Sidepath Safety Model - Bicycle Sidepath Design Factors Affecting Crash Rates

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ABSTRACT
The Florida Department of Transportation has sponsored a project to create a method for determining what bicycle facility types provide the best mobility for bicyclists. This project includes, as a component, developing a model that predicts the relative bicycle / motor vehicle crash rates between on-street facilities and shared use paths located adjacent to a roadway (sidepaths). This paper describes how this Sidepath Safety Model was developed and how it provides important guidance for bicycle facility type selection and sidepath design.

The model was developed using operational and geometric data, user counts, and crash data for twenty-one roadway sections throughout Florida. Four determining factors were found to be significant and are included in the model:

- the sidepath width (possibly a surrogate for user speed),
- the separation of the sidepath from the roadway,
- the posted speed of the roadway, and
- the number of lanes on the adjacent roadway.

The Sidepath Safety Model's R^2 value is 0.81.

The Sidepath Safety Model also serves to quantify some of the concerns expressed in the AASHTO *Guide for the Development of Bicycle Facilities*. Using this model, transportation planners and engineers will be able to test alternative design treatments to find the safest for bicyclists. They will also be able to review existing sidepaths that have crash problems to identify potential solutions. This model provides transportation professionals an important new tool for their use when deciding upon and designing bicycle facilities.

BACKGROUND
On-road bicycle facilities are being constructed in great numbers throughout the United States. Their design and construction are generally according to the nationally adopted roadway cross-sectional guidance provided by the American Association of State Highway and Transportation Officials (AASHTO) *Guide to the Development of Bicycle Facilities* (*1*). While these guidelines were developed considering the operational and safety factors associated with bicycling, they do not address the facilities' ultimate quality of service and/or adequacy for all bicyclists. Frequently, planning and design professionals, elected officials, and the general public question whether off-road (sidepath) facilities would better accommodate the majority of those wishing to ride bikes for transportation. In fact, observations of bicyclists' behavior on roadways with bike lanes in Florida indicate that in many instances, bicyclists ride on the adjacent sidewalk instead of using the standard AASHTO and Florida Department of Transportation (FDOT) prescribed on-road bicycle lane.

There is much debate throughout the United States concerning sidepaths. The vast majority of advocates and bicycle transportation professionals maintain that on-road bike lanes are the most appropriate, safest, most cost efficient and most-utilized facilities. These advocates argue that because of delays, conflicts, and crashes often associated with sidepaths, sidepaths do not adequately serve the needs of many commuter cyclists. In fact, a number of jurisdictions that have built extensive bicycle networks incorporating sidepaths now no longer build those types of facilities because of their operational problems. Others argue that sidepath facilities should be considered in many circumstances, especially in areas near schools and in corridors with intense motor vehicle traffic on the roadway.

The AASHTO *Guide to the Development of Bicycle Facilities* strongly cautions the planner / engineer contemplating a sidepath facility to investigate various elements of the roadway corridor environment and right-of-way before making a decision (*1*). It provides nine cautions / criteria (pp. 34-35); unfortunately, these are not quantitative to provide specific direction, and thus only judgment can be used to determine when a sidepath is an acceptable bicycle facility.

However, much of the information about the operational and safety concerns of sidepaths is apparently not being disseminated to design agencies across the U.S. because the vast majority of design professionals view sidepaths as being much safer than roadway facilities. The FDOT's District One understood the safety concerns of providing sidepaths, but they also knew some people are not comfortable riding on roadway bike lanes. To provide maximum mobility for all bicyclists, FDOT wanted to know in what circumstances sidepaths would be acceptable bicycle facilities.

The FDOT's District One Planning Office contracted Sprinkle Consulting to establish bicycle sidepath and on-road facility selection guidelines. The final product of this study was a methodology to determine under what conditions a sidepath facility would be appropriate in a roadway environment. The following seven steps make up this methodology:

- level of accommodation for bicyclists on the adjacent roadway, paired with the potential bicycle travel demand along the roadway,
- potential safety of a sidepath facility,
- the availability of alternative routes,
- adequacy of right-of-way to accommodate a "safely functioning" sidepath,
- access to probable destinations,
- appropriateness of sidepath length and the design of termini, and
- the level of comfort and safety the proposed sidepath would provide to cyclists.

To accomplish the above steps, two secondary objectives had to be accomplished: first, a method for determining the safety of a sidepath relative to an on-street facility; and second, developing a conceptual level of service framework for sidepaths. This paper addresses the first of these project sub-objectives – how to determine the relative safety of a sidepath with respect to an on-street facility. It was hypothesized that a mathematical model could be developed to predict the relative safety of sidepaths and on-street facilities. This Sidepath Safety Model would be used to assess the potential safety of the sidepath facility, and to provide insight into geometric design

LITERATURE REVIEW

Currently, there is minimal literature that directly relates to this study's objective - to identify those factors which affect the relative safety between sidepath and roadway facilities. However, there are two categories of literature that generally relate to sidepath facilities: (1) research reports that analyze crash data and (2) resources that provide design guidance for bicycle facilities. These are reviewed below.

Research Reports

Numerous studies, both in the United States and in Europe, have been conducted regarding crash rates for cyclists using sidepaths. Most of these studies considered populations of cyclists, their use of different types of facilities and their crash rates while using these facilities. Generally, the studies have demonstrated that riding on the road resulted in lower overall crash risk than riding on sidepaths or sidewalks.

In the United States, Kaplan surveyed adult cyclists in 1974 and determined that sidepaths had a crash rate of 292 crashes per million cycle miles (1.61 million cycle km), compared with 104 and 111 crashes per million cycle miles (1.61 million cycle km) for minor and major roadways, respectively (*2*). A 1996 survey by Moritz concluded that multiple use trails have a crash rate about 40% greater than would be expected from the number of cycle miles (*3*). The Moritz study included shared use paths on independent alignments within its study population, and consequently does not directly relate to the sidepath study. In the early 1990s, Wachtel and Lewiston studied bicycle / motor vehicle collisions in Palo Alto, California and concluded that a cyclist riding on a sidepath or sidewalk was 1.8 times more at risk of a crash than a cyclist riding on the roadway (*4*).

Several international studies have resulted in similar results. A 1995 Finnish study by Räsänen determined that 63% of bicycle-motor vehicle crashes took place at sidepaths and concluded that sidepaths were not well-understood by motorists (*5*). This lack of understanding by motorists is thought to have contributed to the higher crash rate for cyclists on sidepaths. Research conducted in Helsinki, Finland by Pasanen and Räsänen in 1999 found that cycling on a sidepath is 2.5 times more likely to result in a crash than cycling on the roadway; and at intersections, the risk is more than 3 times higher (*6*). According to a 1996 study performed by Summala *et al.* in Helsinki, right-turning drivers looked left more frequently than they looked right, thus failing to notice cyclists coming from the right (*7*). This finding underscores some of the hazards for contra-flow bicyclists using a sidepath facility.

Design Resources

In addition to reviewing research studies, we reviewed bicycle facility design guidance documents from around the U.S. and Europe. All these documents recognized operational and safety problems identified in the international research and further explain the hazards that may result from placing shared-use paths adjacent to roadways. These problems may include, but are not limited to, the following:

- Unless separated, they require one direction of bicycle traffic to ride against motor vehicle traffic, contrary to normal rules of the road (*1, 8*).
- When the path ends, bicyclists going against traffic will tend to continue to travel on the wrong side of the street. Likewise, bicyclists approaching a shared use path often travel on the wrong side of the street to access the bicycle (side) path. Wrong-way travel by bicyclists is a major cause of bicycle/automobile crashes and should be discouraged at every opportunity (*1, 7*).
- Many bicyclists' destinations may be on the opposite side of the street from where the bicycle path is located. In this case, the bicyclists' desire to access these destinations must be addressed (*1, 8, 9*).

These design resources typically go beyond enumerating the cautions and provide guidance on when sidepaths could be used. In some cases they suggest treatments to mitigate the previously stated concerns expressed about sidepaths.

The Oregon Bicycle and Pedestrian Plan provides guidance for evaluating the appropriateness of separated paths along roadways, for example, when high bicycle and pedestrian use is anticipated or when there are no reasonable alternatives for bikeways and sidewalks on nearby parallel streets (*8*).

The League of Illinois Bicyclists developed an algorithm to calculate a suitability score to be used to rate existing sidepaths, determine whether a new sidepath would be an appropriate option for accommodating bicycles, and suggest safety improvements for existing or planned sidepaths. This algorithm considers the following factors:

- number of driveways per mile (1.61 km)
- volumes of the driveways
- speed of the adjacent roadway
- volume of the adjacent roadway
- continuity of the facility
- presence of curb cuts
- pedestrian volumes
- intersection and sidepath separation (*10*).

The Chicagoland Bicycle Federation developed a rating method using a point scale for evaluating the safety of proposed sidepaths. This method considered the total number of points a facility received based on the following: 1 point for each residential driveway, 2 points for each commercial driveway, 2 points for minor streets (< 1,000 vehicles per day), and 4 points for major streets (>1000 vehicles per day). If the total is 1 to 8 points per mile (1.61 km), it is considered low risk, 8 to 16 points is considered moderate risk, and more than 16 points is high risk and a path is not recommended. If a street with more than 10,000 vehicles per day is crossed without a signal, the proposed path is automatically moved to the high risk category (*11*).

Three other documents contain notable design guidance for sidepaths. For example, the *Trail Intersection Design Handbook*, produced by the Florida Department of Transportation, provides design guidance for sidepath intersections and setback dimensions (probably as much as or more information than any other document from the United States) (*12*). The second document, the AASHTO *Guide for the Development of Bicycle Facilities*, recommends wide separation between the roadway and an adjacent shared use path; if a minimum of 5 ft (1.5 m) cannot be obtained, then a physical barrier should be installed (*1*). Additionally, the Minnesota Department of Transportation has detailed guidelines regarding the location of sidepaths (*13*).

European criteria for sidepaths are based on speed and traffic volumes. In the Netherlands, no special bicycle facilities are recommended when traffic speeds are less than 20 mph (32 km/h). Separated paths are recommended under the following conditions:

- With traffic speeds of 25 mph (40 km/h), when traffic volumes are higher than 9,000 vehicles per day (vpd).
- At 30 mph (48 km/h), when volumes are higher than 6,000 vpd.
- At 35 mph (56 km/h), when volumes are higher than 2,500 vpd.
- At 40 mph (64 km/h), when volumes are higher than 1,500 vpd.
- At 45 mph (72 km/h), when volumes are higher than 800 vpd.
- At 50 mph (81 km/h) or above, at any traffic volume.

Recommendations from Denmark and the United Kingdom are similar (*15, 16*).

The recommendations for when a sidepath may be appropriate that are provided in these guidance documents have not been validated based upon actual crash data and the relative safety of in-street and sidepath facilities. Consequently, we cannot determine if they address all the relevant factors with respect to bicyclists' safety, or even if the values they recommend provide safe facilities. Hence, we decided that the question of when a sidepath is an appropriate facility (with respect to safety) has not yet been adequately answered.

DATA COLLECTION AND MODEL DEVELOPMENT

Because of all the previous research and design guidance cautioning against the use of sidepaths, FDOT was very concerned about their safety and wanted to ensure that the sidepaths they might choose to build be would safe for the bicyclists using them. Consequently, as the major effort of this project, the consultants performed an extensive evaluation of the crash rates for roadways with sidepath facilities with respect to the design of the sidepath facilities. This analysis yielded a predictive model to determine the relative safety of on-street versus off-street facilities for bicyclists. Forty-six roadway sections throughout the state of Florida were included in comparing the crash rates of on-street bicyclists to those of off-street bicyclists using the sidepaths. The geometric and operational conditions of each section were evaluated to determine what factors influenced the relative crash rates for the on- and off-street facilities.

Data Collection

Three data collection efforts were performed as part of this effort. First, operational and geometric data were obtained for each of the roadways and sidepaths. Secondly, the bicycle user counts were performed for each facility. Finally, bicycle / motor vehicle crash data were obtained for all of the roadway sections and sidepaths included in the study.

Operational and Geometric Data

Operational and geometric data were obtained from two sources: the FDOT photolog and field measurements. The FDOT photolog, which includes forward and right-side facing photos at fifty-foot intervals along state roadways, was used to obtain data such as the separation width to the sidepath, width of the sidepath, traffic control at sidepath / roadway intersections, and the number of driveways along the sidepath. The dimensional information was field verified by staff performing user counts. Unfortunately, the diversity of the geometric and operational data was not adequately representative of typical field conditions. Consequently, several facilities were added to the final data set. Some facilities were also combined because of their continuity and similar characteristics. The final evaluation dataset included twenty-one (21) sidepaths, two of which were actually sidewalks commonly used as bicycle facilities (Table 1).

User Counts

To determine crash rates, sidepath and roadway user counts were needed. Data collection forms were developed and pilot tested. The researchers solicited the help of Florida's network of DOT and local bicycle and pedestrian coordinators. Several coordinators volunteered to supervise data collection volunteers or temporary employees who counted the number of cyclists (and other non-motorized users) on the sidepath and those on the adjacent roadway. These data were collected for two four-hour periods on each sidepath. One set of counts was performed on a weekday (Tuesday, Wednesday, or Thursday) afternoon and the other on a Saturday morning. The counts were collected in 2004 and 2005.

Crash Data

Crash data were obtained from a variety of sources. Initially, it was thought that the FDOT crash analysis reporting system (CARS) database would provide adequate data for this project. While there are limitations to the data in this database, the researchers felt that the data would at least be consistently limited across all the facilities. Initial modeling using this data found that sidepaths were inherently safer than roadways independent of any operational or geometric characteristics. Because this result is inconsistent with previously published research (as discussed in the literature review) on this subject, we re-examined certain aspects of the CARS dataset. Upon a detailed review of the crashes obtained through the FDOT database, we identified two problems with the data which were impacting the accuracy of any analysis and, if not mitigated, would have led to erroneous conclusions. First, many of the crashes which were coded as having occurred on the roadway may, in fact, have been sidepath users who were entering the roadway or trying to cross an intersecting roadway. Second, crashes occurring along a sidepath may have been recorded as occurring on an intersecting roadway rather than on the roadway paralleling the sidepath, and thus not be represented in the subsequent analysis.

To address these problems we obtained hard copy crash reports for crashes occurring on the state road along which the sidepaths are located. Additionally, local law enforcement agencies were contacted and, working with those agencies, we obtained crash reports for all bicycle crashes occurring along the roadways that intersected the sidepath. The crash reports were individually reviewed to determine their relevance to the project analysis.

Model Development

The researchers considered two different techniques for determining the relative safety of on-roadway facilities and sidepaths. The first was to create predictive crash models for each type of facility; then the results of each model would be compared to determine the relative safety. The second option was to model the difference in the crash rates. Since the bicycle facility selection and sidepath evaluation procedure proposed comparing the relative crash rates for on-roadway and sidepath crashes, we chose the latter option for this project.

The researchers first employed Pearson correlation and factor analysis of the operational and geometric variables with respect to difference in crash rates (the potential roadway crash rate minus the potential sidepath crash rate). Subsequently, they selected the following relevant variables in the second step of the model development process:

- the width of the sidepath,
- the effective distance between the sidepath and the roadway,
- the posted speed limit on the adjacent roadway, and
- the number of lanes on the adjacent roadway.

Other variables were dropped from further consideration because of their poor correlation with the dependent variable, the difference in sidepath and roadway crash rates, or because of their collinearity with more strongly correlated variables. The short list of variables represented the best surrogate measures for some of the more complex operational measures.

Stepwise regression analysis was conducted using the final dataset. Equation 1 shows the terms and coefficients for the Sidepath Safety Model. Table 2 shows the T-statistics for each term of the model. The correlation coefficient (R^2) of the best-fit model is 0.81. The coefficients are statistically significant at the 95 percent level. Actual versus predicted values for delta are plotted in Figure 1.

$$\Delta = W_{sp}\left(6.311 - 0.465W_{sp}\right) + D\left(0.015S - 0.685\right) - 1.528\ln(L) - 17.555 \qquad \text{(Eq. 1)}$$

where:

Δ = predicted bicycle crash rate for a roadway – predicted bicycle crash rate for a sidepath

W_{sp} = width of the sidepath

D = effective distance between the sidepath and the roadway (buffer width + ½ sidepath width)
S = speed limit of the adjacent roadway
L = number of through lanes on the adjacent roadway

As can be seen from the definition of Δ (delta), a positive result from the model predicts that the sidepath would have a lower crash rate than the roadway for bicyclists.

DISCUSSION OF THE MODEL TERMS

Described below are some of the impacts of the Sidepath Safety Model form along with each model term and its implications on how sidepaths can be designed to safely accommodate bicyclists. The figures provided are for specific (example) cases. These figures should not be used to analyze actual roadway scenarios (unless they meet the conditions specified).

Effect of Path Width

Figure 2 presents a graph showing the influence of a sidepath's width on the comparative safety of the sidepath and the roadway. The example roadway used for this analysis is a four-lane, 45 mph (72 km/h) roadway, with a separation (defined as "D" in the equation) to the sidepath of 10 feet (3.1 m). As depicted in the graph, there is an optimum operational width for this sidepath at conflict points – approximately 7 feet (2.1 m). It is hypothesized that the narrow width effectively keeps sidepath traffic speeds low, providing more time for motorists and cyclists to observe each other and avoid a conflict or a crash. This trend, an optimal width of about seven feet, is consistent across all ranges of variables.

The seven-foot optimal width suggests that in many cases it may not be feasible to construct a sidepath that is both safer than the roadway and accommodates all users. AASHTO (1) recommends a minimum trail width of at least 8 feet (2.4 m), recommending 10 feet (3.1m) or more to enable two cyclists to pass each other. Additionally, research (including the recently published *Characteristics of Emerging Road and Trail Users and Their Safety*) shows that several shared use path user types have sweep (operating) widths of at least four feet (1.2 m) and in-line skaters use five feet (1.5 m) of sweep width (*17, 18*).

We believe two other design geometries may result in lower speeds. One method of reducing speeds on the approach to conflict points (such as intersections) might be to shift, or jog, the alignment of the trail in advance of conflict area (driveway or intersection). Much like a chicane along a roadway, this jog in the alignment may slow trail users on the approach to the conflict resulting in a reduced crash rate. Alternatively, simply narrowing the trail on the approach to the conflict area may reduce cyclists' speeds on a sidepath. If this is an effective technique, the sidepath could be built wide enough to accommodate multiple users along a segment and only be restricted at the conflict points.

Effect of Sidepath Separation from the Roadway

As can be seen from the two graphs below (Figures 3 and 4), whether or not increased separation to a sidepath benefits the safety of the sidepath depends upon other factors. Figure 3 shows the influence of the separation from the sidepath to the roadway on the relative bicyclists' crash rates. The roadway used in this example is a four-lane roadway with a 55 mph (89 km/h) posted speed and a sidepath width of 10 feet (3.1 m). Note that with this facility, a separation "D" of 23 feet (7.0 m) or more results in the sidepath having a lower crash rate than the adjacent roadway. Figure 4 shows the influence of the separation to the sidepath to the roadway on the relative sidepath / roadway bicyclists' crash rates on an example roadway of four lanes, 35 mph (56 km/h) posted speed, with a sidepath width of 8 feet (2.4 m). Under these conditions the sidepath should be placed close to the adjacent roadway.

These results suggest that the lower the speed on the adjacent roadway, the safer it is to locate the sidepath near the roadway. Alternatively, if the sidepath is separated from the roadway at midblock locations to increase the comfort of users, it may be appropriate to bring the sidepath close to the roadway at intersections under conditions of low roadway speeds.

Effect of Posted Speed on the Adjacent Roadway

Figure 5 shows the influence of the adjacent roadway's posted speed on the difference in crash rates. The example roadway used for this analysis is a four-lane roadway, with a separation to an eight-foot sidepath of 12 feet (3.7 m). As the speed increases, so does the relative safety of the sidepath compared to the adjacent roadway. At posted speeds of higher than 40 mph (64 mi/h), the sidepath has a lower crash rate than the adjacent roadway. This trend is consistent across all variable ranges.

Effect of the Number of Lanes on the Adjacent Roadway

The final statistically significant variable in the Sidepath Safety Model is the number of lanes on the adjacent roadway. Figure 6 shows the influence of the number of lanes on the difference in crash rates. The example roadway used for this analysis is a 45 mph (72 km/h) roadway, with a separation to an eight-foot (2.4 m) sidepath of 10 feet (3 m). As shown in Figure 6, if the adjacent roadway has two or three lanes, the sidepath has a lower crash rate than the adjacent roadway. On the other hand, if the adjacent roadway has four or more lanes, the roadway has a lower crash rate than the sidepath.

These results suggest that the more lanes there are on the roadway, the more motorists appear to be focused on the opposing motor vehicle travel lanes and turning traffic as opposed to activity on the sidepath. On a two lane roadway, motorists' fields of vision (and concern) for the cyclists appear to include the side of the street as well as the roadway. On wider streets, motorists appear to be more concerned with the increasingly complex roadway environment and, as a result, give less consideration to the non-motorized sidepath users. Additionally, sidepath users may only concern themselves with traffic only in the nearest travel lanes. Both of these behaviors may explain the increased crash rates of sidepaths adjacent to wider, multi-lane roadways.

SUMMARY

As hypothesized, the researchers were able to develop a statistically valid, mathematical Sidepath Safety Model to predict the difference in bicycle / motor vehicle crash rates between sidepath crashes and on-street crashes. The significant terms included within the model suggest that the width of the sidepath (possibly a surrogate for user speed), the separation of the sidepath from the roadway, the posted speed of the roadway, and the number of lanes on the adjacent roadway contribute to the difference in the crash rates.

The Sidepath Safety Model resulting from this study provides important information to the planners and designers of bicycle facilities. By applying this model the designer can determine if a sidepath could be an acceptable facility. Once it is decided to build a sidepath, the Sidepath Safety Model can be used to set the right-of-way cross section elements to ensure the safest possible model. This tool continues to be helpful once a designer determines there is adequate right-of-way. The model can be used to design intersection treatments by providing information on whether the sidepath should be moved away from, or close to, the adjacent roadway at intersections or if some sort of neckdown or other sidepath “traffic calming” type treatment should be used on the approach to conflicts.

The Sidepath Safety Model can also be used to analyze existing sidepaths. If an agency finds that crashes are occurring on a sidepath, the model can be used to find solutions to the crash problem. By suggesting either alignment or operational changes to the pathway, the model can help agencies improve the safety of their existing systems.

The Sidepath Safety Model is a powerful tool for planners, designers, and safety professionals. Using this tool, transportation professionals will be able to better provide for the mobility and safety needs of the bicycling public.

ADDITIONAL RESEARCH

The Sidepath Safety Model addresses the relative safety of a sidepath and an on-street bicycle facility and is a powerful tool for transportation professionals. However the opportunity still exists to provide models to predict the actual crash rates as a function of the specific design criteria for the facility being proposed. For example, what is the on-road facility type being proposed (shared lane, wide curb lane, paved shoulder, or bike lane)? How wide are the adjacent lanes? What is the truck traffic? What is the frequency of driveways? The same could be done to determine the actual crash rates on sidepaths. What treatments are used at signalized intersections? What type of signing is on the adjacent roadway? Will reducing the speed at conflict points only (neck downs, jogs in the alignment) reduce crashes? This research would give planners, designers, and safety engineers comprehensive tools to provide the safest possible bicycle transportation network.

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FIGURE 2 Sidepath width vs. difference in crash rates. (4-lane roadway, 45 mph (72km/h) speed limit, 10 feet (3.1 m) to the adjacent roadway)

FIGURE 3 Separation to roadway vs. difference in crash rates. (Scenario 1 - roadway with four lanes, 55 mph (89 km/h) speed limit, with a sidepath width of 10 feet (3.1 m))

FIGURE 4 Separation to roadway vs. difference in crash rates. (Scenario 2 - roadway of four lanes, 35 mph (56 km/h) speed limit, with a sidepath width of 8 feet (2.4m))

FIGURE 5 Posted speed vs. difference in crash rates. (4-lane, 8-foot (2.4-m) separation, 12-foot (3.7-m) path)

FIGURE 6 Roadway lanes vs. difference in crash rates. (45 mph (72 km/h) speed limit, 8-foot (2.4-m) separation, 10-foot (3.1-m) path)

TABLE 1 Roadway Sections Analyzed in This Study

Road Name	From	To	Length (miles)[a]	Location
US 19	McCormick Drive	Enterprise Rd	0.8	Dunedin
66th St N	Bryan Dairy Rd	118th Ave N	0.4	Pinellas Park
Alt US 19 / SR 595	Access Rd (South of 38th Ave)	Park St	0.5	Seminole
66th St N	5th Ave N	10th St (Before 13th St)	0.3	Gulfport
Gulf Blvd	93rd Street	First Street	0.5	St. Pete Beach
Tamiami Trail	Symmes Rd / Emergency Signal	Beach Ave	0.25	Gibsonton
Cleveland St / SR 60	Highlands Ave	McMullen Booth Rd (Overpass)	4.139	Clearwater
Ulmerton Rd	Belcher Rd	Rose Tree Lane (Monterey Lake Apts)	0.2	Largo
W Hillsborough Ave	Tudor Dr	Sheldon Rd	0.5	Town 'n' Country
W Martin Luther King Blvd	Caraway Dr (West of Williams Rd)	Peak St (East of Hewitt St)	0.9	Mango
66th St N	66th Ave	Park Blvd	0.5	Pinellas Park
S Missouri Ave	East Bay Dr	Court St (North of Rogers St)	3.0	Largo
East Bay Dr-Roosevelt Blvd	Seminole Blvd / Missouri Ave	Bolesta Rd	5.1	Largo
N Dale Mabry	W Cleveland St.	Nassau St / Before I-275 Ramp	0.7	Tampa
S Pasadena Ave	Blind Pass Rd	Park St	0.71	South Pasadena
Fowler Ave	Florida Ave	30th St / Bruce B. Downs	1.8	Tampa
S Pasadena Ave	Blind Pass Rd	Shore Drive S	0.99	St. Pete Beach
Fowler Ave	N Florida Ave	I-275 overpass	0.3	Tampa
Gulf Blvd	Corey Ave	93rd St	1.0	St. Pete Beach
S Dixie Hwy	Ludlum Road / SW 67 Ave	SR 966 / SW 72 St	0.95	Kendall
S Dixie Hwy	SR 966 / SW 72nd St	Maggiore St	2.05	Coral Gables

[a] 1 mi = 1.61 km

TABLE 2 Model Coefficients and Statistics

Model Terms	Coefficients	T-statistics
W_{sp}	6.311	6.026
W_{sp}^2	-0.465	-6.326
D*S	0.015	2.845
D	-0.685	-2.838
ln(L)	-1.528	-2.442
Constant	-17.555	-4.726
Model Correlation (R^2)	0.81	

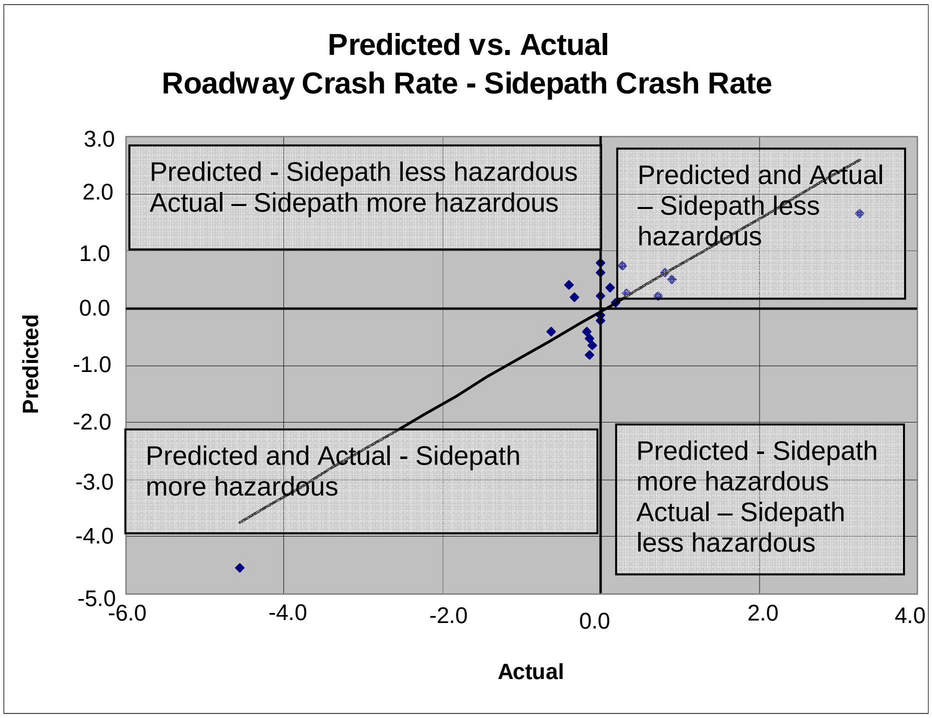

FIGURE 1 Actual vs. predicted values of roadway crash rate – sidepath crash rate.

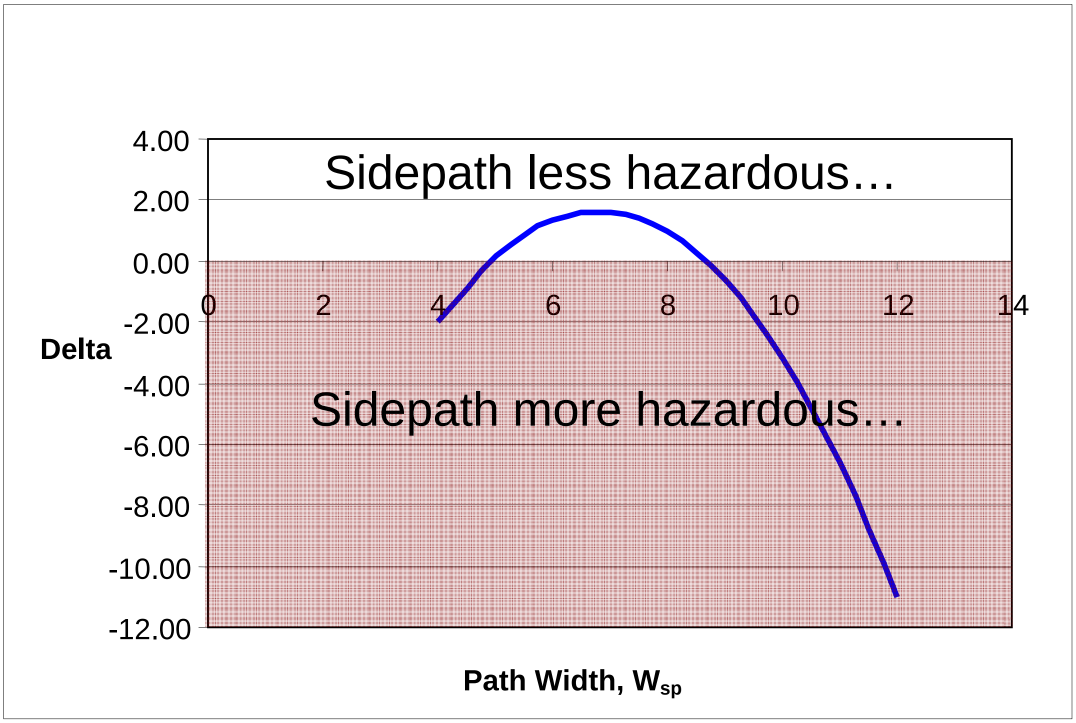

FIGURE 2 Sidepath width vs. difference in crash rates. (4-lane roadway, 45 mph (72 km/h) speed limit, 10 feet (3.1 m) to the adjacent roadway)

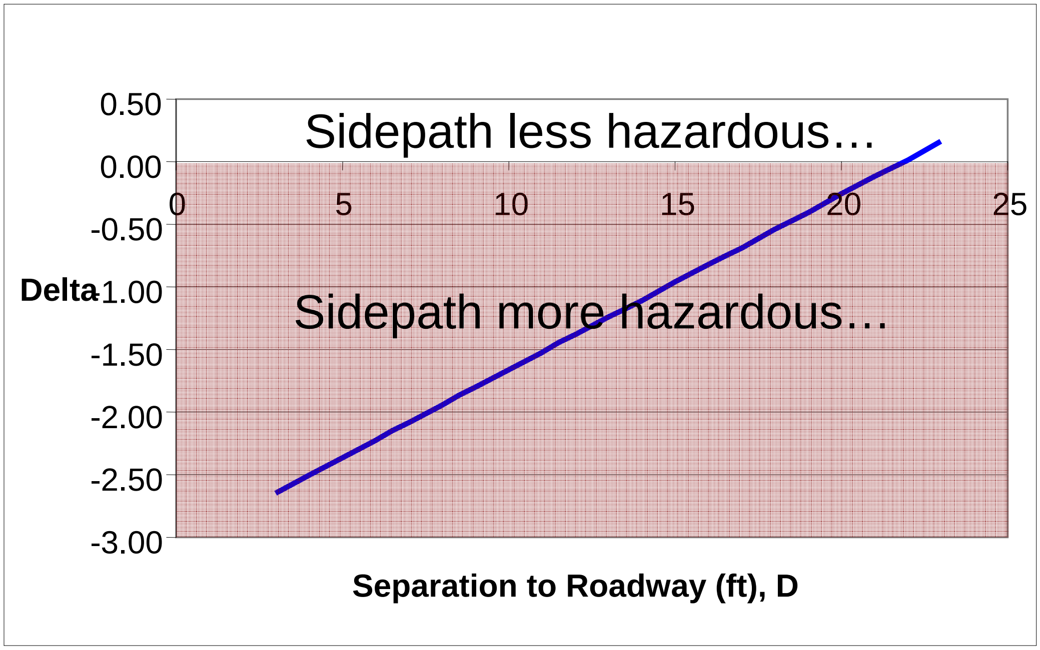

FIGURE 3 Separation to roadway vs. difference in crash rates. (Scenario 1 - roadway with four lanes, 55 mph (89 km/h) speed limit, with a sidepath width of 10 feet (3.1 m))

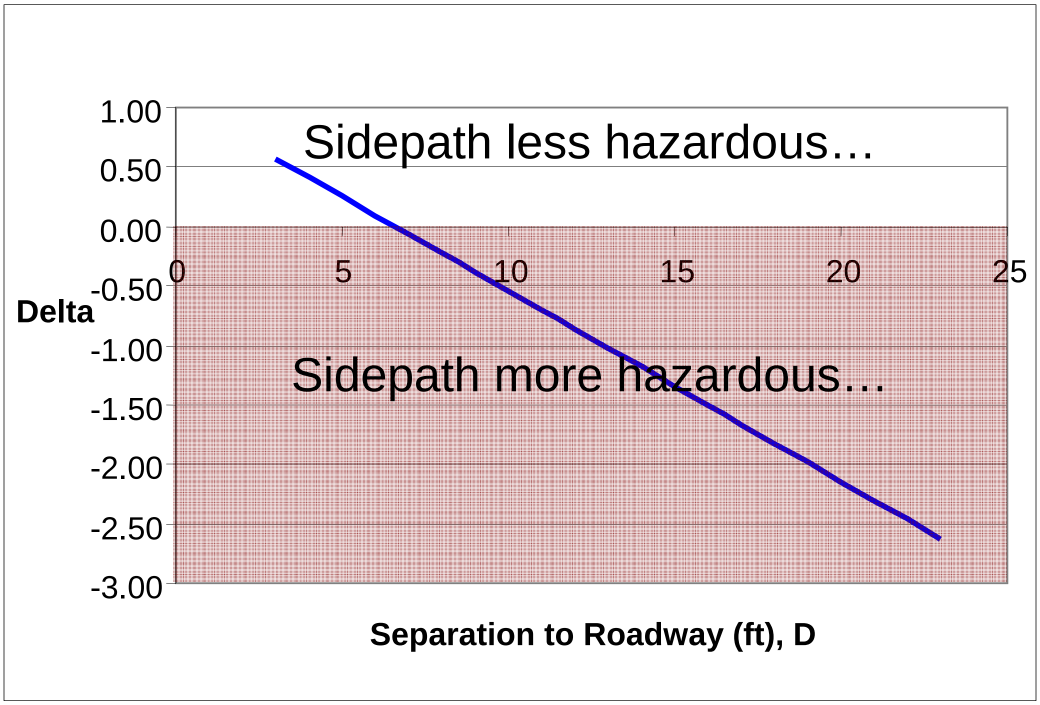

FIGURE 4 Separation to roadway vs. difference in crash rates. (Scenario 2 - roadway of four lanes, 35 mph (56 km/h) speed limit, with a sidepath width of 8 feet (2.4 m))

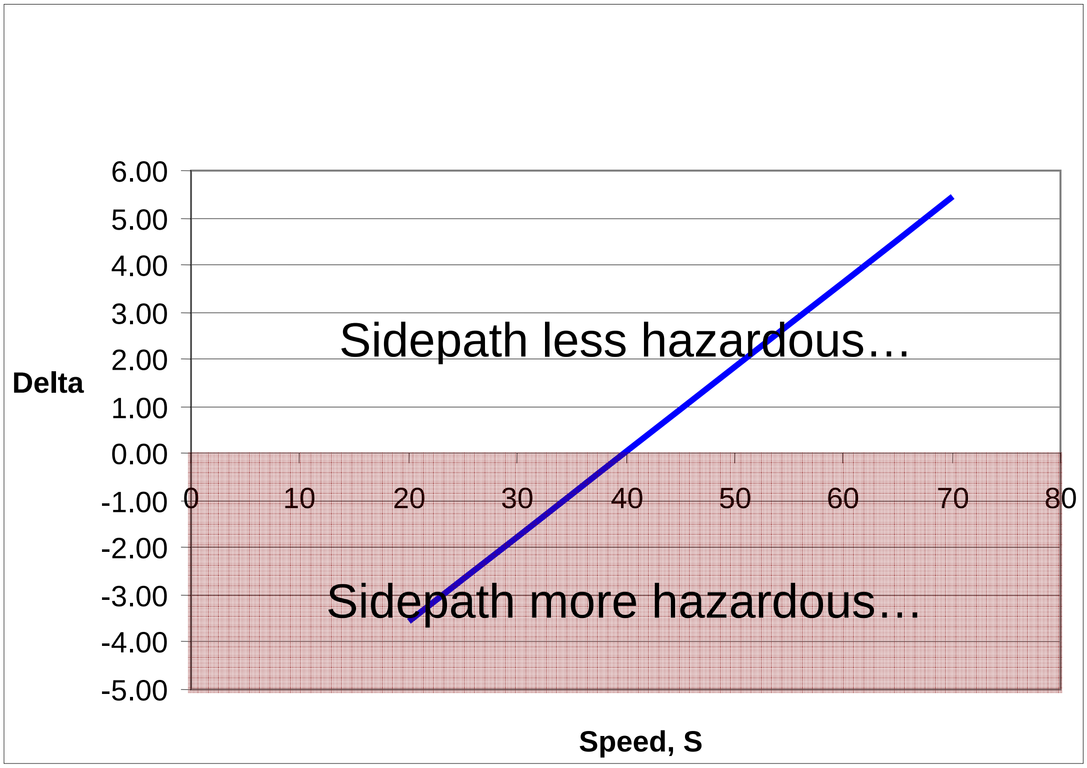

FIGURE 5 Posted speed vs difference in crash rates. (4-lane, 8-foot (2.4-m) separation, 12-foot (3.7-m) path)

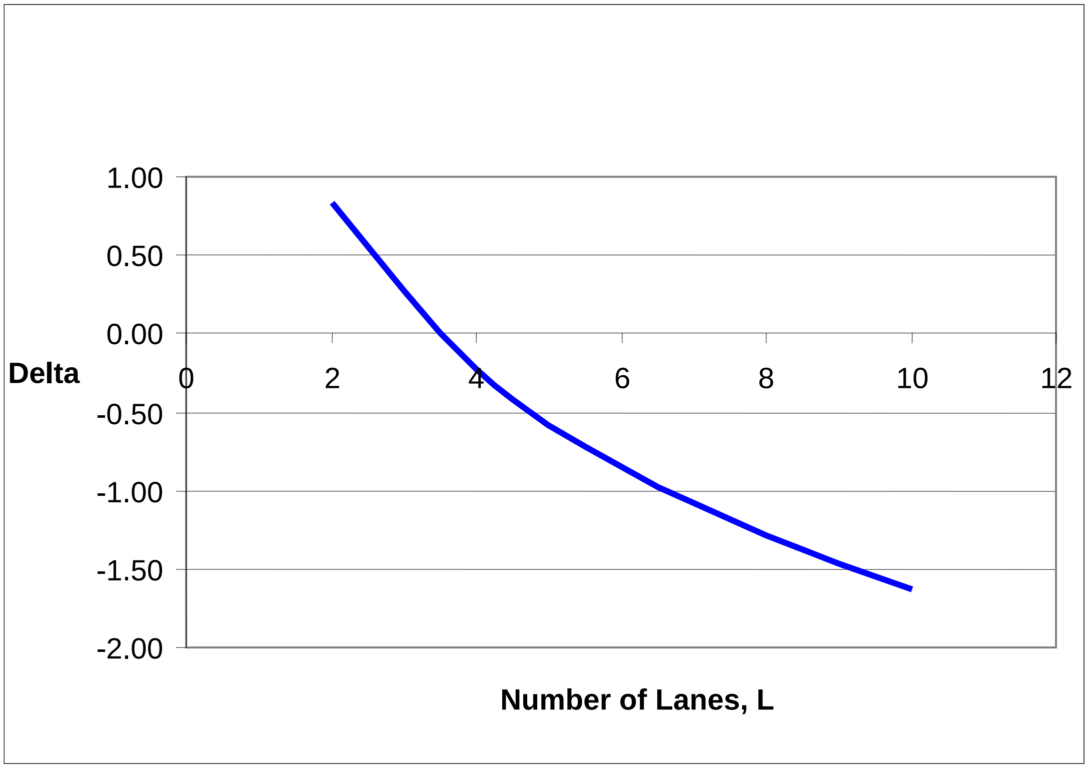

FIGURE 6 Number of lanes vs. difference in crash rates. (45 mph (72 km/h) speed limit, 8-foot (2.4-m) separation, 10-foot (3.1-m) path)