Additional opportunities to experiment with crosswalk enhancements will include considerations for:

- Symbology Patterns – Testing new or different symbols within the crosswalk's high emphasis pattern specifically for school crossings or crosswalks within a certain distance of a school.
- Color Schemes – Testing alternate color patterns within the crosswalk area for designating school-related crosswalks. The MUTCD currently allows experimentation of muted or subdued colors that do not detract from the white retroreflective color required by the MUTCD for all marked crosswalks. According to FHWA Official Ruling 3(09)-24(I), "…subdued-colored aesthetic treatments between the legally marked transverse crosswalk lines are permissible provided that they are devoid of retroreflective properties and that they do not diminish the effectiveness of the legally required white transverse pavement markings used to establish the crosswalk."
- Crosswalk Approach Area – Experimenting with new treatments to the crosswalk approach (in advance of the crosswalk) including center line or advanced warning. Although these treatments may already be allowed through the MUTCD, this area seeks to focus on applying them directly to school-related crosswalks.

Testing of New Experimental Crosswalk Devices – The FDOT operates the statewide Traffic Engineering Research Laboratory (TERL), which is the state's testing and proving ground for all traffic control devices before they are approved for use in Florida through the FDOT Approved Products List (APL). Current TERL programs include testing and evaluation of experimental pedestrian detection devices, wireless sensor in-pavement lighting and other crosswalk-related devices. For example, FDOT plans to test Type XI retroreflective sign sheeting with the fluorescent yellow-green (FYG) sign color to evaluate performance and service life.

Tier III enhancements require additional studies, experimentations and coordination with FHWA, which FDOT already conducts on a regular basis for ongoing and planned RTE's approved through the MUTCD. Tier III also identifies opportunities to submit RTE's as additional innovative treatments become available for large-scale testing. ***Appendix D*** provides example information for developing three optional treatments for further study in Florida.