

Sidepath Application Criteria Development for Bicycle Use

Final Report – June 29, 2018

Prepared for:

The Michigan Department of Transportation

Prepared by:

Toole Design Group, LLC
Rebecca Sanders, Ph.D.
Hannah Pritchard, P.E., PTOE

Wayne State University
Steven Remias, Ph.D.



TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. SPR-1675	2. Government Accession No. N/A	3. Recipient's Catalog No. N/A	
4. Title and Subtitle Sidepath Application Criteria Development for Bicycle Use		5. Report Date June 29, 2018	
		6. Performing Organization Code N/A	
7. Author(s) Rebecca Sanders, Ph.D., Hannah Pritchard, P.E., PTOE, Steven Remias, Ph.D.		8. Performing Organization Report No. N/A	
9. Performing Organization Name and Address Toole Design Group, LLC 8484 Georgia Ave, Suite 800 Silver Spring, MD 20910		10. Work Unit No. N/A	
		11. Contract or Grant No. 2016-0274	
12. Sponsoring Agency Name and Address Michigan Department of Transportation (MDOT) Research Administration 8885 Ricks Road P.O. Box 33049 Lansing, Michigan 48909		13. Type of Report and Period Covered Final Report, 6/1/2016 to 6/30/2018	
		14. Sponsoring Agency Code N/A	
15. Supplementary Notes Conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. MDOT research reports are available at www.michigan.gov/mdotresearch . Alternate title: Development of Differential Criteria for Determining Appropriateness of Sidepath Applications for Bicycle Use Project website: www.michigan.gov/mdot-SidepathResearch			
16. Abstract This project included a crash analysis, resident survey, the development of a practitioner guide titled "Sidepath Intersection and Crossing Treatment Guide," (the Guide) and the development of educational materials for Michigan practitioners and residents. An in-depth crash analysis was performed to understand the impacts of design, land use, traffic volumes, speeds, and other relevant variables on crash risks for bicyclists on sidepaths to characterize bicycle crashes in two Michigan Counties. An address-based survey (n=351) was conducted in fall 2016 to investigate attitudes toward bicycling among drivers and bicyclists, bicycling habits, barriers to bicycling, and roadway design preferences regarding bicycle infrastructure in Michigan. Using the results from the preference survey and the crash analysis, the team developed the Guide to lay out a straight-forward process for integrating best practices in sidepath design into a proposed roadway project. Five informational sheets were developed for distribution to drivers, bicyclists, and practitioners summarizing the findings of the crash analysis and best practices for driving and bicycling behaviors around sidepaths.			
17. Key Words Bicycles, bikeways, sidepaths, crosswalks, crash analysis, surveys, guidelines		18. Distribution Statement No restrictions. This document is also available to the public through the Michigan Department of Transportation.	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 43	22. Price N/A

Disclaimer

This publication is disseminated in the interest of information exchange. The Michigan Department of Transportation (hereinafter referred to as MDOT) expressly disclaims any liability, of any kind, or for any reason, that might otherwise arise out of any use of this publication or the information or data provided in the publication. MDOT further disclaims any responsibility for typographical errors or accuracy of the information provided or contained within this information. MDOT makes no warranties or representations whatsoever regarding the quality, content, completeness, suitability, adequacy, sequence, accuracy or timeliness of the information and data provided, or that the contents represent standards, specifications, or regulations.

Acknowledgements

The authors would like to acknowledge the assistance and support of the following individuals:

Rob Burchfield, P.E. – Toole Design Group
Bill Schultheiss, P.E. – Toole Design Group
Belinda Judelman, MURP, Toole Design Group
Ashley Haire, Ph.D., P.E., Toole Design Group
Darren Flusche, MPP, Toole Design Group
Jesse Boudart, P.E., Toole Design Group

Carissa McQuiston, P.E. – Nonmotorized Safety Engineer
Deb Alfonso – Supervisor Intermodal Services Unit
Jason Latham – Planning Manager, Southwest Region
Suzette Peplinski, P.E. – Traffic, Safety and Operations Engineer, Grand Region
Tom Pozolo – P.E. – Operations Engineer, Oakland TSC Metro Region
Brian Pawlik – Bicycle and Pedestrian Planner, Southeast Michigan Council of Governments

Table of Contents

Executive Summary	1
Key Research Findings.....	2
Sidepath Intersection and Crossing Treatment Guide	3
Educational Materials	5
Conclusion.....	5
Chapter 1 – Introduction and Project Overview	6
1.1 Report Overview	6
1.2 About the Research Team	7
Chapter 2 – Overview of Crash Analysis and Key Findings.....	8
2.1 Statewide Bicycle Crash Analysis	8
Data Collection and Methodology	8
2.2 Case-Control Analysis	8
Data Collection and Methodology	8
2.3 Oakland and Kent Counties Analysis	9
Data Collection and Methodology	9
2.4 Key Findings.....	10
Statewide Analysis	10
Case-Control Analysis.....	11
Oakland and Kent County Analysis.....	11
2.5 Conclusions	13
Chapter 3 – Overview of Survey Methodology and Key Findings.....	14
3.1 Methodology.....	14
Survey Construction and Recruitment.....	14
Respondent Cyclist Typology	14
3.2 Key Findings.....	15
Participant Characteristics.....	15
Barriers for Bicycling.....	15
Factors That Encourage More Bicycling.....	15
Comfort and Roadway Design	16
3.3 Conclusions	17
Chapter 4 – Overview of Sidepath Intersection and Crossing Treatment Guide Development Process	18

Side Path Application Criteria Development for Bicycle Use

4.1 Development of the Guide	19
4.2 Designing for Conflicts with Turning Vehicles	19
4.3 Designing for Contra-Flow Bicycle Traffic	20
4.4 Guide Application.....	20
4.5 Conclusions	22
Chapter 5 – Overview of Educational Materials Development Process	23
5.1 Fact Sheet Process	23
Determining the Content	23
5.2 Video Script Development Process	24
Chapter 6 – Conclusion.....	25
Appendix A. Educational Cut-Sheets	26
Appendix B. Sidepath Safety Research Video Script	27

Figures in Report

Figure 1. Example Sidepath in Context	1
Figure 2. Sidepath Design Process	3
Figure 3. Tier I Driveway Intersection Treatment, Medium Usage.....	4
Figure 4. Bicycle Crash and Injury Severity by Month	10
Figure 5. Bicycle Crash Severity and Location.....	11
Figure 6. Injury Severity for Bicycle Crashes on Sidepaths/Sidewalks Compared to Roadways	11
Figure 7. Number of Crashes Based on AADT of Crossing Street	12
Figure 8. Crash Type Diagram of a Motorist Drive-Out Crash.....	12
Figure 9. Factors That Encourage Bicycling More Often	16
Figure 10. Roadway Design Preferences by Percentage of Respondents Who Would Feel Comfortable Bicycling in Various Scenarios.....	17
Figure 11. Example Sidepath in a Suburban Context	18
Figure 12. MUTCD R10-15 Turning Vehicles Yield to Pedestrians and Bicyclists Sign	19
Figure 13. Colorado DOT’s Non-MUTCD Sidepath Warning Sign.....	20

Side Path Application Criteria Development for Bicycle Use

Figure 14. Tier I Driveway Intersection Treatment, Medium Usage22

Tables in Report

Table 1. Tier I Facility - Driveway Intersection, Medium Usage 4

Table 2. Top Ranked PBCAT Classifications for Bicycle Crashes Traveling Against Traffic on Sidepaths/Sidewalks..... 13

Table 3. Top Ranked PBCAT Classifications for Bicycle Crashes Traveling with Traffic on Sidepath/Sidewalks..... 13

Table 4. Tier I Facility - Driveway Intersection, Medium Usage21

Executive Summary

Sidepaths are used throughout the state of Michigan to provide a separated pedestrian and bicycle facility for nonmotorized users. These facilities are often constructed adjacent to state or county roads and are generally implemented when roadway modifications are made. Sidepaths provide more separation than on-street bicycle facilities and have the potential to create a comfortable environment for bicyclists when well-designed. However, past research has not been clear on sidepath safety, resulting in some hesitation for building them – regardless of community desires.

More recent research by Petritsch et al. (2006)¹ created a sidepath safety model focusing on facility width, distance from roadway, posted roadway speed, and number of road lanes in Florida. The model showed that sidepaths with 7-foot widths were the safest facility design. The model also showed that sidepaths on roadways with speed limits higher than 45 mph should have more separation from the roadway, whereas sidepaths located on roadways with speed limits less than 45 mph can be closer to the roadway. These buffer distances are necessary in order to provide a higher level of safety.

Lusk et al. (2013)² analyzed and compared bicycle facility guidelines from 1972 to 1999 for cities in the United States. They also analyzed cycle track design and crash history for 19 locations. They found that AASHTO guidelines against the use of cycle tracks are not based on in-depth or current research. Through their research, they were able to show that the crash rate for cycle tracks is 2.3 per million bicycle kilometers, far lower than the current published values for on-road cycling crash rates.

In addition to a lack of clarity in research findings, no notable studies of sidepath safety have been conducted in Michigan. To fill this existing gap in research and support their sidepath efforts, the Michigan Department of Transportation (MDOT) funded the Development of Differential Criteria for Determining the Appropriateness of ‘Side-Path’ Applications for Bicycle Use in 2016. The purpose of this project is to explore Michigan residents’ bicycle facility preferences and attitudes and behaviors

Figure 1. Example Sidepath in Context



¹ Petritsch, T.A., B.W. Landis, H.F. Huang, S.K. Challa. Sidepath safety model – bicycle sidepath design factors affecting crash rates. In *Transportation Research Record 1982*, TRB, National Research Council, Washington, D.C., 2006. pp. 194–201. doi: <http://dx.doi.org/10.3141/1982-25>.

² Lusk, A. C., P. Morency, L. F. Miranda-Moreno, W. C. Willett, and J. T. Dennerlein. Bicycle guidelines and crash rates on cycle tracks in the United States. *American Journal of Public Health*: July 2013, Vol. 103, No. 7, pp. 1240-1248. doi: [10.2105/AJPH.2012.301043](https://doi.org/10.2105/AJPH.2012.301043).

toward bicycling, and to conduct primary research to understand bicycle crash characteristics along sidepaths in the service of better sidepath design guidance. Toole Design Group (TDG) led this effort, with Wayne State University as a key partner in conducting the sidepath safety analysis.

Key Research Findings

The research team conducted a safety analysis with six years of bicycle-related crashes occurring in Kent and Oakland counties. Due to constraints in crash data report descriptions as well as usage patterns in the area, sidepath crashes and sidewalk crashes were combined into one crash category. Below are the five statistically significant trends found in the data.

- Bicyclists riding against traffic are at higher risk than those riding with traffic.
- In particular:
 - Bicyclists riding against traffic have a higher risk of crashes with right-turning vehicles.
 - Bicyclists riding against traffic have a higher crash risk at commercial driveways and signalized intersections.
- Bicyclists riding through signalized intersections have a higher risk than at intersections with other types of traffic control, which may be due in part to higher vehicle volumes at those intersections.
- At signalized and unsignalized intersections, sidepath/sidewalk bicycle crashes tend to occur with left- or right-turning vehicles.

The research team also conducted a survey of Michigan residents to understand roadway design preferences when bicycling with children, bicycling alone, and driving on multi-lane, commercial streets. The findings overwhelmingly suggested a preference for more bicycle accommodations, and more separated facilities in particular. Seventy-five percent of all survey respondents indicated that the installation of separated bicycle facilities would encourage them to bicycle more, with almost twice as many rare cyclists (those who bicycle occasionally, but less than once a month) choosing separated bike facilities over more facilities in general.

Relatedly, safety concerns, distance, and weather appeared to be the most limiting barriers for all cyclist types. Nearly 89 percent of respondents reported that safety concerns about riding in fast and/or busy traffic at least somewhat limited their ability to bike to work or school, with 68 percent saying that safety concerns limited them “quite a lot” or “absolutely.” As expected, frequent cyclists were less likely to indicate barriers than other cyclists.

The presence of bicycle facilities also increases respondents’ comfort and willingness to try bicycling on a roadway. Most respondents would feel considerably more comfortable bicycling on a roadway with any type of bike facility over one lacking a bicycle facility, and this preference was even stronger when the facility was separated from drivers by a physical barrier. Separation was even more important when considering cycling with children, with comfort levels declining rapidly without separation from cars when children are considered. Respondents were also more likely to indicate comfort while driving with greater separation from bicyclists.

While the public clearly prefers separated bicycle facilities, such as sidepaths, bicyclists using these facilities can potentially experience conflicts with motorists, especially with left or right turning motorists at intersections. Armed with these findings, the research team developed the evidence-based Sidepath Intersection and Crossing Treatment Guide in an effort to guide decision-making and mitigate conflicts between sidepath users and motorists.

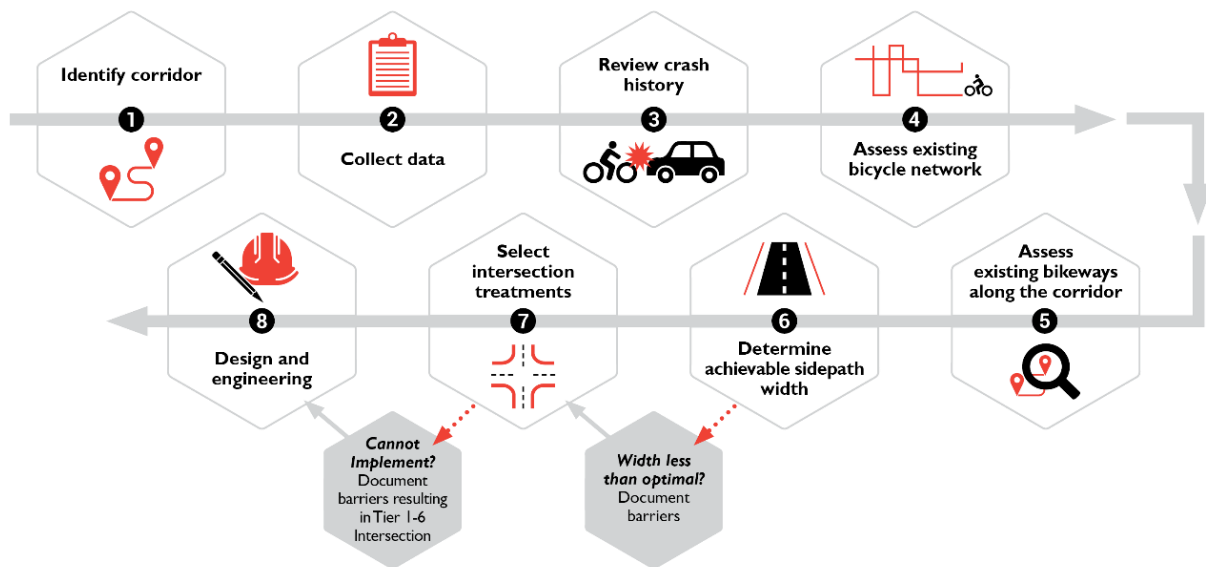
Sidepath Intersection and Crossing Treatment Guide

The Sidepath Intersection and Crossing Treatment Guide assumes that the designers have determined a sidepath is the desired facility to accommodate bicyclists in a given corridor; as such, this guide facilitates a method for selecting and designing appropriate sidepath infrastructure. The method can be replicated and tailored to each sidepath project and allows for the incorporation of sidepaths in primarily three different types of projects:

- A) New construction
- B) Reconstruction/expansion projects
- C) Construction projects within existing right of way

The flexible method described in the toolkit is shown in Figure 2 below.

Figure 2. Sidepath Design Process



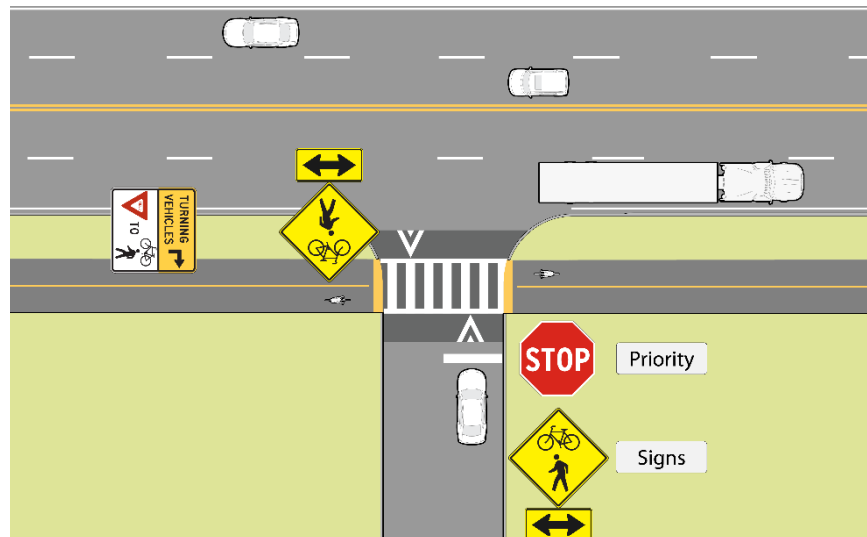
In addition to providing a replicable method, the toolkit provides intersection treatment practices that prioritize bicycle safety at the most crucial locations: where sidepath users interact with motorists. The team created a tiered system for intersection treatments, with the highest tier, Tier I, indicating the optimal sidepath intersection treatment. For instance, a Tier I intersection treatment for a driveway intersection with medium usage (10-50 vehicles per hour crossing a two-way sidepath) has a selection of elements and addresses the intersection treatment categories shown in Table 1 and Figure 3.

Sidepath Application Criteria Development for Bicycle Use

Table 1. Tier 1 Facility - Driveway Intersection, Medium Usage

Treatment	Intersection Treatment Category		
	Crossing Priority	Speed Reduction	Sidepath User Visibility
Motorist stop/yield signs - Bicyclists have priority through intersection.	✓		
Raised crossing - Motorists ramp up to sidepath by at least 6 inches and crossing hump is designed for 10 mph.		✓	✓
Signs - Sidepath user warning signs are provided to alert motorists to their potential presence.			✓
Striping - White pavement markings across the intersection crossing increase sidepath user visibility.			✓

Figure 3. Tier 1 Driveway Intersection Treatment, Medium Usage³



Optimally, motorist stop/yield signs should be installed at these intersections, which ensures bicyclists have crossing priority. A stop sign warrant should be performed. Raised crossings can also reduce speed and increase the sidepath user visibility. Signs indicating that sidepath users may be crossing an approaching intersection and striping across the intersection also help to increase the sidepath users' visibility.

³ As of June 2018, the use of the R10-15b as portrayed in Figure 3 is not consistent with the current MUTCD standards. This sign is currently only suggested for use at signalized intersections, and will require FHWA approval.

The described design process is intended to provide the designer with sufficient information to create an optimal sidepath design. However, no guide can anticipate every context or design situation, and engineering judgment should always be used when considering nonmotorized facilities.

Educational Materials

The project team also worked to create educational materials that MDOT can use to inform bicyclists and motorists about safe bicycling and driving practices on and around sidepaths. Combined with an educational video that MDOT plans to produce, these materials aim to build on the improvements in sidepath design by instructing and encouraging safe behavior.

Conclusion

This project used an in-depth crash analysis and survey of Michigan residents to clarify safety problems for sidepath usage and the larger transportation context in which sidepaths are a design option. The Sidepath Intersection and Crossing Treatment Guide and educational materials developed from the research will hopefully improve bicycling safety on these desirable facilities in Michigan and beyond.

Chapter 1 – Introduction and Project Overview

Sidepaths are used throughout the state of Michigan to provide a separated pedestrian and bicycle facility for nonmotorized users. These facilities are often constructed adjacent to state or county roads and are generally implemented when roadway modifications are made. In an effort to further understand the public's bicycle facility preferences, sidepath safety, and appropriate sidepath design, and to improve the selection of the most appropriate bikeway in conjunction with proposed roadway projects, in 2016 the Michigan Department of Transportation (MDOT) funded the Development of Differential Criteria for Determining the Appropriateness of 'Side-Path' Applications for Bicycle Use project (the Project). The resulting work supports evidence-based decision-making for the design and implementation of sidepaths and provides a body of educational materials for MDOT and other agencies to use to promote the safety of bicyclists.

1.1 Report Overview

The Project had four key components, each described in the following chapters in this report:

Chapter 2 - Sidepath Crash Analysis

This chapter provides an overview of the crash analysis conducted to examine bicycle crashes by facility type in Michigan. The crash analysis aimed to understand the impacts of design, land use, traffic volumes, speeds, and other relevant variables on crash risks for bicyclists on sidepaths. There were three components to the analysis:

- 1) A statewide analysis to understand general bicycle crash characteristics;
- 2) A case-control methodology for eight counties to conduct a bi- and multi-variate analysis to understand characteristics of bicycle crashes on sidepaths; and
- 3) An in-depth comparison of sidepath crashes to non-sidepath crashes in two high-crash counties in Michigan.

Chapter 3 – Residential Survey

This chapter gives an overview of the address-based survey (n=351) conducted in fall 2016 to provide insight that could inform the development of the ultimate sidepath Guide. In particular, the survey investigated attitudes toward bicycling among drivers and bicyclists, bicycling habits, barriers to bicycling, and roadway design preferences regarding bicycle infrastructure in Michigan. The survey was the first of its kind to explore design preferences while bicycling with children, bicycling by oneself, and driving.

Chapter 4 - Sidepath Intersection and Crossing Treatment Guide

This chapter provides an overview of the key deliverable of this project, the Sidepath Intersection and Crossing Treatment Guide. Using the results from the preference survey and the crash analysis, the team developed the Guide to lay out a straight-forward process for integrating best practices in sidepath design into a proposed roadway project.

Chapter 5 - Educational Materials

This chapter describes the process used to develop the fact sheets and a video script about bicycle safety aimed to educate both bicyclists and drivers on safe behavior.

The report concludes with a final concluding chapter and appendices for the educational materials.

1.2 About the Research Team

The research team consisted of Toole Design Group (TDG) and Wayne State University (WSU). TDG managed the project, conducted the survey and analyzed the data, and developed the Sidepath Intersection and Crossing Treatment Guide and related educational materials. WSU conducted the crash analysis and supported the survey. All efforts were reviewed and supported by Josh DeBruyn, MDOT's Pedestrian and Bicycle Coordinator, and the Research Advisory Panel.

Chapter 2 – Overview of Crash Analysis and Key Findings

WSU led a bicycle crash analysis to understand the impacts of design, land use, traffic volumes, speeds and other relevant variables on crash risk, particularly for bicyclists on sidepaths.⁴ The research had three components:

- 1) A statewide analysis to understand general bicycle crash characteristics;
- 2) A case-control methodology for eight counties to conduct a bi- and multi-variate analysis to understand characteristics of bicycle crashes on sidepaths; and
- 3) An in-depth examination of two high-crash counties to compare sidepath crashes to non-sidepath crashes.

2.1 Statewide Bicycle Crash Analysis

Data Collection and Methodology

To examine general bicycle crash characteristics, WSU obtained data from the Michigan Traffic Crash Facts website (www.michigantrafficcrashfacts.org). The Team aggregated data from the years 2010 through 2015 to understand temporal attributes of bicycle crashes, injury severity, roadway location, and demographics of those involved in crashes.

2.2 Case-Control Analysis

Data Collection and Methodology

WSU initially applied a simple case-control framework to eight counties with high bicycle-vehicle crash rates: Allegan, Kalamazoo, Kent, Macomb, Oakland, Ottawa, Washtenaw, and Wayne. Case sites were intersections with two or more bicycle crashes and control sites were intersections with one or no bicycle crashes. The team then compared the following characteristics from the case sites to the control sites, collected through state crash records, police crash reports and GPS location:

- Number and severity of bike crashes,
- Number and severity of car crashes,
- Vehicle AADT (annual average daily travel) for intersections,
- Bicycle volume (either manually collected or approximated using STRAVA data),
- Roadway geometry,
- Sidepath geometry,
- Crosswalk geometry,
- Miscellaneous geometry (e.g., land use and intersection angle for right turns), and
- Census data.

Each variable was analyzed to determine its relationship to crash outcomes.

The team then used multi-variate analysis to analyze the sub-selection of variables that appeared to have a significant correlation with crash outcomes. This closer look at how variables interact between case

⁴ Please see the final report for additional details, found at www.michigan.gov/mdot-SidepathResearch.

and control sites allowed the team to understand how combinations of variables may result in locations with a higher number of bicycle crashes. The multivariate analysis did not reveal any significant findings, so the team then employed a more in-depth case study approach, discussed further in the following section.

2.3 Oakland and Kent Counties Analysis

Data Collection and Methodology

Because multi-variate findings had limited significance, the research team implemented a case-study approach to further examine bicycle crashes on sidepaths. Two Michigan counties with high numbers of bicycle crashes and diverse geography were selected for this additional crash analysis: Oakland and Kent counties.

Crash Data

A total of 2,253 reports and their attendant crash descriptions were reviewed to obtain information on the types of facilities present and the actions involved in the bicycle crashes. The crash itself was given a three-digit coding as described by the Pedestrian and Bicycle Crash Analysis Tool (PBCAT). This coding was selected to best describe the situational aspects surrounding the crash and are listed below:

- 111 - Motorist Turning Error - Left Turn
- 112 - Motorist Turning Error
- 114 - Bicyclist Turning Error - Left Turn
- 115 - Bicyclist Turning Error - Right Turn
- 120 - Bicyclist Lost Control
- 130 - Motorist Lost Control
- 141 - Motorist Drive Out - Sign-Controlled Intersection
- 142 - Bicyclist Ride Out - Sign-Controlled Intersection
- 143 - Motorist Drive Through - Sign-Controlled Intersection
- 144 - Bicyclist Ride Through - Sign-Controlled Intersection
- 147 - Multiple Threat - Sign-Controlled Intersection
- 152 - Motorist Drive Out - Signalized Intersection
- 153 - Bicyclist Ride Out - Signalized Intersection
- 154 - Motorist Drive Through - Signalized Intersection
- 155 - Bicyclist Ride Through - Signalized Intersection
- 156 - Bicyclist Failed to Clear - Trapped
- 157 - Bicyclist Failed to Clear - Multiple Threat
- 211 - Motorist Left Turn - Same Direction
- 212 - Motorist Left Turn - Opposite Direction
- 213 - Motorist Right Turn - Same Direction
- 214 - Motorist Right Turn - Opposite Direction
- 215 - Motorist Drive-In / Out Parking
- 221 - Bicyclist Left Turn - Same Direction
- 222 - Bicyclist Left Turn - Opposite Direction
- 223 - Bicyclist Right Turn - Same Direction
- 224 - Bicyclist Right Turn - Opposite Direction
- 225 - Bicyclist Ride Out - Parallel Path
- 231 - Motorist Overtaking - Undetected Bicyclist
- 232 - Motorist Overtaking - Misjudged Space
- 235 - Motorist Overtaking - Bicyclist Swerved
- 241 - Bicyclist Overtaking - Passing on Right
- 800 - Unusual Circumstances
- 242 - Bicyclist Overtaking - Passing on Left
- 243 - Bicyclist Overtaking - Parked Vehicle
- 244 - Bicyclist Overtaking - Extended Door
- 250 - Head-on Bicyclist / Motorist / Unknown
- 311 - Bicyclist Ride Out - Residential Driveway
- 320 - Motorist Failed to Yield - Midblock
- 321 - Motorist Drive Out - Residential Driveway
- 357 - Multiple Threat - Midblock
- 400 - Bicycle Only
- 600 - Backing Vehicle
- 700 - Play Vehicle-Related

Geometry data

The following geometry variables were collected via Google Earth for all 2,253 bicycle crashes:

- Control type,
- Total lanes of roadway being crossed,
- Number of through/combined lanes,
- Number of designated left turns,
- Number of designated right turns,
- Number of entering lanes on crosswalk,

Sidepath Application Criteria Development for Bicycle Use

- Whether roadway is one-way or two-way,
- Presence of median-buffer lane,
- Number of lanes entering intersection,
- Number of left turns entering crosswalk,
- Number of right turns entering crosswalk,
- Number of through-lanes on adjacent roadway,
- One-way or two-way adjacent road, and
- Presence of opposing bicycle facility.

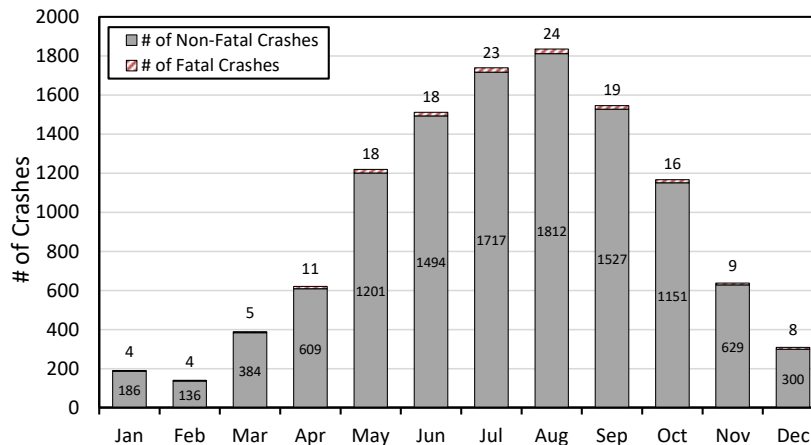
To the extent data was available, traffic volumes were also considered.

2.4 Key Findings

Statewide Analysis

Over the six-year period from 2010 to 2015 in Michigan, bicycle crashes increased as the months became warmer and decreased as temperatures dropped. Logically, this supports the notion that warmer weather tends to increase the volume of bicyclists and thus their exposure levels. The number of fatalities is dependent on overall crash numbers and ranged from 1.5 to 3 percent of overall crash totals. Higher fatality rates were observed in winter months when increased darkness and poorer weather conditions may contribute to increased crash risk due to visibility and braking issues (Figure 4).

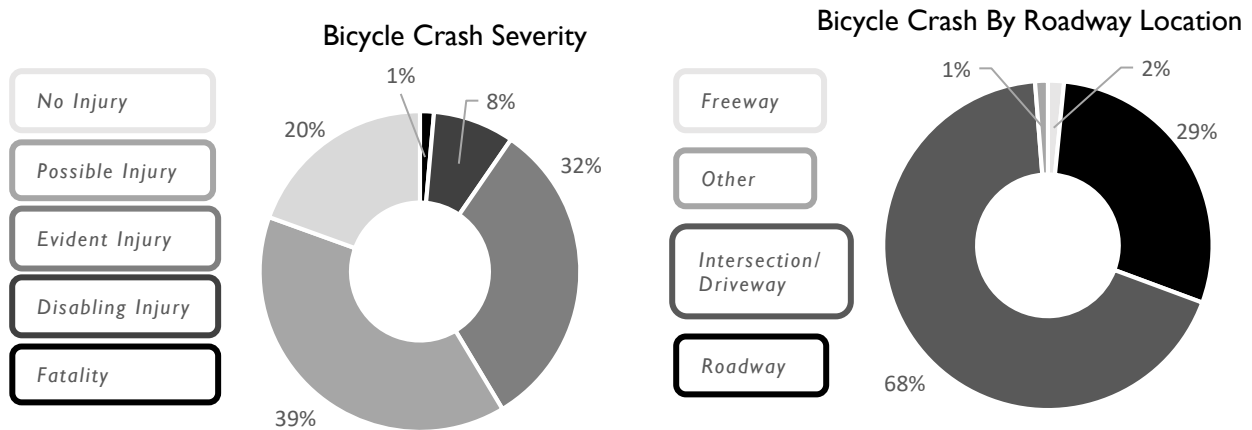
Figure 4. Bicycle Crash and Injury Severity by Month



The majority of crashes did not result in a severe or fatal injury. Of the 11,305 crashes that occurred statewide, 1,086 (9.6 percent) resulted in severe injury or death. In terms of the location of the crashes, two-thirds of all crashes occurred at roadway intersections or in driveway areas. Twenty-nine percent of all crashes occurred along the roadways. These values are seen in Figure 5.

Sidepath Application Criteria Development for Bicycle Use

Figure 5. Bicycle Crash Severity and Location



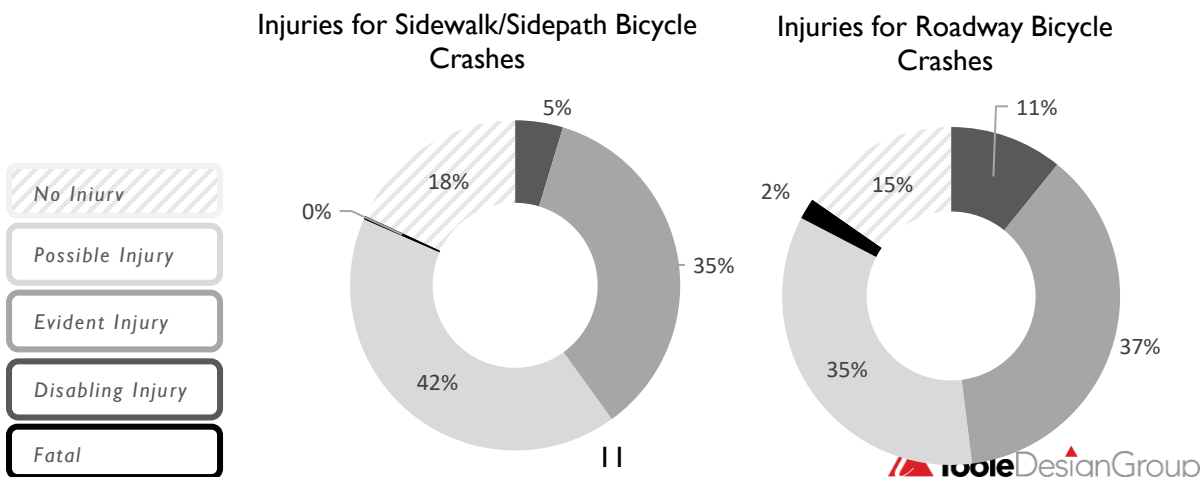
Case-Control Analysis

The initial case-control analysis indicated a significant relationship between an intersection having two or more bicycle crashes and several variables, including median presence, crosswalk presence, intersection curb presence, facility width, AADT, and multi-unit residential land use. Lack of a curb, the presence of multiple sidepaths, any adjacent land use, facility terminus, and a path distance from the roadway of 21 to 30 feet were found to be attributes of control sites, or safer intersections for bicyclists. However, the multi-variate analysis resulted in limited significant variables to make wide-scale transportation decisions. The lack of strong results from the multivariate analysis prompted a change in approach and supported using Oakland and Kent counties as in-depth case studies.

Oakland and Kent County Analysis

Analyzing Oakland and Kent counties in-depth gave the team an opportunity to understand more detail around bicycle crashes along sidepaths or sidewalks in comparison to roadways. Of the total crashes that occurred in both counties between 2010 and 2015, more crashes occurred on sidepaths and sidewalks (65 percent) rather than on roadways (31 percent). However, injury severity was more severe for those that occurred on roadways (Figure 6): 16 percent of roadway crashes resulted in an incapacitating injury or fatal outcome, compared to just 5 percent on sidewalks or sidepaths.

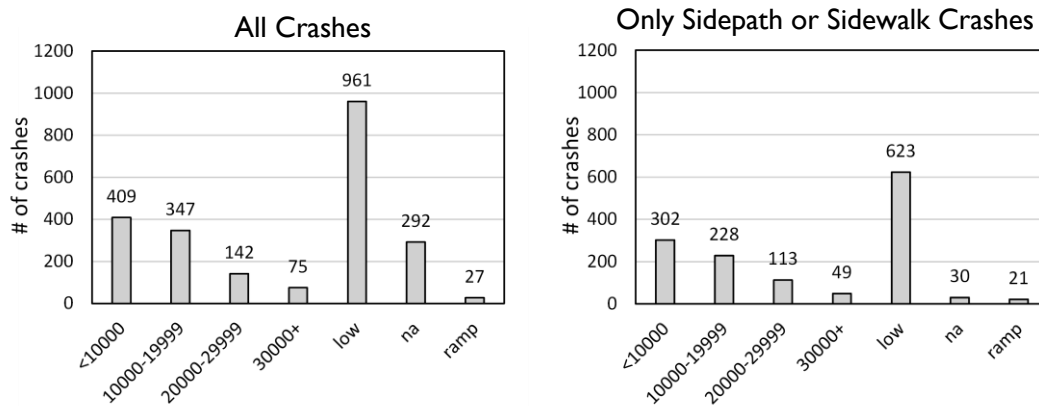
Figure 6. Injury Severity for Bicycle Crashes on Sidepaths/Sidewalks Compared to Roadways



Sidepath Application Criteria Development for Bicycle Use

Another key finding is that the number of bicycle crashes on sidewalks and sidepaths is substantially higher when the bicyclist is traveling against traffic (65 percent) than with traffic (31 percent). Additionally, more collisions (43 percent) occurred when a bicycle was crossing a low volume roadway* than other facility types. When looking at just the sidewalk/sidepath facilities, the disparity is slightly higher, with 46 percent of crashes occurring when crossing low volume roadways (Figure 7).

Figure 7. Number of Crashes Based on AADT of Crossing Street



*A low-volume roadway is defined as residential roads and driveways that do not have AADT collected.

In terms of crash types, the top crash type in this study was the motorist drive-out, an example of which is pictured in Figure 8. This suggests a need to educate motorists to be more aware of bicyclists and to educate bicyclists to use caution when crossing intersections or driveways.

Figure 8. Crash Type Diagram of a Motorist Drive-Out Crash

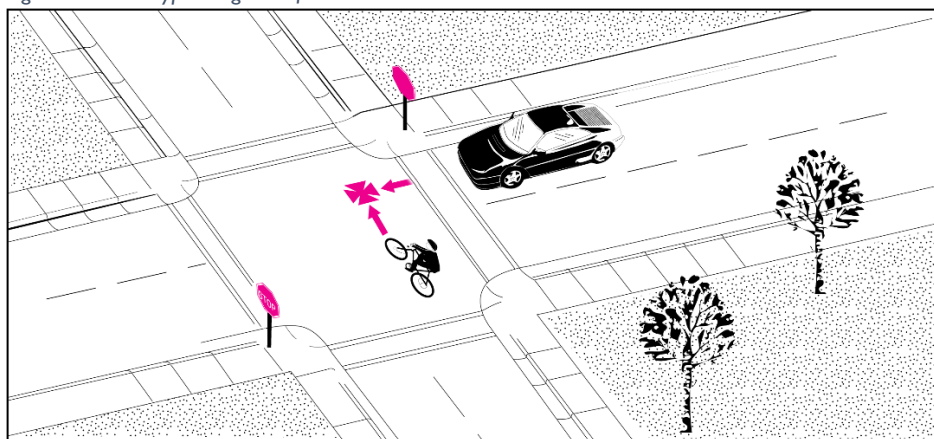


Image source: Pedestrian and Bicycle Crash Analysis Tool (PBCAT); modified by TDG

The prevalence of crash types differed when the cyclist's direction of travel was considered: the top crash type for bicyclists traveling with traffic on sidewalk/sidepaths was motorists turning right while traveling in the same direction (19.8 percent), whereas the top crash type for bicyclists traveling against traffic on sidewalk/sidepaths was motorists driving out at signalized intersections (31 percent) (see Table 2 and Table 3).

Sidepath Application Criteria Development for Bicycle Use

Table 2. Top Ranked PBCAT Classifications for Bicycle Crashes Traveling Against Traffic on Sidepaths/Sidewalks

Rank	PBCAT Crash Type	# of Crashes (%)
1	152 - Motorist Drive Out - Signalized Intersection	270 (30.5%)
2	141 - Motorist Drive Out - Sign-Controlled Intersection	227 (25.6%)
3	321 - Motorist Drive Out - Residential Driveway	86 (9.7%)
4	214 - Motorist Right Turn - Opposite Direction	61 (6.9%)
5	153 - Bicyclist Ride Out - Signalized Intersection	56 (6.3%)
6	155 - Bicyclist Ride Through - Signalized Intersection	46 (5.2%)
7	142 - Bicyclist Ride Out - Sign-Controlled Intersection	40 (4.5%)
8	211 - Motorist Left Turn - Same Direction	37 (4.2%)
9	120 - Bicyclist Lost Control	21 (2.4%)
10	156 - Bicyclist Failed to Clear - Trapped	8 (0.9%)

Table 3. Top Ranked PBCAT Classifications for Bicycle Crashes Traveling with Traffic on Sidepath/Sidewalks

Rank	PBCAT Crash Type	# of Crashes (%)
1	213 - Motorist Right Turn - Same Direction	85 (19.8%)
2	212 - Motorist Left Turn - Opposite Direction	73 (17.0%)
3	152 - Motorist Drive Out - Signalized Intersection	59 (13.8%)
4	141 - Motorist Drive Out - Sign-Controlled Intersection	55 (12.8%)
5	155 - Bicyclist Ride Through - Signalized Intersection	35 (8.2%)
6	153 - Bicyclist Ride Out - Signalized Intersection	25 (5.8%)
7	321 - Motorist Drive Out - Residential Driveway	20 (4.7%)
8	156 - Bicyclist Failed to Clear - Trapped	18 (4.2%)
9	142 - Bicyclist Ride Out - Sign-Controlled Intersection	11 (2.6%)
10	120 - Bicyclist Lost Control	10 (2.3%)

2.5 Conclusions

These findings underscore the extent to which direction of travel impacts bicycle safety, provide insight into the safety dynamics of sidepaths and sidewalks versus the roadway, and clarify the top crash types to target when sidepaths are constructed. These insights were incorporated into the Sidepath Intersection and Crossing Treatment Guide described in Chapter 4 and the educational materials described in Chapter 5.

The analysis also provided insight into some of the limitations of using bicycle crash data to diagnose bicycle safety issues; in particular, a lack of exposure data to contextualize bicycle crash frequency precludes the development of meaningful crash rates. Additional information collected as part of crash reports could contribute to new crash mitigation techniques and design features. In the future, as these data are collected more regularly, additional research and modeling can improve crash modification factors and help clarify underlying factors that contribute to bicycle crashes.

Chapter 3 – Overview of Survey Methodology and Key Findings

TDG conducted an address-based sample survey (n=351) in fall 2016 to understand the public's bicycle facility preferences, barriers to bicycling, and factors that encourage bicycling.⁵ The purpose of the survey was to help understand and integrate the public's perspective in the development of the sidepath design recommendations.

3.1 Methodology

Survey Construction and Recruitment

In October 2016, approximately 5,000 letters printed in both English and Spanish were mailed to a random selection of Michigan residents who were in the telephone directory asking them to take the survey. The letter explained the purpose of the survey and directed the recipients to the website www.michdrivebike.org, where there was a link to take the survey in either English or Spanish; recipients could also request a paper copy of the survey. To mitigate potential response bias, the letter requested that only the person in the household whose birthday was most recent and who was at least age 18 take the survey. Privately donated survey incentives of a \$5 “gourmet coffee gift card” were offered for participation.

Respondent Cyclist Typology

To facilitate analysis, respondents were categorized according to how often they bicycled for “work/school,” “transportation other than to work or school (e.g., errands),” and recreation or exercise. The categories equated to the following:

- **Frequent cyclist (n=116):** Respondent who reported bicycling at least once a week for any purpose (transportation, recreation, or exercise), and not being “absolutely limited” by not having a bike or not knowing how to ride a bike.
- **Occasional cyclist (n=83):** Respondent who reported bicycling at least once a month (but less than once a week) for any purpose, or reported biking at least once a week but also reported being “absolutely limited” by not having a bike or not knowing how to bike.
- **Rare cyclist (n=93):** Respondent who reported bicycling occasionally, but less than once a month for any purpose.
- **Never cyclist (n=54):** Respondent who reported never bicycling for any purpose; or who did not indicate how often they bike for a particular purpose but is either “absolutely limited” by not knowing how to ride a bike or not owning a bike, or indicated that they “cannot bike at all.”

Five respondents were unable to be classified because they did not provide sufficient information about their bicycling frequency and ability.

⁵ The full report of survey findings can be found at www.michigan.gov/ (insert link for final location)

3.2 Key Findings

Participant Characteristics

The 351 respondents live in more than 20 different cities and towns across Michigan, ranging in size from less than 3,000 to more than 500,000. The median age range of respondents was 45 to 54. There were more respondents older than age 65 than between the ages of 18 and 24, which may be due to the representation of those age groups in a telephone directory-based sample. As seen in the description of the cyclist typology in Section 3.1, the respondents represented a range of cycling frequencies and abilities.

Respondents were also asked about their commute habits and how often they bicycle for “transportation other than to work or school,” fun/recreation/leisure, and exercise/fitness. Nearly 90 percent of the sample drives alone to work or school at least once a week. However, the sample also includes a fair amount of walking and bicycling, with approximately 26 percent walking to work or school at least once a week, and approximately 14 percent bicycling at least once a week for the same purpose.

Barriers for Bicycling

Safety concerns, distance, and weather appeared to be the most limiting barriers for all cyclist types. Nearly 89 percent of respondents reported that safety concerns about riding in fast and/or busy traffic at least somewhat limited their ability to bike to work or school, with 68 percent saying that safety concerns limited them “quite a lot” or “absolutely.” Frequent cyclists were less likely to indicate barriers than other cyclists but seemed more focused on safety and roadway/infrastructure when they did indicate barriers. Moreover, the large majority (73 percent) of the sample agreed or strongly agreed with the idea that “many drivers don’t seem to notice bicyclists,” suggesting that people may not feel safe bicycling due to driver behavior.

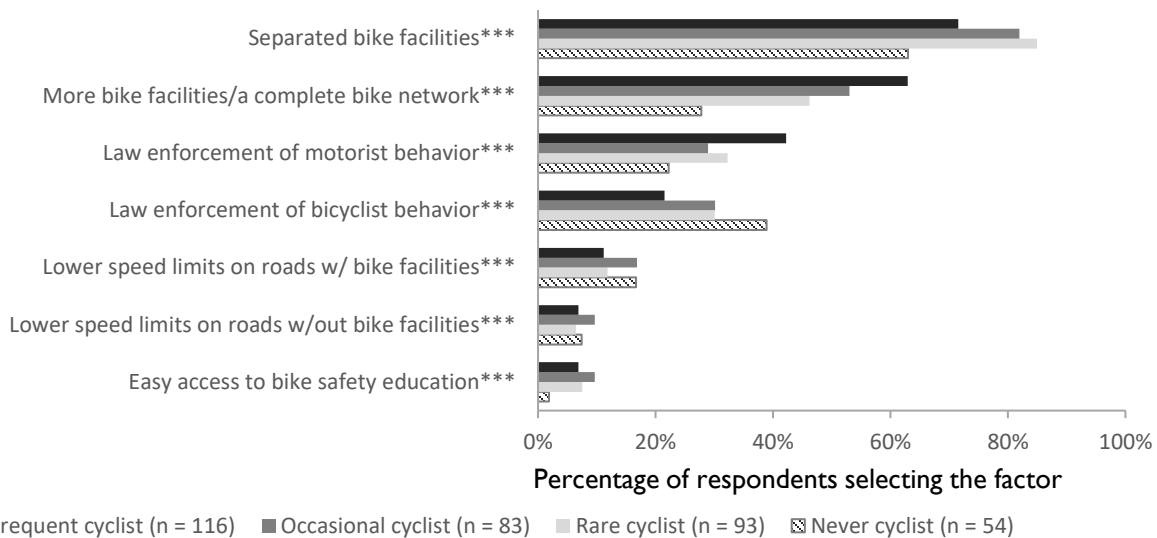
Factors That Encourage More Bicycling

The findings overwhelmingly suggest a preference for more bicycle accommodations, and more separated facilities in particular (Figure 9). Seventy-five percent of all respondents indicated that the installation of separated bicycle facilities would encourage them to bicycle more. Rare cyclists were more likely to choose this response than occasional cyclists, corroborating past research finding that separated bicycle facilities are likely key to encouraging more cycling. The fact that about 72 percent of frequent cyclists also chose separated bike facilities suggests that this lack of comfort and safety is experienced even by those who currently bicycle.

In comparison, about half of respondents indicated that adding more bicycle facilities/a complete bicycle network would encourage them to bicycle more. Only a minority of respondents suggested that improved law enforcement of motorist and cyclist behavior, easier access to education, and lower speed limits would encourage them to bicycle more.

Sidepath Application Criteria Development for Bicycle Use

Figure 9. Factors That Encourage Bicycling More Often



***p < 0.001

Notes: Separated bicycle facilities include those that provide increased separation from traffic (e.g., median, landscape buffer, etc.). Percentages do not add up to 100 because respondents could choose up to three factors.

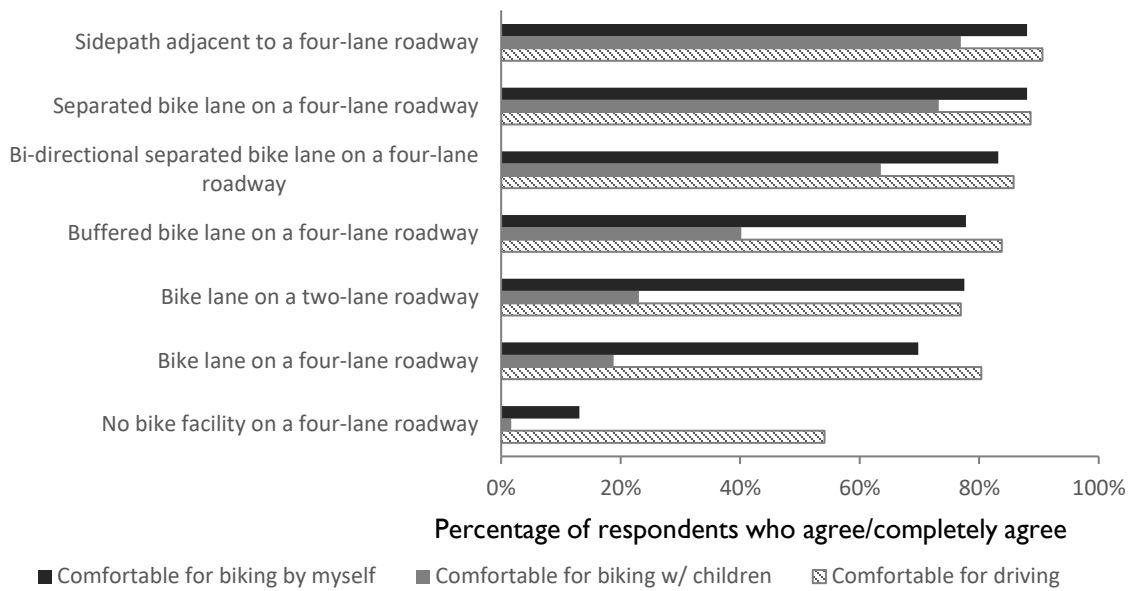
Comfort and Roadway Design

Figure 10 shows an examination of comfort bicycling alone, bicycling with children, and driving near various types of bicycle facilities. Most respondents felt considerably more comfortable bicycling on a roadway with some type of bike facility over one with no facility; this preference is particularly strong when the facility was separated from drivers by a physical barrier. Separation was even more important when considering cycling with children, with comfort levels declining rapidly without separation from cars when children are considered. Respondents were also more likely to indicate comfort while driving with greater separation from bicyclists.

When considering bicycling with children, however, comfort declines rapidly without separation from cars: less than 50 percent of the sample would be comfortable in a buffered bicycle lane; less than 20 percent would be comfortable in a regular bicycle lane on a four-lane roadway; and less than 2 percent would be comfortable on a four-lane roadway with no bicycle facility. These findings underscore the increased perceived vulnerability of bicycling with children and the commensurate need for clear and strong separation from traffic for comfort.

Sidepath Application Criteria Development for Bicycle Use

Figure 10. Roadway Design Preferences by Percentage of Respondents Who Would Feel Comfortable Bicycling in Various Scenarios



Comfort was also examined by type of bicycling (non-transport cycling compared to all-purpose cycling). The same preference order was found for both groups, although non-transport cyclists were significantly less likely to feel comfortable bicycling alone or with children than all-purpose cyclists on all facilities except the sidepath and separated bike lane designs.

3.3 Conclusions

These findings underscore the importance of bicycle facilities – and particularly physically-separated bicycle facilities – on bicyclists’ perceptions of comfort and propensity to bicycle. These insights were incorporated into the Sidepath Intersection and Crossing Treatment Guide described in the Chapter 4.

Chapter 4 – Overview of Sidepath Intersection and Crossing Treatment Guide Development Process

The initial intent of this task was the development of a tool for use by planners and designers to determine if the use of a sidepath was appropriate on a given corridor, based on the characteristics of that corridor. However, crash analysis findings in this research did not indicate that typical roadway features such as speed, average daily traffic (ADT), or driveway density were significant factors in sidepath crashes. Thus, there was no clear yes or no as to whether or not a sidepath should be built according to surrounding roadway features in conjunction with or in lieu of on-road facilities for bicyclists. Rather, the primary findings – that bicyclists riding against traffic and those experiencing conflicts with turning vehicles are at a greater risk of crash – suggested that a sidepath design guide may be a more useful tool.

The decision to incorporate a sidepath into a corridor design therefore becomes a planning decision. The benefits of incorporating sidepaths into certain corridor contexts outweigh the drawbacks. For example, on suburban arterials, destinations, signalized intersections, and crossing opportunities are farther apart. These longer distances mean that crossing to the correct side of the street to ride with the direction of traffic is more challenging. In this context, vehicle speeds and volumes are higher, leading to a greater need for separation between modes. Providing a two-way sidepath along one side of the street allows for a comfortable bikeway to be included, while limiting the amount of right of way needed (see Figure 11).

Figure 11. Example Sidepath in a Suburban Context



Rather than providing guidelines on where not to install sidepaths, the development of this guide assumed that a sidepath had already been selected as the bikeway of choice for a given corridor. The following section provides some discussion of key features of the guide, which can be found at www.michigan.gov/mdot-SidepathResearch.

4.1 Development of the Guide

Based on experience designing sidepaths, bikeways at intersections, and trail crossings, TDG developed an eight-step process for designers to use to select and incorporate treatments that would improve bicyclists' safety at sidepath crossings and intersections. The guide provides suggestions such as sidepath offset distances, raised crossings, and signs. These treatment suggestions are based on best practices for designing trail crossings and intersection treatments as described in the Massachusetts DOT Separated Bike Lane Planning and Design Guide and the upcoming revision to the AASHTO Guide for the Development of Bicycle Facilities.

The guide was reviewed by MDOT staff, including several engineers. Some of the suggested treatments go beyond MDOT's current standard practices. For example, at the time of this writing, the use of bicycle signals in order to provide exclusive bicycle phases is not currently standard practice in Michigan. However, multiple other states and municipalities have successfully used bicycle signals to separate bicycle and vehicle movements, so this treatment is included for consideration by Michigan designers.

4.2 Designing for Conflicts with Turning Vehicles

Sidepath crossings at intersections can be considered crosswalks. The Michigan Vehicle Code defines a crosswalk but does not indicate whether drivers should yield to pedestrians. The Uniform Traffic Code (UTC) indicates that drivers should yield to pedestrians "within a crosswalk;" however, municipal adoption of the UTC is not required. This yield requirement, when in use, can be assumed to apply to bicyclists as well. The guide recommends signs indicating sidepath priority, such as stop or yield signs for the minor street, or the Turning Vehicles Yield to Pedestrians and Bicyclists sign (R10-15b, pictured in Figure 12). As of June 2018, the use of the R10-15b at unsignalized crossings is not consistent with the current MUTCD standards. This sign is currently only suggested for use at signalized intersections, and will require FHWA approval for this application.

Figure 12. MUTCD R10-15 Turning Vehicles Yield to Pedestrians and Bicyclists Sign



In the event that the UTC has not been adopted in a Michigan community, the need to establish priority at a sidepath crossing is even greater. By defaulting to drivers yielding to sidepath users, safety for these users is improved with minimal delay for the driver. Design features that have been shown to improve yielding include stop/yield signs, raised crossings, smaller curb radii, an offset sidepath, warning signs, and striping.

4.3 Designing for Contra-Flow Bicycle Traffic

On two-way streets, one-way bikeways on each side of the street are typically preferred over a two-way bikeway on one side of the street. However, in some situations, one-way bikeways are not practical or desirable. The guidance provided to address safety for contra-flow bicyclists acknowledges that, while contra-flow bicycling is less safe than riding with traffic, it is sometimes unavoidable. The guide provides suggestions on how to warn drivers of two-way bicycle traffic, such as the non-MUTCD sidepath warning sign in use by the Colorado DOT pictured in Figure 13. As of June 2018, this sign is not consistent with the current MUTCD standards, and will require FHWA approval its use.

Figure 13. Colorado DOT's Non-MUTCD Sidepath Warning Sign



The design treatments that encourage drivers to reduce their speed yield to sidepath users can also address safety for contra-flow bicyclists.

4.4 Guide Application

The guide was developed based on trends established from crash data in Michigan. It's application, therefore, is oriented toward the context of sidepaths in Michigan. Its use is not limited to MDOT roadways since many sidepaths occur on city or county roads. As discussed, some of the suggested treatments go beyond MDOT's standard practice, so application of the guide should include communication with MDOT and other agencies with respect to sign placement, marking application, and the use of bicycle signals.

The planning process described, as well as the recommended treatments, come from national best practices and could be applied in other states. The following design process is intended to provide the designer with sufficient information to create an optimal sidepath design. However, no guide can anticipate every context or design situation, and engineering judgment should always be used when considering nonmotorized facilities.

The guide outlines an eight-step planning and design process that is intended to help the designer evaluate the sidepath context and document any barriers to incorporating the suggested treatments. These steps are:

- Step 1 – Identify corridor
- Step 2 – Collect data

Sidepath Application Criteria Development for Bicycle Use

- Step 3 – Review crash history
- Step 4 – Assess existing bicycle network
- Step 5 – Assess existing bikeways along the corridor
- Step 6 – Determine achievable sidepath width
- Step 7 – Select intersection treatments
- Step 8 – Design and engineering

Note that Step 4 encourages the designer to look outside the corridor they are focused on and evaluate how it fits into the larger bicycle network. In communities with a published bicycle plan, this step is straightforward. In communities where a bicycle plan has not been created, this step may require more consideration.

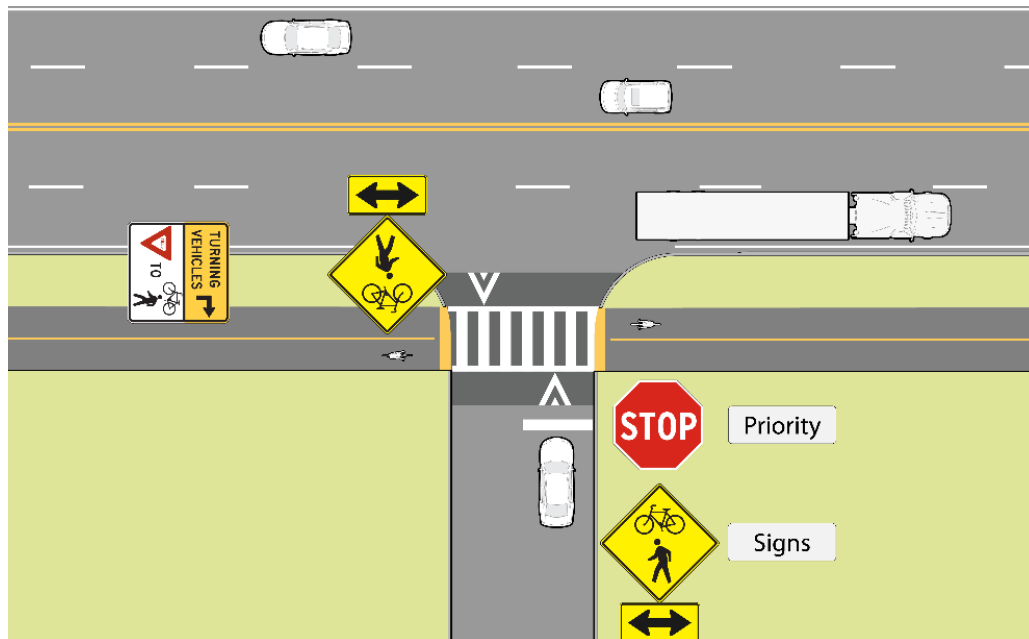
Step 7 illustrates the suggested intersection treatments to address crossing priority, speed reduction, and sidepath user visibility. The suggested treatments are scaled based on the usage/traffic volumes at the intersection. A low-volume driveway requires fewer treatments than a high-volume intersection. The treatments used are graded on a tier system, with crossings incorporating more treatments achieving a higher tier.

The highest tier, Tier I, is the optimal sidepath intersection treatment. For instance, a Tier I intersection treatment for a driveway with medium usage (10-50 vehicles per hour crossing a two-way sidepath) has several treatment elements that can address several of the identified intersection treatment categories, as shown below in Table 4 and illustrated in Figure 14. Optimally, motorist stop/yield signs should be installed at these intersections, which ensures bicyclists have crossing priority. A stop sign warrant should be performed. Raised crossings can also reduce speed and increase sidepath user visibility, benefiting both bicyclists and pedestrians. Signs indicating to motorists that there may be sidepath users at an approaching intersection and striping across the intersection also help to increase the visibility of sidepath users.

Table 4. Tier I Facility - Driveway Intersection, Medium Usage

Treatment	Intersection Treatment Category		
	Crossing Priority	Speed Reduction	Sidepath User Visibility
Motorist stop/yield signs - Bicyclists have priority through intersection.	✓		
Raised crossing - Motorists ramp up to sidepath by at least 6 inches and crossing hump is designed for 10 mph.		✓	✓
Signs - Sidepath user warning signs are provided for motorists.			✓
Striping - White pavement markings are provided for the intersection crossing.			✓

Figure 14. Tier I Driveway Intersection Treatment, Medium Usage⁶



4.5 Conclusions

The Sidepath Intersection and Crossing Treatment Guide was developed based on a detailed bicycle crash analysis and survey of roadway users' design preferences. Clearly, the sidepath is an important and preferred option in a designer's toolkit. This Guide provides a significant step forward in helping designers proactively address potential issues via safe sidepath design.

The Guide is available to the public at www.michigan.gov/mdot-SidepathResearch. Aspects of the Guide were also incorporated into the educational materials described in the following chapter.

⁶ As of June 2018, the use of the R10-15b as portrayed in Figure 3 is not consistent with the current MUTCD standards. This sign is currently only suggested for use at signalized intersections, and will require FHWA approval.

Chapter 5 – Overview of Educational Materials Development Process

5.1 Fact Sheet Process

The goal of the fact sheets is to communicate to the public the key research findings and tips for safe bicycling on and driving near sidepaths. To develop content for the fact sheets, TDG consulted with MDOT staff to determine the topics most appropriate for a broad general audience. The team decided on the following five educational cut-sheets:

- 1) Common Sidepath Crash Types
- 2) (Safety Tips for) Bicycling on Sidepaths
- 3) (Safety Tips for) Driving near Sidepaths
- 4) Why Build Sidepaths and Separated Bicycle Lanes? (Results of a Survey of Michiganders)
- 5) Sidepath Design Best Practices

Determining the Content

The team then reviewed the complete crash analyses, survey results, and design guidance to identify the key findings, safety lessons, and design imperatives resulting from the research. Highlights of these efforts relevant to the cut-sheets are described further below.

Crash Analysis

The research showed that crashes disproportionately occur at intersections and driveways, on quiet sidepaths where drivers may not expect or be looking for bicyclists, when drivers turn across sidepaths without looking for bicyclists, and when bicyclists are riding in the opposite direction as the motor vehicles on the adjacent roadway.

Resident Survey

The surveys showed that bicycling is popular in Michigan but that there are safety concerns about sharing the road with motor vehicles. A majority of respondents indicated that they would feel comfortable bicycling if there is separation between bicyclists and motor vehicles. This holds true for people driving, people biking by themselves, and people biking with children.

Design Guidance

The TDG team's design guidance recommended several features to improve safety, including signs, truck aprons, raised crossings, reduced curb radii, and pavement markings. Based on these findings, an outline was developed for each element with key data points, facts, and findings and reviewed with MDOT.

Selecting the Graphic Approach

To develop the graphic approach, TDG reviewed examples of safety-related, one-page infographics for inspiration and debated several visual approaches. The team decided to use Sketch-Up graphics to visualize bicyclists/motorist interactions and design features. The survey results were shown using bar charts.

The fact sheets underwent several rounds of revisions with MDOT technical and communications staff. The final fact sheets concisely summarize the important safety and design findings of the research, and can be found in Appendix A.

5.2 Video Script Development Process

Based on successful examples of informational videos, such as a popular separated bike lane usage video produced by the City of Fort Worth, TDG proposed that MDOT produce an educational video to share the results of the sidepath research. The video serves the following purposes:

1. Familiarize people with the concept of sidepaths,
2. Show public support for separated bicycle infrastructure, and
3. Provide safety tips to drivers and bicyclists.

MDOT provided a video script template with a column for visual notes on the left, the time in middle column, and the text for the narration in the right column. TDG then produced a draft script that defined sidepaths, showed supportive survey results, described MDOT's role in developing research, and presented tips to drivers and bicyclists for traveling on or near sidepaths. Much of the content was based on the previously approved fact sheet content, creating a mutually reinforcing public messaging campaign. MDOT provided initial feedback on the draft, which was incorporated into a follow-up draft that can be found in Appendix B of this report. MDOT will produce and market the final video.

Chapter 6 – Conclusion

This multi-pronged project provides robust research and supporting materials to allow for the implementation of sidepath designs that are grounded in research and best practices. Through research conducted as part of the project, it is evident that the public strongly prefers separated bicycle facilities, such as sidepaths, especially when bicycling with children but also as drivers. Survey respondents indicated that building more separated bicycle facilities and a more connected bicycle network will help encourage them to bicycle more.

At the same time, safety while using sidepaths remains important. This research found that, while more crashes between vehicles and bicyclists occur on sidepaths and sidewalks in comparison to on roadways (not adjusted for bicycle volumes in these locations), these conflicts result in less severe injuries. The two most common vehicle actions that result in bicycle crashes along a sidepath for bicyclists traveling with traffic are right and left turns. Contrarily, the most common vehicle action that results in bicycle crashes when the bicyclist is traveling against traffic is the motorist driving out. Mitigating potential negative conflicts between bicyclists and vehicles along all roadways, and specifically along sidepaths, will provide a safe environment for the public to bicycle and feel comfortable, and will improve motorist and pedestrian safety in the process.

The results of this research also informed the development of the Sidepath Intersection and Crossing Treatment Guide. This Guide can act as a resource to help mitigate points of conflict between bicyclists and vehicles along sidepaths. Using the proposed methodology and tiered intersection treatment, planners and engineers now have a methodology for how to improve safety and reduce the likelihood of crashes. The Guide proposes a holistic method to identify the optimal intersection treatment based on vehicular usage, intersection type, and available right of way. The Guide defines the purpose for each treatment at an intersection, which provides planners and designers with rationale for their decisions to prioritize safety along sidepaths.

In addition to implementation, education is also an important aspect of creating behavioral change among both bicyclists and drivers. The educational cut-sheets and online video (once produced) will help raise awareness about crash risks for bicyclists and teach people how to behave safely. Ultimately, these educational materials may also encourage the public to bicycle more through providing a better understanding of how to do so safely.

Potential next steps for MDOT to further this work include developing, implementing, and evaluating targeted bicycle safety campaigns using the educational materials created through this project. MDOT could consider researching the impacts on bicycling and driving behavior and safety when sidepaths are designed according to the Sidepath Intersection and Crossing Treatment Guide.

Appendix A. Educational Cut-Sheets

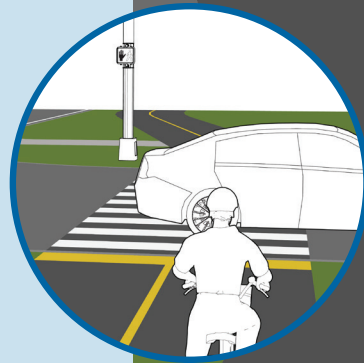
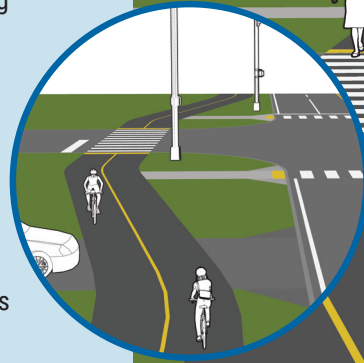
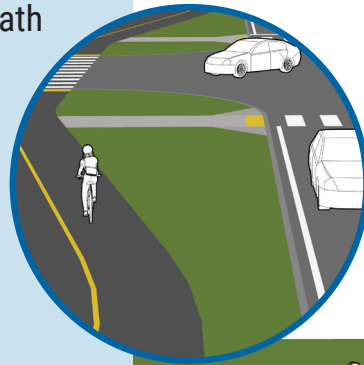
Common Sidepath Crash Types

CRASH ANALYSIS FINDINGS

A statistical analysis of sidepath crashes in Michigan found two statistically significant patterns in crashes.

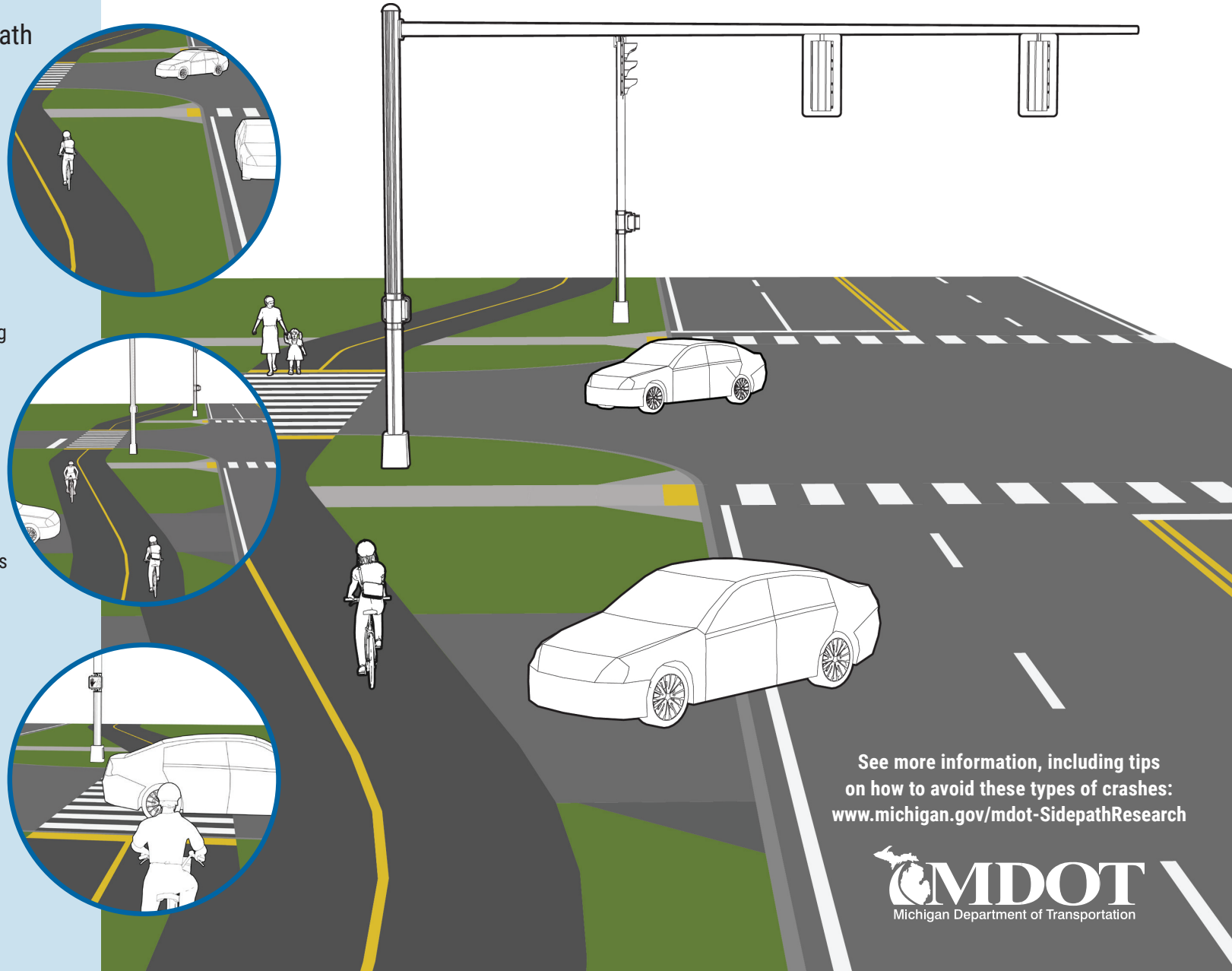
RIDING AGAINST THE DIRECTION OF TRAFFIC

- Sidepaths are two-way facilities, yet bicyclists riding against traffic are at higher risk of a crash than those riding with traffic
- Specifically, bicyclists riding against traffic have a higher risk of crashing with right-turning vehicles than those riding with traffic
- Bicyclists riding against traffic have a higher crash risk at commercial driveways and signalized intersections than those riding with traffic



AT INTERSECTIONS

- Bicyclists riding through signalized intersections—which generally have higher amounts of vehicle traffic—have a higher crash risk than at intersections with other types of traffic control
- At intersections, sidepath bicycle crashes tend to occur with turning vehicles.



See more information, including tips on how to avoid these types of crashes:
www.michigan.gov/mdot-SidepathResearch

Bicycling on Sidepaths

SAFETY TIPS

USE CAUTION AT INTERSECTIONS

Watch for turning vehicles, which are involved in many of the bicycle crashes on sidepaths. Look for street signs indicating who has the right of way.

USE CAUTION AT DRIVEWAYS

Control your speed and be alert for cars and trucks at driveways. Drivers are often looking for gaps in traffic rather than bicyclists. Make eye contact to confirm that the driver can see you before asserting your right of way.

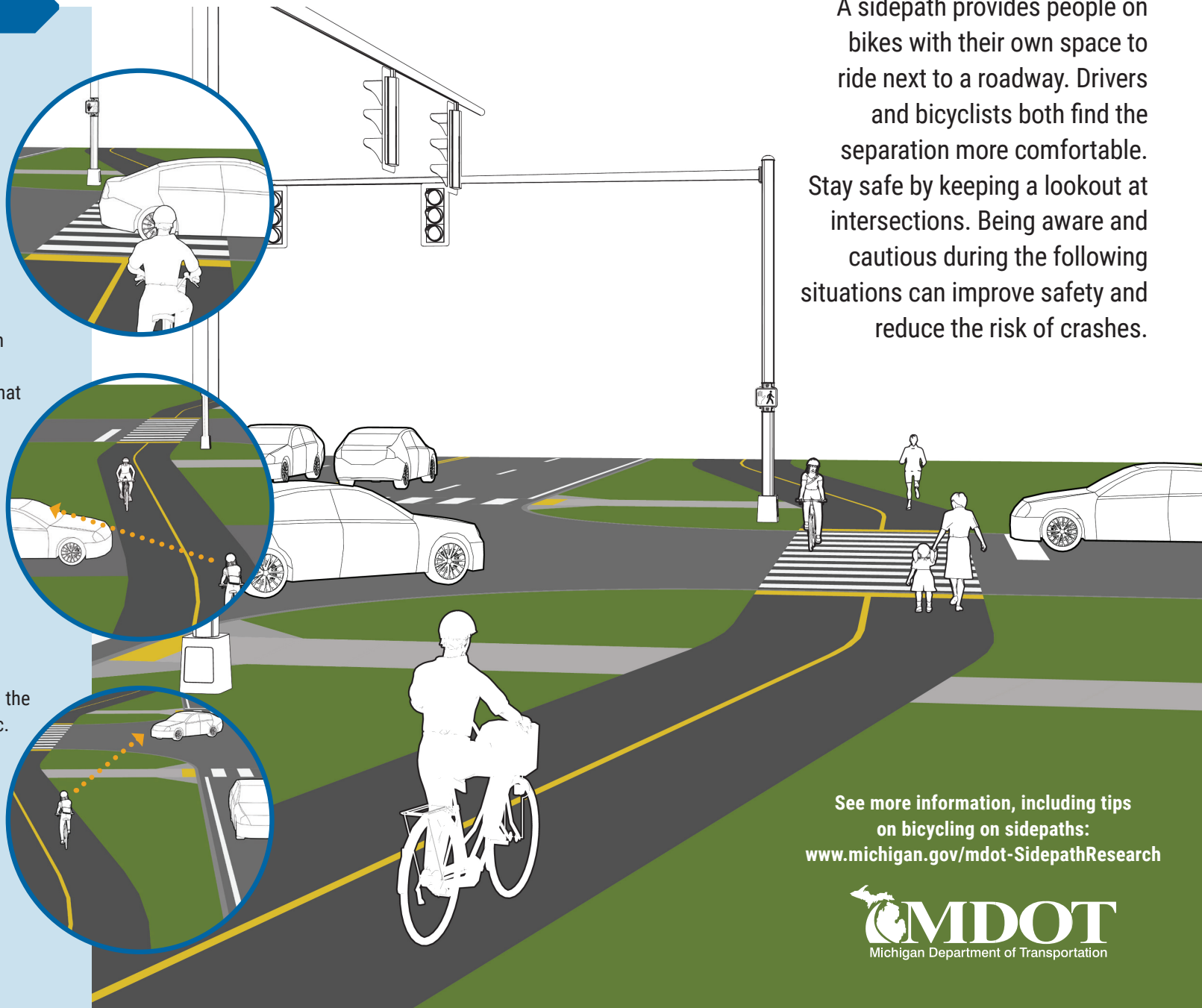
BE ALERT WHEN RIDING AGAINST THE DIRECTION OF TRAFFIC

On a two-way sidepath, bicyclists may ride in either direction. However, be especially alert when riding against the direction of traffic on the adjacent road. Drivers may not expect you to come from the opposite direction of motor vehicle traffic.

Pay special attention when encountering the following:

- Commercial driveways
- Signalized intersections
- Right-turning vehicles

Research shows that the risk of a crash is higher under these conditions.



A sidepath provides people on bikes with their own space to ride next to a roadway. Drivers and bicyclists both find the separation more comfortable. Stay safe by keeping a lookout at intersections. Being aware and cautious during the following situations can improve safety and reduce the risk of crashes.

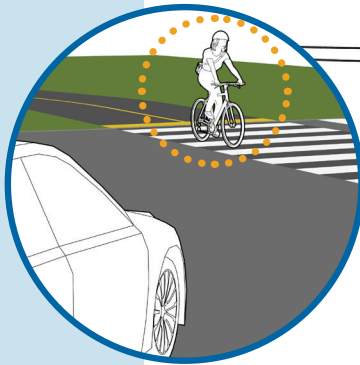
See more information, including tips
on bicycling on sidepaths:
www.michigan.gov/mdot-SidepathResearch

Driving Near Sidepaths

SAFETY TIPS

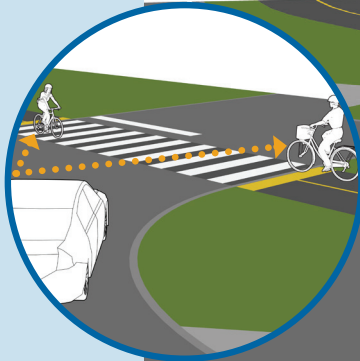
ALWAYS EXPECT PEOPLE ON SIDEPATHS

Crashes are more likely at crossings of less crowded sidepaths because drivers may not be expecting to see people on bikes there. Always look for sidepath users, even on quiet paths and at off-peak times.



LOOK BOTH WAYS!

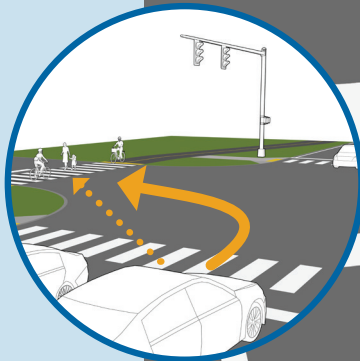
Remember that people ride bikes in both directions on sidepaths. Look both ways when crossing sidepaths at driveways and intersections.



BE CAREFUL MAKING TURNS, ESPECIALLY AT TRAFFIC LIGHTS

Sidepath bicycle crashes at intersections tend to occur when drivers are making turns. When making a turn, look both ways for people using sidepaths to avoid a crash.

It's especially important to look for bicyclists at signalized intersections. You should always double check for people on bikes before turning, even if you have a green light.



A sidepath provides people on bikes with their own space to ride next to a roadway. Drivers and bicyclists both find the separation more comfortable.

Help keep everyone safe by keeping a lookout at sidepaths. Be prepared to slow down for turns and to look for people riding bikes in both directions.

See more information, including tips on driving near sidepaths:
www.michigan.gov/mdot-SidepathResearch

Why Build Sidepaths and Separated Bicycle Lanes?

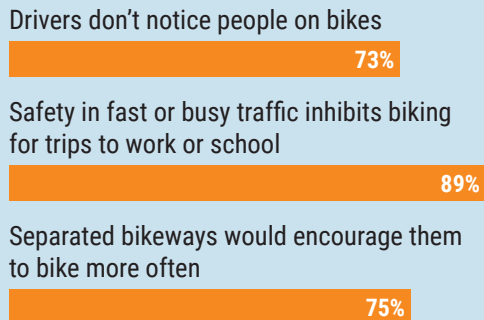
RESULTS OF A SURVEY OF MICHIGANDERS*



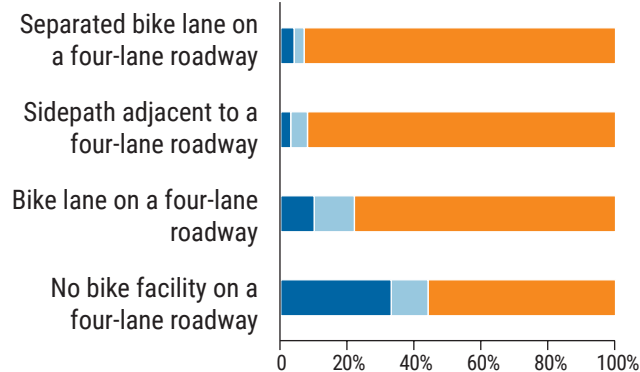
FAVORABLE VIEWS OF BICYCLING AND WALKING



CONCERNS AND ENCOURAGEMENT

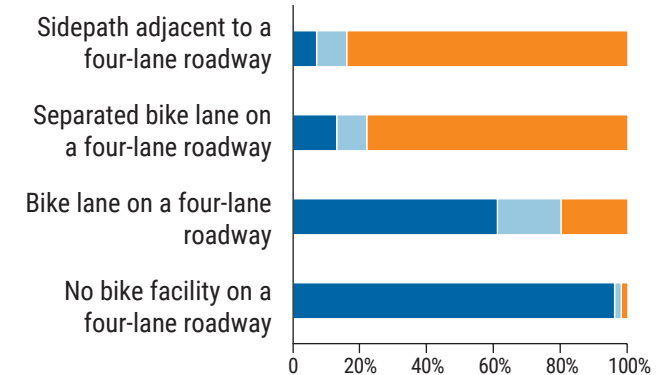


COMFORTABLE FOR DRIVING

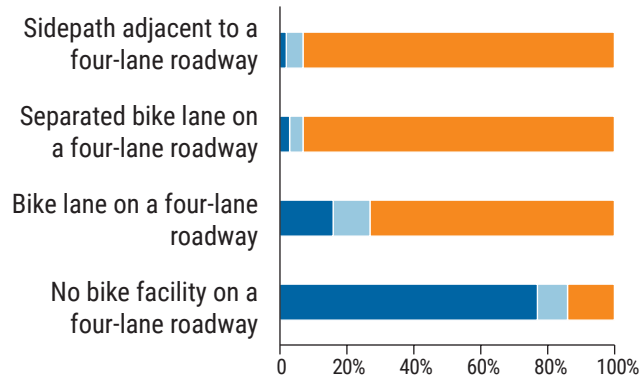


COMFORTABLE FOR BIKING WITH CHILDREN

For more information, see full reports.



COMFORTABLE FOR BIKING



KEY: ■ Disagree or completely disagree
■ Neutral
■ Agree or completely agree

*Footnote indicating the date and total response rate for the survey.

See more information:
www.michigan.gov/mdot-SidepathResearch



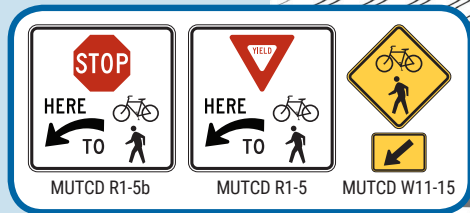
Sidepath Design Best Practices

HIGHLIGHTS

Designers may reduce crash risk for bicyclists by raising the visibility of bicyclists going in both directions, establishing priority, and reducing speed. Following are some examples of how this can be achieved through treatments such as signs, truck aprons, and raised crossings.

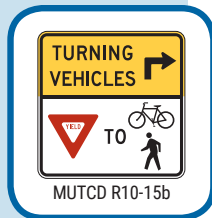
1 STANDARD SIGNS

Providing clear signs and pavement markings warns motorists of a bicycle contraflow conflict. The guide shows applicable regulatory, signal, and warning signs related to sidepaths and provides suggestions on when they should be used.



2 NON-STANDARD SIGNS

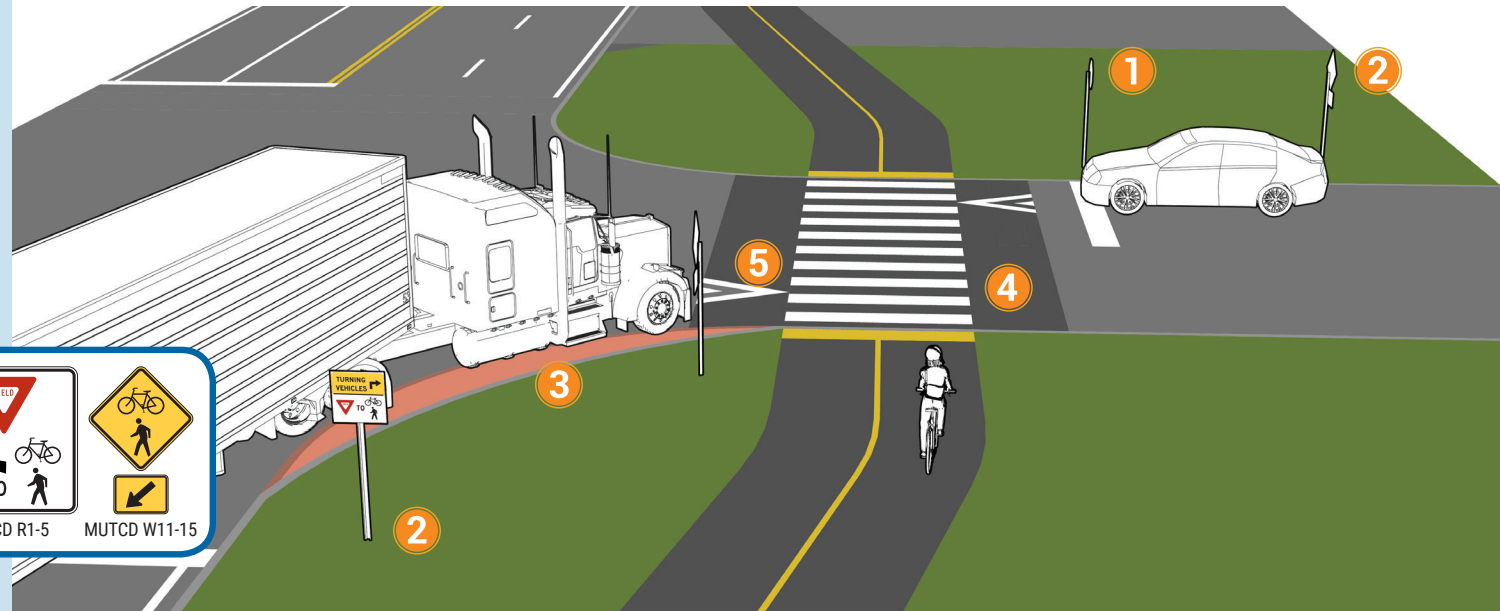
An option for warning motorists of contraflow bicycle conflict is the R10-15b sign, which is usually found at signalized locations. Use of this sign at unsignalized intersections will require FHWA approval.



4 RAISED CROSSINGS

Creating a raised crossing encourages drivers to slow down and pay more attention to the crossing, helping to achieve the desired vehicle speed and driver awareness.

MDOT's Sidepath Intersection and Crossing Treatment Guide contains information on the latest state-of-the-practice principles for designing sidepath crossings. This handout highlights just some of the guidance. Refer to the full guide for more information on these designs and their application. The process in the guide is designed to help practitioners evaluate the appropriateness of elements such as those shown here.



EXAMPLE INTERSECTION

There are many designs for roads and sidepaths that improve safety for bicyclists. This example intersection graphic shows several treatments that designers may employ.

- 1 In this example, the **stop sign** for drivers gives bicyclists the priority through the intersection. At signalized intersections, this can be achieved using a **dedicated bicycle signal phase** or **leading interval**, depending on vehicle volumes.
- 2 A **sign** warns motorists to look for sidepath users ahead*.
- 3 The **curb radii** entering and exiting the intersection are reduced to slow vehicles and increase motorist yielding. The **truck apron** shown allows for truck movements. The **offset distance** between the sidepath and the motorist travel lane is increased to slow vehicles.

- 4 The **raised crossing** is designed to slow motorists by requiring them to ramp up to the sidepath. This design also provides a level crossing for the sidepath users.
- 5 White intersection **pavement markings** are provided to alert drivers of the potential for crossing bicyclists.


* The use of the R10-15b as portrayed in the figure above is not consistent with current MUTCD standards and will require FHWA approval.

See more information:
www.michigan.gov/
mdot-SidepathResearch



Appendix B. Sidepath Safety Research Video Script

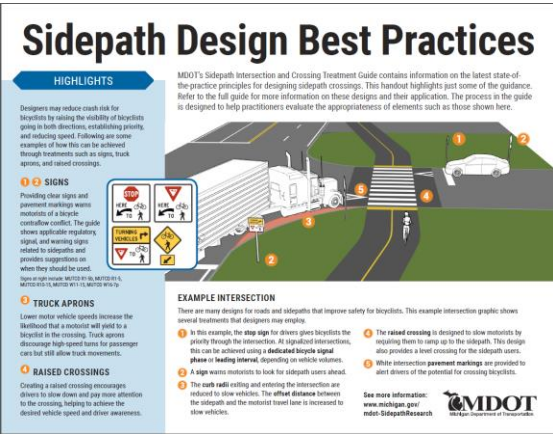
(3:20)

VIDEO	Time	AUDIO
<p>Video of smiling people riding bikes on a well-designed, two-way sidepath with people bicycling, walking, and adjacent motor vehicle movement.</p>	(0:00)	<p>Safe bicycling is an important and growing part of how Michiganders get around.</p>
<p>The following numbers appear large on the screen and fade after the bullet points are spoken:</p>		<p>A recent Michigan Department of Transportation survey shows that a large majority of Michiganders:</p>
<p style="text-align: center;">81%</p>	(0:12)	
<p style="text-align: center;">64%</p>	(0:15)	<ul style="list-style-type: none"> • Like the idea of occasionally walking or biking instead of taking a car (81% - % shown not spoken)
<p style="text-align: center;">73%</p>	(0:19)	<ul style="list-style-type: none"> • Would like to see more people bicycling where they live (64%)
<p style="text-align: center;">73%</p>	(0:24)	<ul style="list-style-type: none"> • And, enjoy riding bikes themselves (73%)
<p style="text-align: center;">89%</p>	(0:26)	<p>But the survey also shows concerns that:</p>
 <p>FAVORABLE VIEWS OF BICYCLING AND WALKING</p> <ul style="list-style-type: none"> Exercise is important: 88% Like the idea of sometimes walking or biking instead of taking a car: 81% Like biking: 73% Would like to see more people bicycling where they live: 64% <p>CONCERNS AND ENCOURAGEMENT</p> <ul style="list-style-type: none"> Drivers don't notice people on bikes: 73% Safety in fast or busy traffic inhibits biking for trips to work or school: 89% Separated bikeways would encourage them to bike more often: 75% 		<ul style="list-style-type: none"> • Drivers don't notice people on bikes (73%) • And that fast or busy traffic keeps people from biking to work or school (89%)

VIDEO	Time	AUDIO
<p>Sidepath footage continues.</p> <p>Statistics – use the sidepath statistics for drivers, biking, and biking with children:</p> <div data-bbox="224 814 787 1260"> <p>COMFORTABLE FOR DRIVING</p> <p>COMFORTABLE FOR BIKING WITH CHILDREN For more information, see full reports.</p> <p>COMFORTABLE FOR BIKING</p> <p>KEY: Disagree or completely disagree (Dark Blue), Neutral (Light Blue), Agree or completely agree (Orange)</p> <p>*Footnote indicating the date and total response rate for the survey.</p> <p>See more information: www.michigan.gov/mdot-SidepathResearch</p> <p>MDOT Michigan Department of Transportation</p> </div>		

Sidepath Application Criteria Development for Bicycle Use

VIDEO	Time	AUDIO
<p>TEXT appears: "When Driving"</p> <p>Video: View from a car, approaching a sidepath.</p> <p>Video shows a quiet sidepath.</p> <p>A bicyclist approaches an intersection; they are seen from driver's perspective.</p> <p>Driver slows and allows the bicyclist to pass. Bicyclist smiles and waves.</p> <p>Video: View from a car, approaching a sidepath.</p>	(1:08)	
<p>Bicyclists approach from both directions on the sidepath. Pedestrian also present. View from outside of car of driver looking both ways and seeing bicyclists. Driver yields to people crossing in both directions.</p>	(1:30)	<p>MDOT and other agencies are installing sidepaths along some roadways to improve safety and comfort for everyone.</p>
<p>Video of signalized intersection with an adjacent sidepath crossing.</p>	(1:36)	<p>Although sidepaths separate bicyclists and walkers from traffic, crashes <u>can</u></p>
<p>Driver with a green light makes a turn and yields to pedestrians and/or bicyclists crossing at the sidepath crossing.</p>	(1:38)	<p>occur. Therefore, MDOT initiated a research project to assess motor vehicle/bicycle crashes on sidepaths to determine crash causes and help inform sidepath design.</p>
<p>TEXT appears: "When Bicycling on a sidepath"</p> <p>Bicyclists at intersections look up and see motor vehicles turning.</p>	(1:40)	<p>The research shows that everyone has a role in improving safety. To avoid crashes, follow these tips:</p>
<p>The appropriate user stops, based on who has a stop sign or signal (depends on the intersection chosen).</p>	(1:50)	<p>When driving:</p>
<p>Video shows bicyclists paying attention at driveways, controlling speed, yielding as needed.</p>	(2:00)	<p>Expect people on all sidepaths, even quiet ones</p>

VIDEO	Time	AUDIO
<p>Bicyclists make eye contact with drivers, smile, wave.</p>		<ul style="list-style-type: none"> You may be surprised to learn that crashes are more common at the intersections of less crowded sidepaths than busy ones because drivers may not be expecting people there.
<p>Video shows bicyclists approaching intersections from opposite direction of travel. Bicyclist uses caution and proceeds with crossing. (If needed to illustrate the point, graphic arrows should appear on screen to show what is meant by “opposite direction of traffic” to the closest adjacent traffic lane.)</p>	(2:18)	<ol style="list-style-type: none"> Look both ways <ul style="list-style-type: none"> Remember that people walk and ride bikes in both directions on sidepaths. Look both ways when crossing sidepaths at driveways and intersections.
<p>Show use of caution at a commercial driveway and signalized intersection.</p>	(2:19)	
	(2:27)	
<p>TEXT: For more information on the Michigan DOT’s sidepath safety research see: www.Michigan.gov/mdot-SidepathResearch</p>	(2:37)	<ol style="list-style-type: none"> Be careful making turns...especially at traffic lights <ul style="list-style-type: none"> When making a turn, look at the sidepath crossing. This is especially important at signalized intersections, since there can be a lot to pay attention to. Always double check for people on bikes before turning, even if you have a green light.
<p>Fades out on final shot of happy, smiling sidepath users.</p>	(2:52)	<p>When bicycling on a sidepath:</p> <ol style="list-style-type: none"> Use caution at intersections <ul style="list-style-type: none"> Watch for turning vehicles, and
	(3:06)	

VIDEO	Time	AUDIO
	3:20	<ul style="list-style-type: none"> • Look for stops signs and signals indicating who has the right of way. <p>2. Use caution at every driveway</p> <ul style="list-style-type: none"> • Control your speed and be alert. • Drivers are often looking for gaps in traffic rather than bicyclists. • Make eye contact to confirm that the driver can see you. <p>3. Be alert when riding in the opposite direction of motor vehicle traffic</p> <ul style="list-style-type: none"> • Sidepaths are designed for two-way travel and bicyclists may ride in either direction. But, be especially alert when riding in the opposite direction of traffic. • Drivers may not be expecting you. <p>MDOT's sidepath research is helping us all be safer. People driving and bicycling should follow these tips to increase safety. And MDOT has produced research and created a guide to help inform sidepath design and operation.</p>

Sidepath Application Criteria Development for Bicycle Use

VIDEO	Time	AUDIO
		<p>Please visit www.Michigan.gov/mdot-SidepathResearch for more information about this initiative.</p> <p>(End: 3:20)</p>