# Designing for Bicyclist Safety

*September, 2016*

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*September 2016*

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## Learning Outcomes:

- Relate national objectives and priorities to improve bicycle travel.
- Identify means of assessing quality of bicyclist facilities.
- Describe core bicyclist safety concepts.
- Distinguish between various bicyclist facilities.
- Identify innovative design features to enhance bicyclist safety.

## Note of caution:

The knowledge and practice of designing for bicyclists is rapidly changing. Images in these materials and other guidelines may be outdated. Always check for the latest MUTCD interim approvals and experimental traffic control devices.

# Agenda

The workshop will generally follow this agenda; however, the instructors will adjust as needed to conform to the specific needs of the participants.

## Day 1

| | |
|---|---|
| | Registration and Participant Introductions |
| Module A | Introduction |
| Module B | Designing for On-Road Bikeways |
| | Exercise |
| Module C | Intersection Design Treatments |

# Introduction

*Module A*

## Learning Outcomes:

- ✖ Discuss why we should include bicycles in the transportation network.
- ✖ Explain the challenges and opportunities to analyze bicyclist safety.
- ✖ Identify key safety factors for bicyclists.

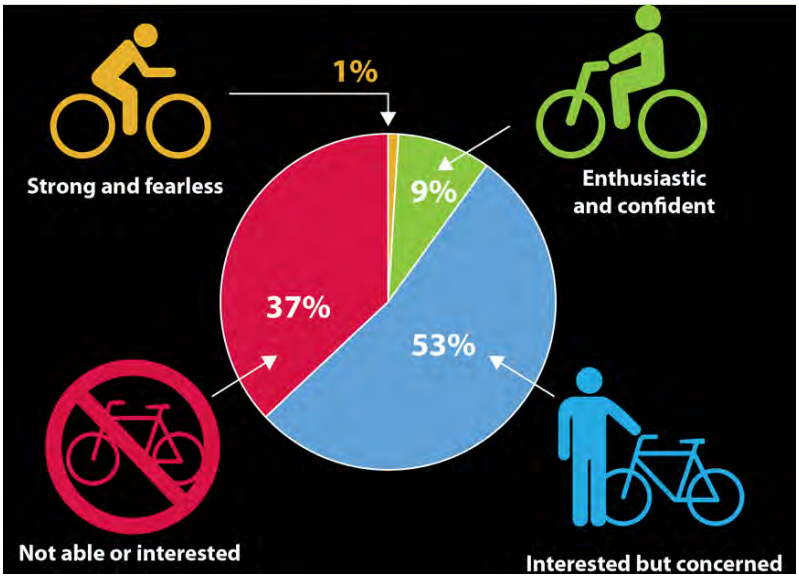
## IMPERATIVE FOR IMPROVEMENT

### What are the Opportunities?

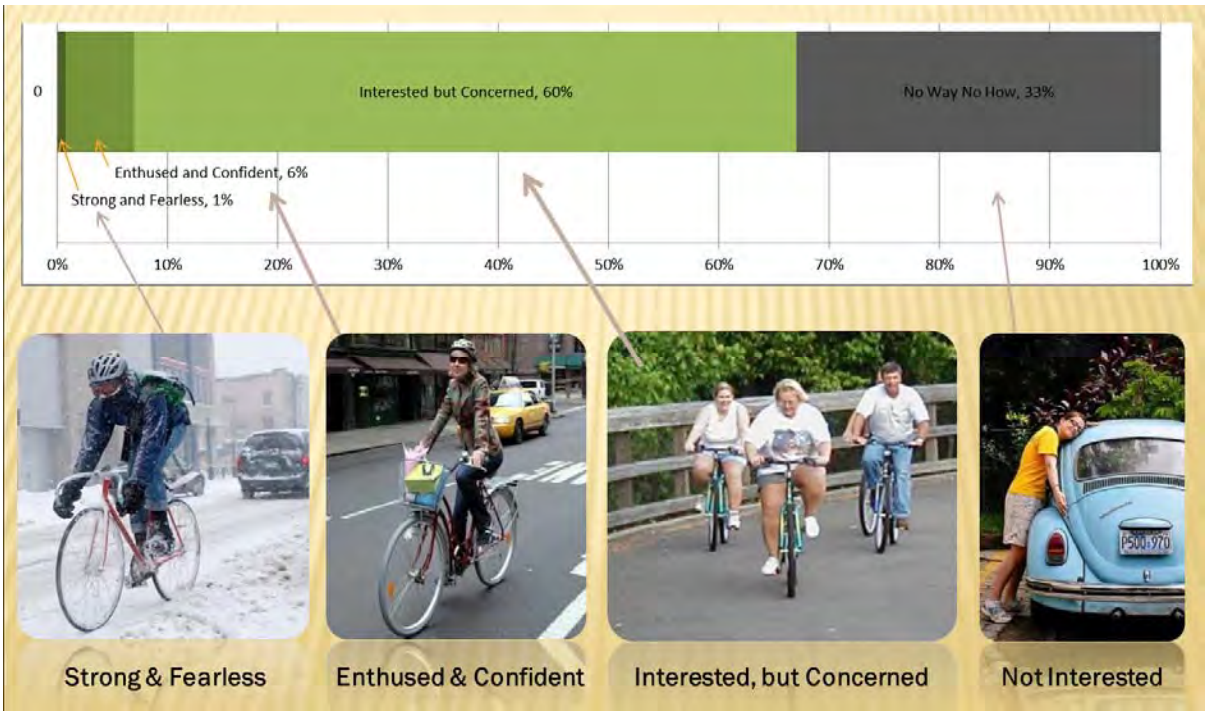
- ✖ 50% of trips are ≤ 3 miles
- ✖ 1/3 of U.S. adults say they would commute by bike if safe facilities were available
- ✖ 1 out of every 11 U.S. households do not own an automobile

Sources:
https://www.bikewalkalliance.org/storage/documents/reports/2014BenchmarkingReport.pdf, p. 69
nhts.ornl.gov/2009/pub/stt.pdf

## Bicyclist Skill & Comfort




Source:
Portland Bicycle Program, Roger Geller



| Experienced & Confident | Casual/Less Confident |
|---|---|
| ✖ **Navigate on streets**<br>✖ **Some prefer bike lane, shoulders, shared-use paths when available**<br>✖ **Prefer direct route**<br>✖ **Speeds up to 25 mph on level and 45 mph on downgrade**<br>✖ **Longer trips** | ✖ Difficulty gauging traffic or unfamiliar with rules of road<br>✖ Prefer shared use paths or bike lanes on low volume streets<br>✖ Prefer separation from traffic<br>✖ May ride on sidewalk<br>✖ Avoid traffic<br>✖ Speeds of 8 to 12 mph<br>✖ Trips of 1 to 5 miles |

*In order for [the casual/less confident] group to regularly choose bicycling as a mode of transportation, as physical network of visible, convenient, and well-designed bicycle facilities is needed.*

Source: AASHTO, *Guide for Development of Bicycle Facilities,* 2012.

## Bicyclist Characteristics

Photo taken by Tiffany Robinson, Montclair New Jersey, 2010.


Photo taken by Harvey Muller, 1996.

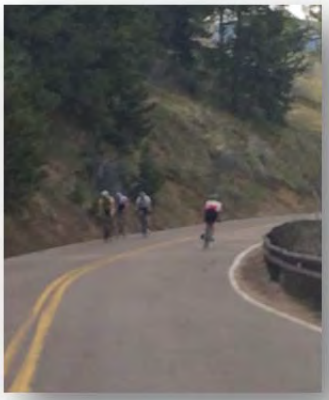

Photo taken by Harvey Muller

## Reasons for bicycling

- Recreation 26.0%
- Exercise or health reasons 23.6%
- To go home 14.2%
- Personal errands 13.9%
- To visit a friend or relative 10.1%
- Commuting to school/work 5.0%
- Bicycle ride 2.3%
- Other 4.9%

## Preferences

- ✖ Feel safe
- ✖ Feel secure
- ✖ Lower speed
- ✖ Lower volume
- ✖ Lower truck %
- ✖ Fewer lanes



## Behaviors

- ✖ Violate traffic control
- ✖ Slow on uphill
- ✖ Fast on downhill

## Types of Bicycles

- ✖ Design Vehicle
  - \+ Typical bicycle dimensions
  - \+ Key performance criteria

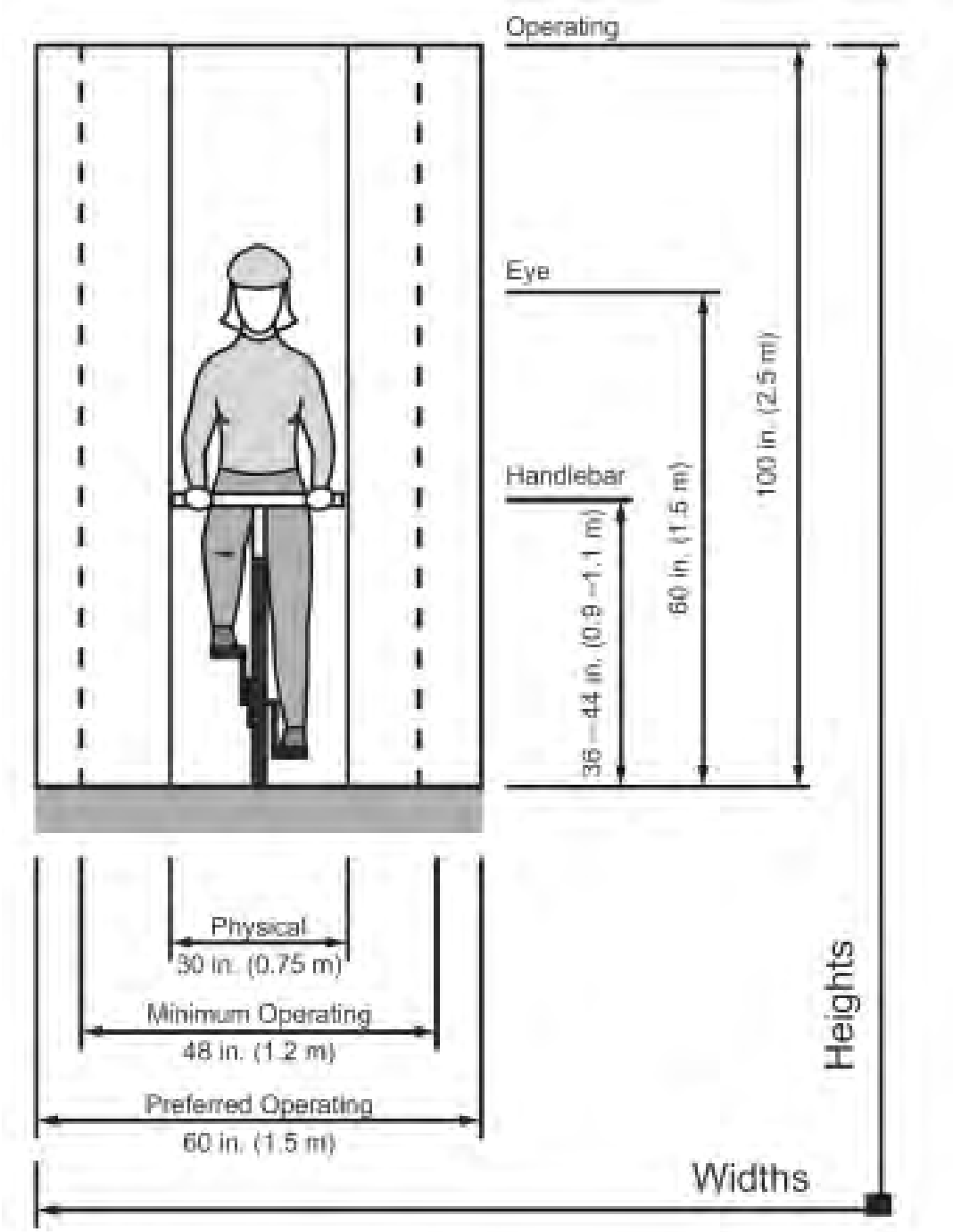
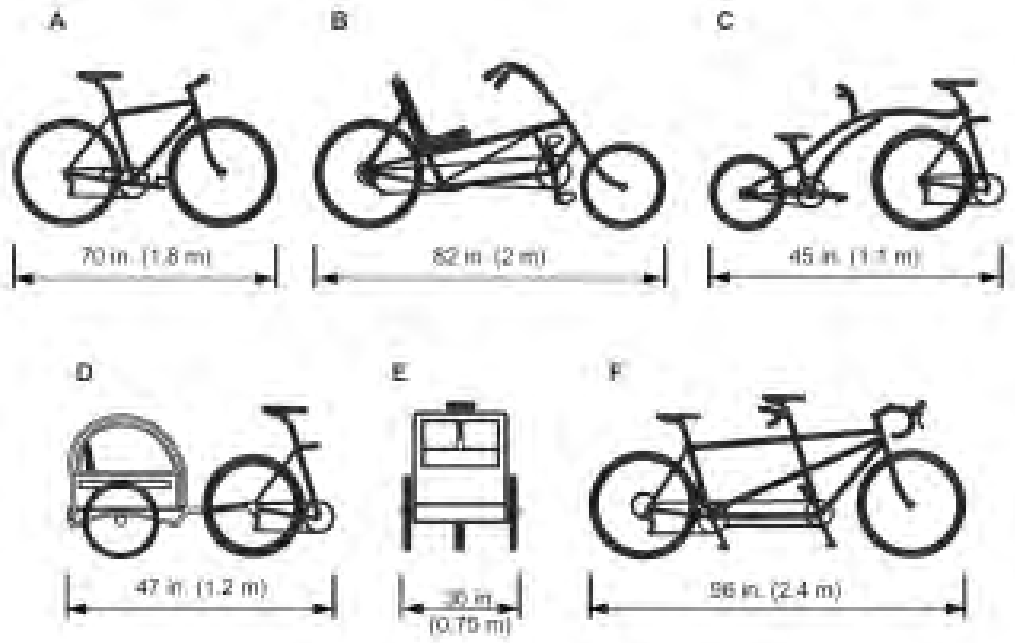



Figure 3-1. Bicyclist Operating Space

Source: AASHTO, *Guide for Development of Bicycle Facilities,* 2012.




A. Adult Typical Bicycle
B. Adult Single Recumbent Bicycle
C. Additional Length for Trailer Bike
D. Additional Length for Child Trailer
E. Width for Child Trailer
F. Adult Tandem Bicycle

Figure 3-2. Typical Bicyle Dimensions

Table 3-1. Key Dimensions

| User Type | Feature | Dimension | |
|---|---|---|---|
| | | U.S. Customary | Metric |
| Typical upright adult bicyclist | Physical width (95th percentile) | 30 in. | 0.75 m |
| | Physical length | 70 in. | 1.8 m |
| | Physical height of handlebars (typical dimension) | 44 in. | 1.1 m |
| | Eye height | 60 in. | 1.5 m |
| | Center of gravity (approximate) | 33–44 in. | 0.8–1.0 m |
| | Operating width (minimum) | 48 in. | 1.2 m |
| | Operating width (preferred) | 60 in. | 1.5 m |
| | Operating height (minimum) | 100 in. | 2.5 m |
| | Operating height (preferred) | 120 in. | 3.0 m |

## Deaths and Injuries

In 2014

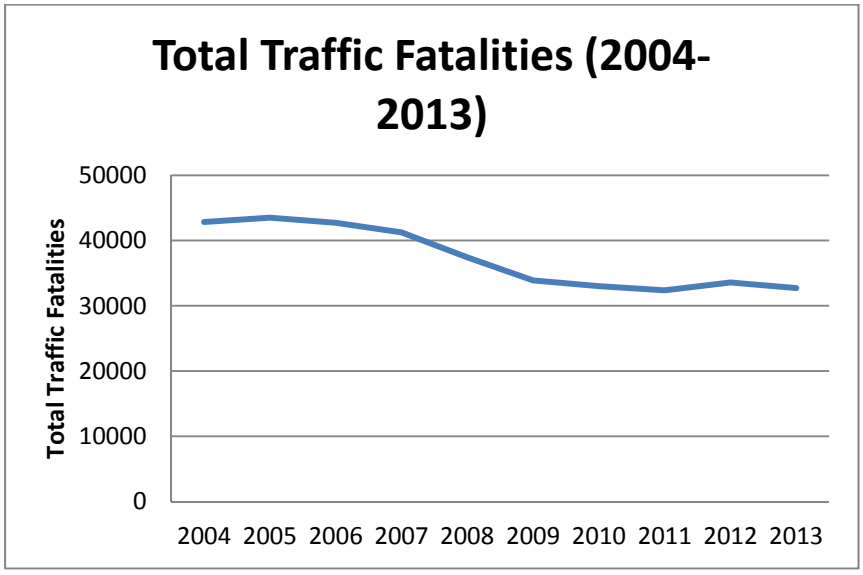
- ✖ 726 bicyclists killed
- ✖ 50,000 bicyclists injured
- ✖ Cyclists accounted for 2.2% of all traffic fatalities, **but make up fewer than 1% of all trips.**

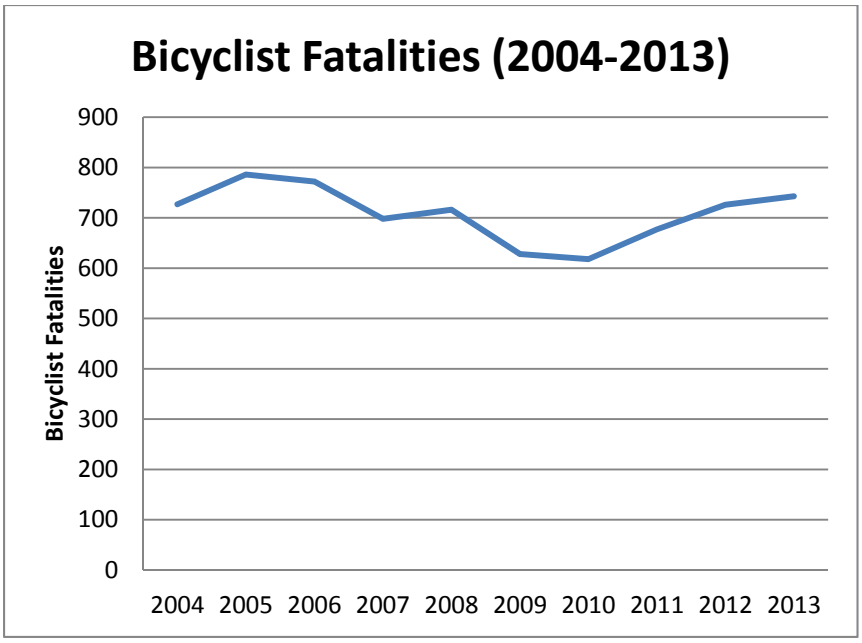
Source: NHTSA, "Traffic Safety Facts", May 2016, http://www-nrd.nhtsa.dot.gov/Pubs/812282.pdf.

## Bicycle Fatalities by Year

From 2004 to 2013

- ✖ Total traffic fatalities decreased by almost 24%
- ✖ Bicyclist fatalities increased slightly (2%)

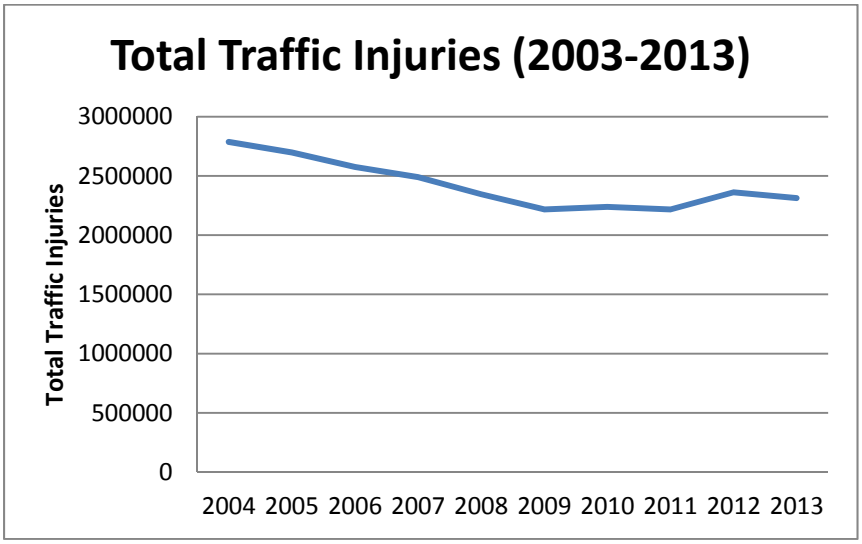


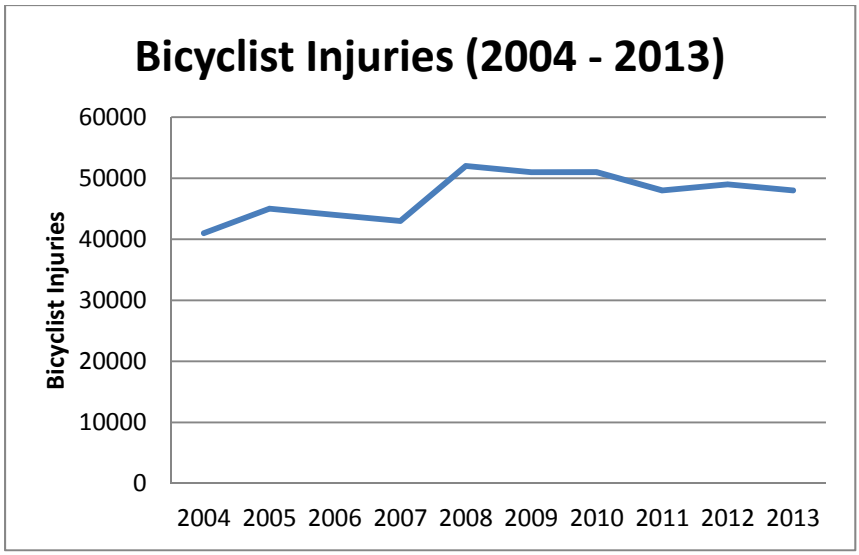



## Bicycle Injuries by Year

From 2004 to 2013

- ✖ Total traffic injuries <u>decreased</u> by 17%
- ✖ Bicyclist injuries <u>increased</u> by 17%






## Bicycle Crash Characteristics

- ✖ Crashes in urban areas occur more frequently (68%)
- ✖ Crashes in rural areas are usually more severe

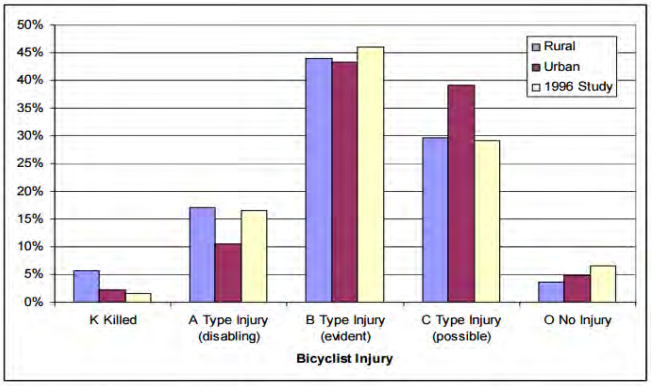



**Figure 3. General Comparison - Bicyclist Injury**

Source: Carter and Council, "Factors Contributing to Pedestrian and Bicycle Crashes on Rural Highways", UNC Highway Safety Center, June 2006.

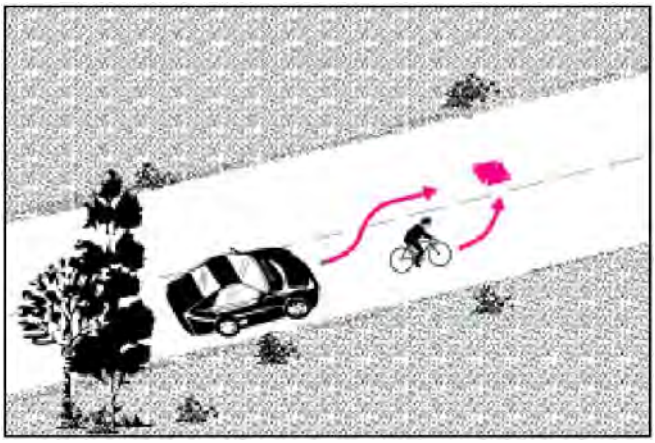
## Most Common Crashes

*For bicycle crashes, the most common crash types were different for rural and urban areas. "Bicyclist turn/merge into path of motorist" and "motorist overtaking" were some of the most common for rural bicycle crashes, and "motorist failed to yield", "bicyclist failed to yield at midblock", and "bicyclist failed to yield at intersection" were some of the most common for urban crashes. One prominent difference is that common rural crash types are ones that would occur at midblock segments while the urban crash types would occur at intersections.*

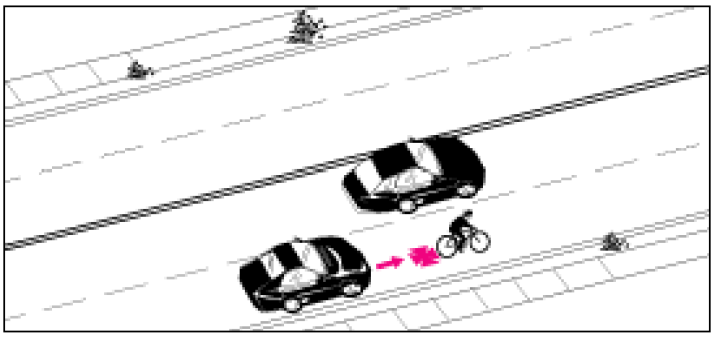
Source: http://www.hsisinfo.org/pdf/HSIS-Rural-PedBike-Final-Report.pdf

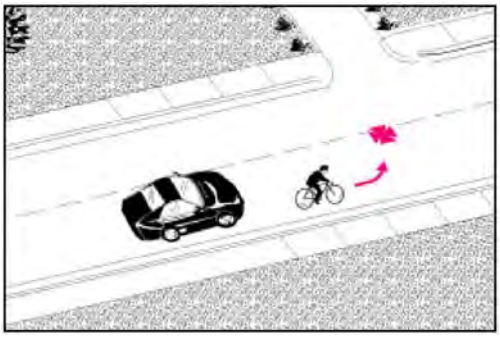
## Rural

### *Turn/merge into path of motorist*



### *Motorist overtaking*

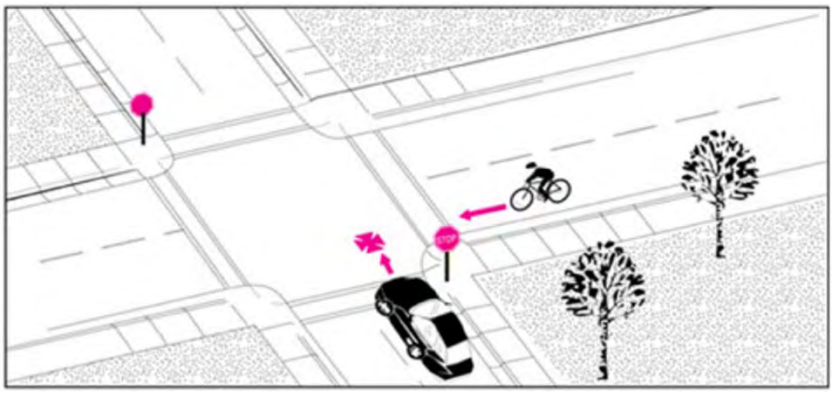


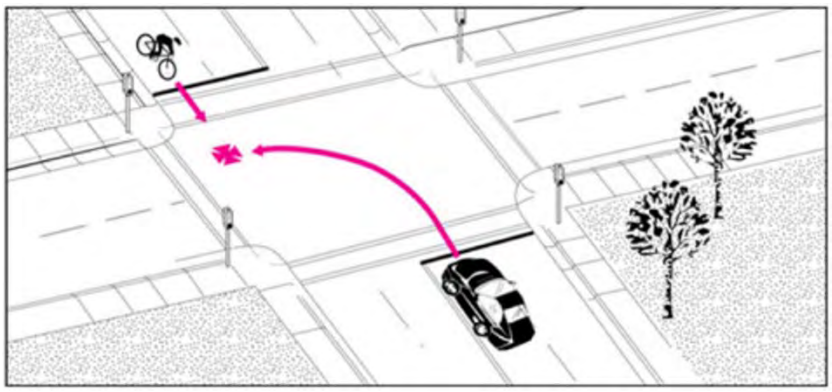


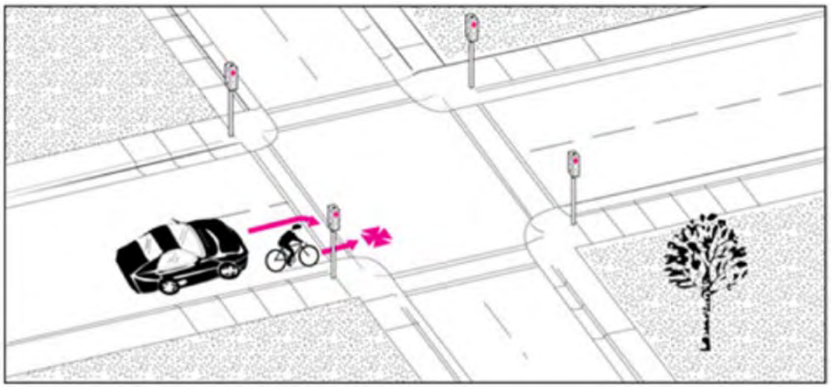
Source: http://www.bicyclinginfo.org/bikesafe/crash_analysis-types.cfm

## Urban

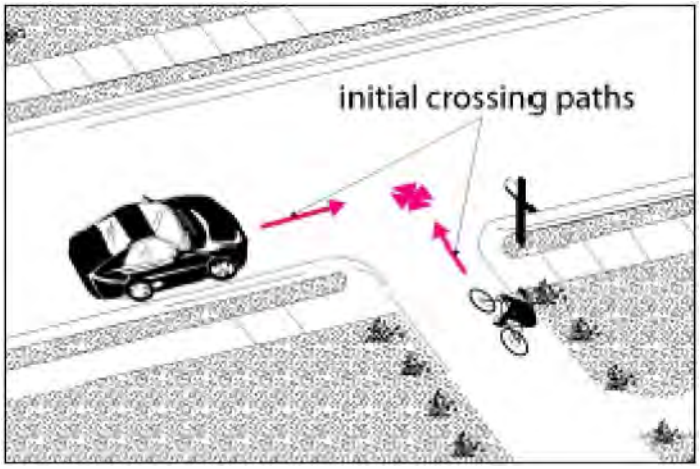
### *Motorist failed to yield*



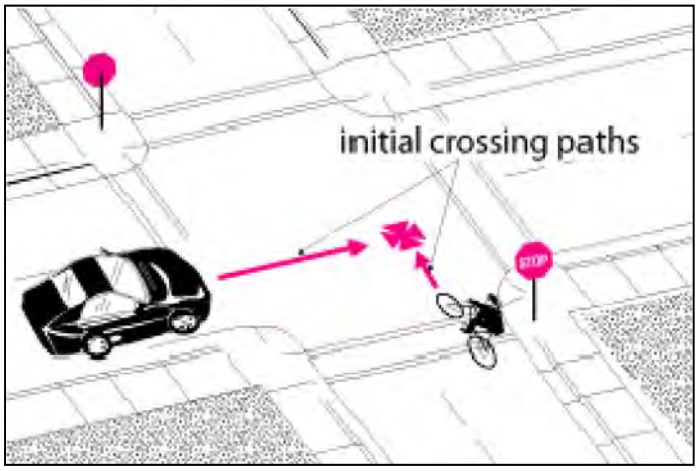


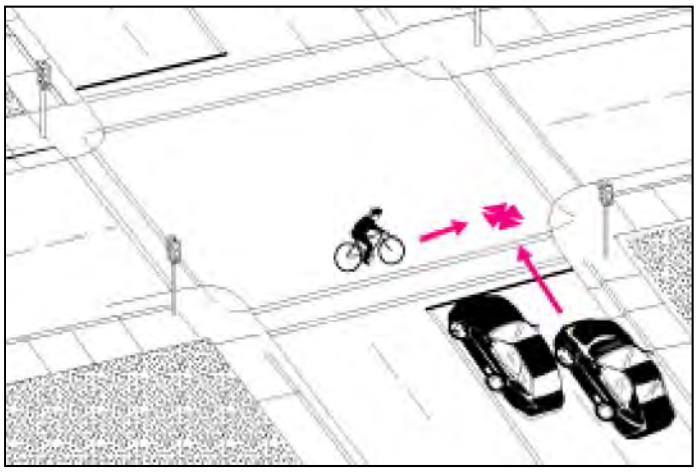


***Bicyclist failed to yield at midblock***




***Bicyclist failed to yield at intersection***



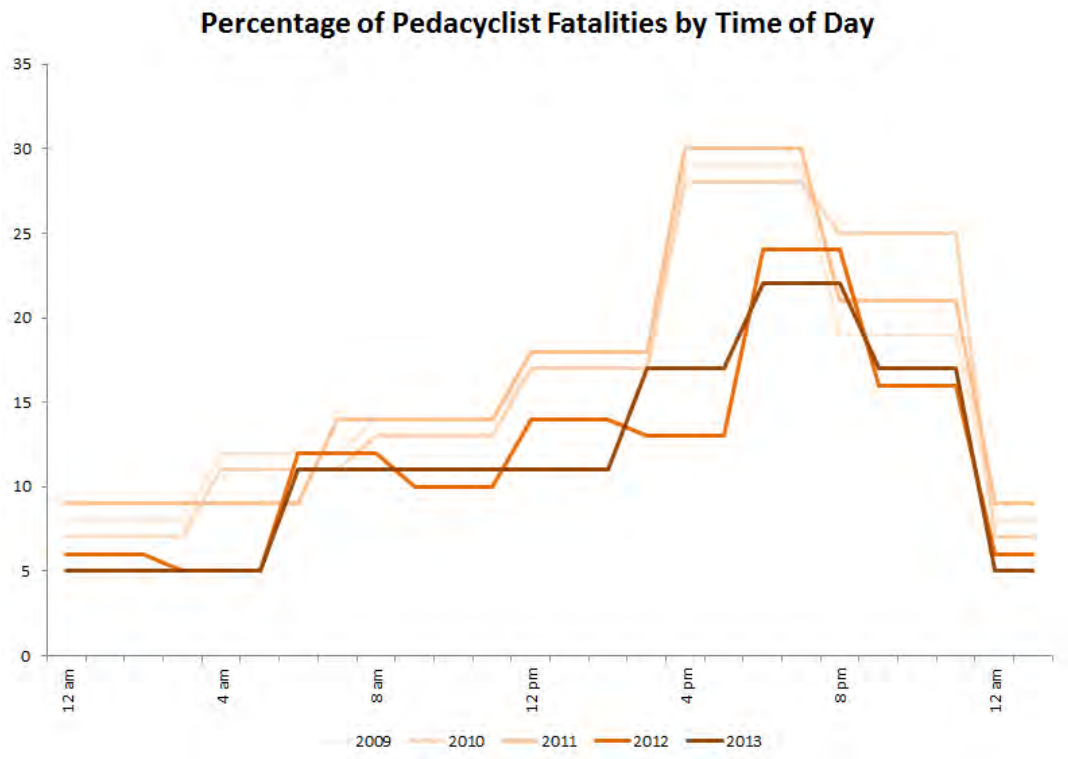



## Bicycle Crash Characteristics

- ✖ 57% of fatalities at non-intersection locations
- ✖ 58% of injuries at intersections

Fatalities by time of day

- ✖ 17% occur 3-6 pm
- ✖ 22% occur 6-9 pm
- ✖ 17% occur 9-midnight




## Health Benefits

Data synthesis

We quantified the impact on all-cause mortality when 500,000 people would make a transition from car to bicycle for short trips on a daily basis in the Netherlands. We have expressed mortality impacts in life-years gained or lost, using life table calculations. For individuals who shift from car to bicycle, we estimated that beneficial effects of increased physical activity are substantially larger (3–14 months gained) than the potential mortality effect of increased inhaled air pollution doses (0.8–40 days lost) and the increase in traffic accidents (5–9 days lost). Societal benefits are even larger because of a modest reduction in air pollution and greenhouse gas emissions and traffic accidents.

Conclusions

On average, the estimated health benefits of cycling were substantially larger than the risks relative to car driving for individuals shifting their mode of transport.

Source: Jeroen Johan de Hartog, Hanna Boogaard, Hans Nijland, and Gerard Hoek; "Do the Health Benefits of Cycling Outweigh the Risks?", *Environmental Health Persepctives*, v. 118(8), Aug. 2010; http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2920084/

Increased Physical activity reduces risk of:

- ✖ Cardiovascular disease
- ✖ Depressioni
- ✖ Dementia
- ✖ Diabetes
- ✖ Breast cancer
- ✖ Colon cancer

Source: James Woodcock, Phil Edwards, Cathryn Tonne, et al.;"Public health benefits of strategies to reduce green house-gas emissions: urban land transport", *Lancet* 2009; 374: 1930-43, http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(09)61714-1/abstract

## Other Benefits

Reduced

- ✖ Traffic congestion
- ✖ Traffic emissions
- ✖ Traffic noise
- ✖ Cost/mile travelled

Increase

- ✖ Social interaction
- ✖ Commercial activity
- ✖ Safety for all users

## Federal Law

*Bicycle transportation facilities and pedestrian walkways shall be considered, where appropriate, in conjunction with all new construction and reconstruction of transportation facilities, except where bicycle and pedestrian use are not permitted.* 23 U.S.C. 217(g)(1)

*Transportation plans and projects shall provide due consideration for safety and contiguous routes for bicyclists and pedestrians.* 23 U.S.C. 217(g)(2)

## USDOT Policy

**United States Department of Transportation Policy Statement on Bicycle and Pedestrian Accommodation Regulations and Recommendations**

**Signed on March 11, 2010 and announced March 15, 2010**

**Purpose**

The United States Department of Transportation (DOT) is providing this Policy Statement to reflect the Department's support for the development of fully integrated active transportation networks.

The establishment of well-connected walking and bicycling networks is an important component for livable communities, and their design should be a part of Federal-aid project developments. Walking and bicycling foster safer, more livable, family-friendly communities; promote physical activity and health; and reduce vehicle emissions and fuel use. Legislation and regulations exist that require inclusion of bicycle and pedestrian policies and projects into transportation plans and project development. Accordingly, transportation agencies should plan, fund, and implement improvements to their walking and bicycling networks, including linkages to transit. In addition, DOT encourages transportation agencies to go beyond the minimum requirements, and proactively provide convenient, safe, and context-sensitive facilities that foster increased use by bicyclists and pedestrians of all ages and abilities, and utilize universal design characteristics when appropriate. Transportation programs and facilities should accommodate people of all ages and abilities, including people too young to drive, people who cannot drive, and people who choose not to drive.

**Policy Statement**

The DOT policy is to incorporate safe and convenient walking and bicycling facilities into transportation projects. Every transportation agency, including DOT, has the responsibility to improve conditions and opportunities for walking and bicycling and to integrate walking and bicycling into their transportation systems. Because of the numerous individual and community benefits that walking and bicycling provide — including health, safety, environmental, transportation, and quality of life — transportation agencies are encouraged to go beyond minimum standards to provide safe and convenient facilities for these modes.

**Authority**

This policy is based on various sections in the United States Code (U.S.C.) and the Code of Federal Regulations (CFR) in Title 23—Highways, Title 49—Transportation, and Title 42—The Public Health and Welfare. These sections, provided in the Appendix, describe how bicyclists and pedestrians of all abilities should be involved throughout the planning process, should not be adversely affected by other transportation projects, and should be able to track annual obligations and expenditures on nonmotorized transportation facilities.

**Recommended Actions**

The DOT encourages States, local governments, professional associations, community organizations, public transportation agencies, and other government agencies, to adopt similar policy statements on bicycle and pedestrian accommodation as an indication of their commitment to accommodating bicyclists and pedestrians as an integral element of the transportation system. In support of this commitment, transportation agencies and local communities should go beyond minimum design standards and requirements to create safe, attractive, sustainable, accessible, and convenient bicycling and walking networks. Such actions should include:

Considering walking and bicycling as equals with other transportation modes: The primary goal of a transportation system is to safely and efficiently move people and goods. Walking and bicycling are

efficient transportation modes for most short trips and, where convenient intermodal systems exist, these nonmotorized trips can easily be linked with transit to significantly increase trip distance. Because of the benefits they provide, transportation agencies should give the same priority to walking and bicycling as is given to other transportation modes. Walking and bicycling should not be an afterthought in roadway design.

Ensuring that there are transportation choices for people of all ages and abilities, especially children: Pedestrian and bicycle facilities should meet accessibility requirements and provide safe, convenient, and interconnected transportation networks. For example, children should have safe and convenient options for walking or bicycling to school and parks. People who cannot or prefer not to drive should have safe and efficient transportation choices.

Going beyond minimum design standards: Transportation agencies are encouraged, when possible, to avoid designing walking and bicycling facilities to the minimum standards. For example, shared-use paths that have been designed to minimum width requirements will need retrofits as more people use them. It is more effective to plan for increased usage than to retrofit an older facility. Planning projects for the long-term should anticipate likely future demand for bicycling and walking facilities and not preclude the provision of future improvements.

Integrating bicycle and pedestrian accommodation on new, rehabilitated, and limited-access bridges: DOT encourages bicycle and pedestrian accommodation on bridge projects including facilities on limited-access bridges with connections to streets or paths.

Collecting data on walking and biking trips: The best way to improve transportation networks for any mode is to collect and analyze trip data to optimize investments. Walking and bicycling trip data for many communities are lacking. This data gap can be overcome by establishing routine collection of nonmotorized trip information. Communities that routinely collect walking and bicycling data are able to track trends and prioritize investments to ensure the success of new facilities. These data are also valuable in linking walking and bicycling with transit.

Setting mode share targets for walking and bicycling and tracking them over time: A byproduct of improved data collection is that communities can establish targets for increasing the percentage of trips made by walking and bicycling.

Removing snow from sidewalks and shared-use paths: Current maintenance provisions require pedestrian facilities built with Federal funds to be maintained in the same manner as other roadway assets. State Agencies have generally established levels of service on various routes especially as related to snow and ice events.

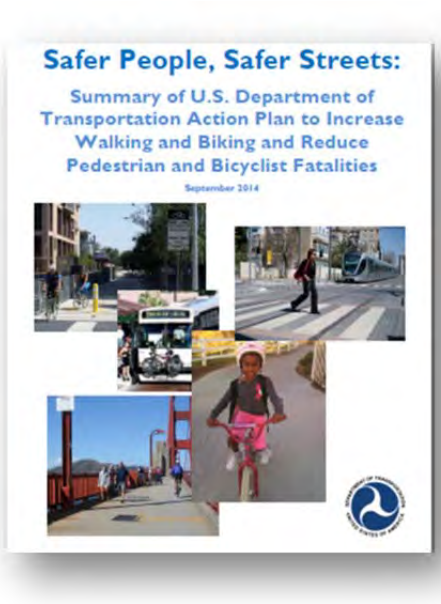
Improving nonmotorized facilities during maintenance projects: Many transportation agencies spend most of their transportation funding on maintenance rather than on constructing new facilities. Transportation agencies should find ways to make facility improvements for pedestrians and bicyclists during resurfacing and other maintenance projects.

**Conclusion**

Increased commitment to and investment in bicycle facilities and walking networks can help meet goals for cleaner, healthier air; less congested roadways; and more livable, safe, cost-efficient communities. Walking and bicycling provide low-cost mobility options that place fewer demands on local roads and highways. DOT recognizes that safe and convenient walking and bicycling facilities may look different depending on the context — appropriate facilities in a rural community may be different from a dense, urban area. However, regardless of regional, climate, and population density differences, it is important that pedestrian and bicycle facilities be integrated into transportation systems. While DOT leads the effort to provide safe and convenient accommodations for pedestrians and bicyclists, success will ultimately depend on transportation agencies across the country embracing and implementing this policy.

**Ray LaHood, United States Secretary of Transportation**

Source: http://www.fhwa.dot.gov/environment/bicycle_pedestrian/overview/policy_accom.cfm




*The Department will promote the development of multimodal networks which include interconnected pedestrian/and or bicycle transportation facilities that allow people of all ages and abilities to safely and conveniently get where they want to go.*

Source:
http://www.dot.gov/sites/dot.gov/files/docs/safer_people_safer_streets_summary_doc_acc_v1-11-9.pdf

## Mayors' Challenge

MAYORS' CHALLENGE FOR SAFER PEOPLE AND SAFER STREETS

Executive Summary

The Mayors' Challenge for Safer People and Safer Streets is a call to action by U.S. Department of Transportation (USDOT) Secretary Foxx for mayors and local elected officials of any political jurisdiction whether town, city, county, tribal lands, territory, or State to take significant action to improve safety for bicycle riders and pedestrians of all ages and abilities over the next year. The challenge is based on the 2010 USDOT Policy Statement on Bicycle and Pedestrian Accommodation

to incorporate safe and convenient walking and bicycling facilities into transportation projects. USDOT recognizes the many benefits walking and bicycling provide — including health, safety, environmental, transportation, and quality of life.

Mayors or top elected local officials are challenged to:

- Issue a public statement about the importance of bicycle and pedestrian safety
- Form a local action team to advance safety and accessibility goals
- Take local action on seven Challenge activities

USDOT will invite Mayors' Challenge participants to attend the Mayors' Challenge Summit kick-off event at USDOT's Headquarters' office in Washington, DC on Thursday, March 12, 2015. The Summit will bring together participating cities to network and learn more about the Challenge activities. USDOT Staff members will share the resources and tools available to help cities with Challenge activities. Challenge cities will also have the opportunity to participate in peer-to-peer sessions, topical webinars, receive USDOT updates, and other benefits added throughout the challenge year. At the conclusion of the Challenge year they will be invited to a capstone event to celebrate accomplishments and share best practices.

Challenge cities win by improving walking and biking that contributes to the health, safety, environmental, transportation, and quality of life for its community members. Below is a listing of the Challenge activities with just a sampling of the many resources we will be offering over the Challenge year.

Challenge activities:

1. Take a Complete Streets approach

The Complete Streets approach considers walking and bicycling as equals with other transportation modes. Challenge cities will have opportunities to learn from other cities who successfully implemented Complete Streets policies and the tools that are available to them.

2. Identify and address barriers to make streets safe and convenient for all road users, including people of all ages and abilities and those using assistive mobility devices

Pedestrian and bicycle facilities should meet accessibility requirements and provide safe, convenient, and interconnected transportation networks for people of all ages and abilities, especially children, by identifying and addressing barriers. Among other resources, Challenge participants will learn more about the FTA program and bicycle-related funding opportunities and how to use FHWA's recently released Resident's Guide for Creating Safer Communities for Walking and Biking.

3. Gather and track biking and walking data

Communities that routinely collect walking and bicycling data are able to track trends and prioritize investments to ensure the success of new facilities. FHWA's 2013 edition of the Traffic Monitoring Guide provides the most up to date guidance to State highway agencies in the policies, standards, procedures, and equipment typically used in a traffic monitoring program. Cities can learn how to use this and other resources to help them with this Challenge activity.

4. Use designs that are appropriate to the context of the street and its uses

Transportation agencies are encouraged, when possible, to avoid designing walking and bicycling facilities to the minimum standards. Planning projects for the long-term should anticipate likely future demand for bicycling and walking facilities and not preclude the provision of future improvements. The Challenge will help participants sort through many existing resources, and FHWA will share its recently released Road Diet Informational Guide that provides information regarding the benefits of road diets including speed reduction, decreases in accidents, and the opportunity to provide improved accommodations for pedestrians and bicyclists.

5. Take advantage of opportunities to create and complete pedestrian and bicycle networks through maintenance

Many transportation agencies spend most of their transportation funding on maintenance rather than on constructing new facilities. Transportation agencies should find ways to make facility improvements for pedestrians and bicyclists during resurfacing and other maintenance projects. For example, Challenge cities will learn about the soon to be released Workbook for Building On-Road Bicycle Networks through Routine Resurfacing Programs, and about best practices through peer learning opportunities.

6. Improve walking and biking safety laws and regulations

Strengthening codes, ordinances, and practices can help to protect non-motorized users. Ideal local ordinances clarifies and promotes safe road uses, allow for shared or designated and proper road use by all, clearly outlines consequences for harmful traffic violations, and promotes cooperation and commitment to follow the rules. NHTSA’s Countermeasures that Works will be one of the resources offered to cities addressing this Challenge area.

7. Educate and enforce proper road use behavior by all

A comprehensive education and enforcement program can be effective in reducing pedestrian and bicyclist injuries and fatalities. NHTSA recently released their Pedestrian Safety Enforcement Operations: How-to-Guide. Cities will learn about the cities successes highlighted in the guide. Challenge cities will be free to focus on Challenge activities where they can make the most progress and to document previous achievements in the Challenge areas. Throughout the year, opportunities will be provided for peer exchange and additional group technical assistance in each of the seven Challenge areas. No direct financial assistance is associated with the Challenge.

Source: https://www.transportation.gov/sites/dot.gov/files/docs/Mayors'%20Challenge%20Executive%20Summary%20Final_0.pdf

## FHWA Program Guidance

Bicycle and pedestrian ways shall be established in new construction and reconstruction projects in all urbanized areas unless one or more of three conditions are met:

- ✖ Bicyclists and pedestrians are prohibited by law from using the roadway. In this instance, a greater effort may be necessary to accommodate bicyclists and pedestrians elsewhere within the right of way or within the same transportation corridor.
- ✖ The cost of establishing bikeways or walkways would be excessively disproportionate to the need or probable use. Excessively disproportionate is defined as exceeding twenty percent of the cost of the larger transportation project.
- ✖ Where sparsity of population or other factors indicate an absence of need. For example, the Portland Pedestrian Guide requires "all construction of new public streets" to include sidewalk improvements on both sides, unless the street is a cul-de-sac with four or fewer dwellings or the street has severe topographic or natural resource constraints.

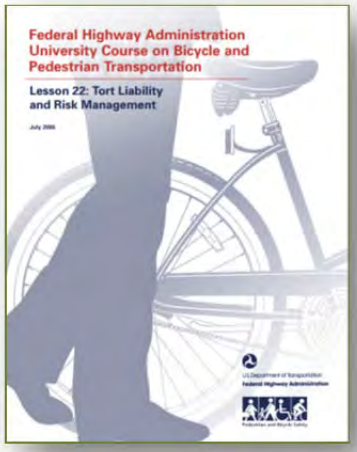
In rural areas, paved shoulders should be included in all new construction and reconstruction projects on roadways used by more than 1,000 vehicles per day, as in States such as Wisconsin. Paved shoulders have safety and operational advantages for all road users in addition to providing a place for bicyclists and pedestrians to operate.

Source: http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design.cfm

## Reduces Liability

*It is no longer acceptable to plan, design, or build roadways that do not fully accommodate use by bicyclists and pedestrians…*
*With every passing year, the courts become less and less sympathetic to agencies that have not understood the message: bicyclists and pedestrians are intended users of the roadway.*

Source:
www.fhwa.dot.gov/publications/research/safety/pedbike/05085/pdf/lesson22lo.pdf



# ANALYZING NEEDS

## Data Collection Goals

- Identify high crash locations, corridors, areas
- Identify locations, corridors, areas with high crash potential
- Prioritize high crash locations, corridors, areas
- Identify appropriate treatments

## Data Collection Guidelines

- Collect only what you need
- Collect only what you can use
    - Do you need 5 years' worth of data if 3 years' worth give you a good idea of the problem?
    - Do you need crash data for the entire state to be collected if you're focused on a small area?
    - Do you need detailed reports if the raw numbers give a good picture of the problem?
    - But don't jump to conclusions too soon: incomplete data could give a false perspective of the problem
- Timely crash data
    - Try to get the most recent data possible
    - Make sure they go back far enough to be representative (min 3 years)
    - Don't go too far back: conditions change over time

## Types of Safety Projects

- Spot Locations *(individual intersections and non-intersections)*
- Corridors *(½ mile to 5 or more miles in length)*
- Targeted Areas *(neighborhood, business district, or large area where pedestrian crashes are high)*
- Entire Jurisdictions *(addressed through system-wide changes)*

## Crash Data Analysis

Crash data analysis can:

- Discover prevalent crash types and behaviors
- Target specific areas

- ✖ Inform selection of bicycle facility

Understanding the limitations:

- ✖ Bicycle-related crashes are generally underreported (tend to only include bicycle-motor vehicle crashes or crashes resulting in major injuries
- ✖ Fails to capture locations characterized by frequent near-misses
- ✖ Crash data is often lacking, non-traditional sources such as hospital records are difficult to collect and analyze
- ✖ Data can be difficult to interpret, is often scattered through different systems and departments, does not always yield enough crashes at a single location to produce statistically reliable results
- ✖ Process of analyzing data can involve significant effort
- ✖ Crash reporting method may leave gaps in info such as actual location or cause of crash, or other important details

## Safety Evaluation Tools

### Highway Safety Manual Methodology

#### *Urban & Suburban Segments*

$N_{biker} = N_{br} \times f_{biker}$

Where:

$N_{biker}$ – vehicle-bicycle collision frequency

$N_{br}$ – crash frequency, excluding bikes and peds

$f_{biker}$ – bicycle crash adjustment factor

**Table 12-8.** Pedestrian Crash Adjustment Factor for Roadway Segments

| | Pedestrian Crash Adjustment Factor (fpedr) | |
|---|---|---|
| **Road Type** | **Posted Speed 30 mph or Lower** | **Posted Speed Greater than 30 mph** |
| 2U | 0.036 | 0.005 |
| 3T | 0.041 | 0.013 |
| 4U | 0.022 | 0.009 |
| 4D | 0.067 | 0.019 |
| 5T | 0.030 | 0.023 |

Note: These factors apply to the methodology for predicting total crashes (all severity levels combined). All pedestrian collisions resulting from this adjustment factor are treated as fatal-and-injury crashes and none as property-damage-only crashes.
Source: HSIS data for Washington (2002–2006)

Source: *Highway Safety Manual*, 1st edition, Volume 2, 2010.

## *Urban & Suburban Intersections*

$N_{bikei} = N_{bi} \times f_{bikei}$

Where:

$N_{bikei}$ -- vehicle-bicycle collision frequency

$N_{bi}$ -- predicted intersection crashes (no bikes/peds)

$f_{bikei}$ – bicycle crash adjustment factor

**Table 12-17.** Bicycle Crash Adjustment Factors for Intersections

| Intersection Type | Bicycle Crash Adjustment Factor ($f_{bikei}$) |
|---|---|
| 3ST | 0.016 |
| 3SG | 0.011 |
| 4ST | 0.018 |
| 4SG | 0.015 |

Note: These factors apply to the methodology for predicting total crashes (all severity levels combined). All bicycle collisions resulting from this adjustment factor are treated as fatal-and-injury crashes and none as property-damage-only crashes. Source: HSIS data for California (2002–2006)

Source: *Highway Safety Manual*, 1st edition, Volume 2, 2010.

## *CMF Limitations*

▼ Countermeasure: Install bicycle lanes

| CMF | CRF(%) | Quality | Crash Type | Crash Severity | Area Type | Reference | Comments |
|---|---|---|---|---|---|---|---|
| 1.05 | -5 | ★★★☆☆ | All | All | Urban | Jensen, 2008 | |
| 0.944 | 5.6 | ★★★☆☆ | All | All | Urban | Chen et al., 2012 | |
| 1.509 | -50.9 | ★★★☆☆ | Vehicle/bicycle | All | Urban | Chen et al., 2012 | |
| 1.057 | -5.7 | ★★★☆☆ | All | All | Urban | Chen et al., 2012 | Includes signalized, all-way stop controlled, ... [*read more*] |
| 1.281 | -28.1 | ★★★☆☆ | Vehicle/bicycle | All | Urban | Chen et al., 2012 | Includes signalized, all-way stop controlled, ... [*read more*] |

▼ Countermeasure: Installation of bicycle lanes at signalized intersections

| CMF | CRF(%) | Quality | Crash Type | Crash Severity | Area Type | Reference | Comments |
|---|---|---|---|---|---|---|---|
| 1.37 | -37 | ★★☆☆☆ | Vehicle/bicycle | All | Urban and suburban | Turner et al., 2011 | |
| 0.8 | 20 | ★★☆☆☆ | Vehicle/bicycle | All | Urban and suburban | Turner et al., 2011 | |
| 0.63 | 37 | ★★☆☆☆ | Vehicle/bicycle | All | Urban and suburban | Turner et al., 2011 | Crossing crashes at 90 degrees ... [*read more*] |
| 1.33 | -33 | ★★☆☆☆ | Vehicle/bicycle | All | Urban and suburban | Turner et al., 2011 | Crash Type: Cyclist through, left ... [*read more*] |
| 1.01 | -1 | ★★☆☆☆ | Vehicle/bicycle | All | Urban and suburban | Turner et al., 2011 | Crash Type: Rear end & ... [*read more*] |

Source: Selected crash modification factors from http://www.cmfclearinghouse.org/

## Bicyclist Intersection Safety Indices


Source: http://www.fhwa.dot.gov/publications/research/safety/pedbike/06130/06130.pdf

WHAT ARE THE PEDESTRIAN AND BICYCLE INTERSECTION SAFETY INDICES?

The Pedestrian and Bicycle Intersection Safety Indices (Ped ISI and Bike ISI) are a set of models that enable users to identify intersection crossings and intersection approach legs that should be the greatest priority for undergoing pedestrian and bicycle safety improvements. Using observable characteristics of an intersection crossing or approach leg, the tool produces a safety index score, with higher scores indicating a greater priority for an indepth safety assessment. Each leg of an intersection may have different characteristics affecting pedestrian or bicyclist safety; therefore the tools are intended to provide an evaluation of the safety of an individual crossing (Ped ISI) or approach leg (Bike ISI) rather than evaluating the intersection as a whole. A practitioner can use the tool to develop a prioritization scheme for a group of pedestrian crossings or bicyclist approaches. This method enables the practitioner to prioritize and proactively address sites that are the most likely to be a safety concern for pedestrians or bicyclists.

WHY ARE PED ISI AND BIKE ISI NEEDED?

The need to address pedestrian and bicyclist safety is ever present. National crash statistics for 2004 show that 4,641 pedestrians and 725 pedalcyclists were killed in crashes, accounting for approximately 13 percent of all traffic fatalities in the United States.(1) Most of these crashes occur at intersections. Many States and municipalities have pedestrian and bicycle safety programs to identify and address high crash locations. Although these safety programs can treat pedestrian or bicyclist hazards as they are identified, it would be preferable to use a proactive method of prioritizing which intersections should be examined first to ensure that potentially risky locations are addressed before they become crash problems.

WHAT ARE THE BENEFITS OF PED ISI AND BIKE ISI?

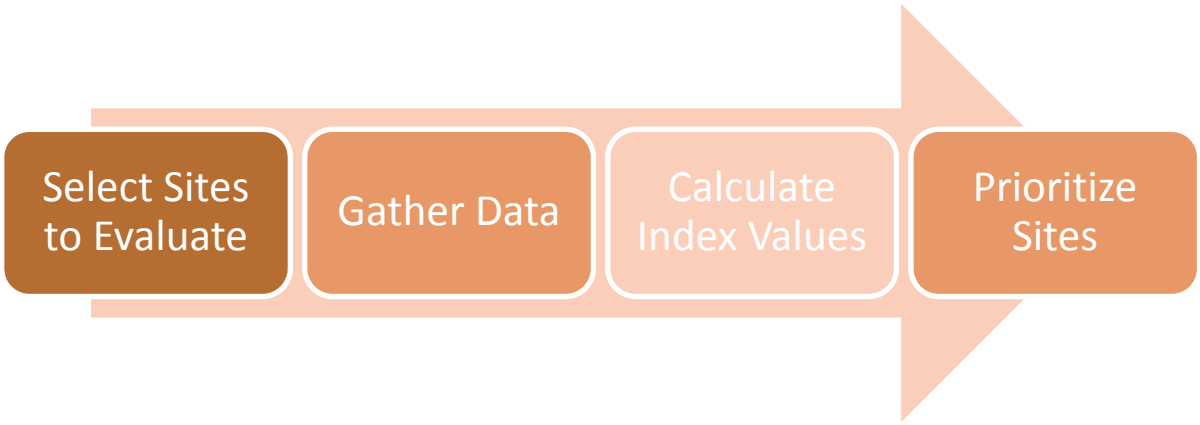
Ped ISI and Bike ISI proactively prioritize pedestrian crossings and bicyclist approaches with respect to safety. They also provide forward-looking State and local planning agencies with a safety rating tool for proposed intersections. Each tool uses observable and easy-to-gather data.

WHERE CAN PED ISI AND BIKE ISI BE USED?

Ped ISI and Bike ISI were developed at urban and suburban intersections with the following characteristics:

- Three-leg and four-leg intersections.
- Signalized, two-way stop, and four-way stop.
- Traffic volumes from 600 to 50,000 vehicles per day.
- One-way and two-way roads.
- One to four through lanes.
- Speed limits from 24.1 to 72.4 kilometers per hour (km/h) (15 to 45 miles per hour (mi/h)).

Ped ISI and Bike ISI are used most appropriately at intersections that meet the above ranges. Safety index values produced for intersections with characteristics outside these ranges should be used only with the understanding that the models were not developed using intersections of that type.




STEPS FOR USING THE PED ISI AND BIKE ISI

1. Select Sites To Evaluate—Identify pedestrian crossings (Ped ISI) or intersection approaches (Bike ISI) to evaluate. It is not necessary to evaluate all intersections in a given locality at once, especially where there is a large number of sites. Here are some useful tips for considering how to begin selecting sites:

   – Are there sites in the planning stage that could be modified in the design phase to avoid potential problems?

– Is there an area where there may be moderate to high pedestrian and/or bicyclist activity, such as in a central business district or near a popular pedestrian or bicyclist attractor?

– Are there sites that have already been identified in the community (including residents or other users) as possible problems?
– Are there sites where a crash has occurred? Typically these tend to naturally receive focused attention, but it may also prove useful to develop a safety index score to provide perspective, or to help identify what factor(s) may be affecting safety.

2. Gather Data—Gather data on geometric and operational characteristics of the selected sites, either through electronic databases or brief field visits. If the sites are in the planning stages, determine what characteristics the sites are expected to have. See the list of data required for the safety indices on page 7. A sample data collection form is available in Appendix A.

3. Calculate Index Values—Use Ped ISI and Bike ISI to produce index values for each site. Each site will receive a safety index value between 1 (safest) and 6 (least safe). The Ped ISI equation is shown on page 8; the Bike ISI equation is shown on page 11. Example calculations of index values are found starting on page 20. Users may also opt to use the Quick Reference Tables found in Appendix B to determine safety index values when a computer is not available. 4. Prioritize Sites—Sort sites according to index values. Sites with the highest index values generally have the highest priority for further indepth evaluation of pedestrian and/or bicycle safety. However, the existence of a high Ped ISI or Bike ISI value does not mean that a crosswalk or intersection approach is necessarily “hazardous.” There are many characteristics and behaviors at an intersection that will result in a pedestrian or bike crash, and no method can include all of these factors. Knowledge of the area should also be used in the prioritization of sites. The Ped ISI/Bike ISI method merely provides a way to prioritize locations to identify those which may warrant more indepth study.

**Table 2. Bike ISI models and variable descriptions.**

| | |
|---|---|
| Through | Bike ISI = 1.13 + 0.019**MAINADT** + 0.815**MAINHISPD** + 0.650**TURNVEH** + 0.470(**RTLANES***BL) + 0.023(**CROSSADT***NOBL) + 0.428(**SIGNAL***NOBL) + 0.200**PARKING** |
| Right Turn | Bike ISI = 1.02 + 0.027**MAINADT** + 0.519**RTCROSS** + 0.151**CROSSLNS** + 0.200**PARKING** |
| Left Turn | Bike ISI = 1.100 + 0.025**MAINADT** + 0.836**BL** + 0.485**SIGNAL** + 0.736(**MAINHISPD***BL) + 0.380(**LTCROSS***NOBL) + 0.200**PARKING** |

where:

| Bike ISI | *Safety index values (through, right, left)* | |
|---|---|---|
| BL | Bike lane presence | 0 = NONE or wide curb lane (WCL)<br>1 = bike lane (BL) or bike lane crossover (BLX) |
| CROSSADT | Cross street traffic volume | ADT in thousands |
| CROSSLNS | Number of through lanes on cross street | 1, 2, … |
| LTCROSS | Number of traffic lanes for cyclists to cross to make a left turn | 0, 1, 2, … |
| MAINADT | Main street traffic volume | ADT in thousands |
| MAINHISPD | Main street speed limit ≥ 56.3 km/h (35 mi/h) | 0 = no<br>1 = yes |
| NOBL | No bike lane present | 0 = BL or BLX<br>1 = NONE or WCL |
| PARKING | Onstreet parking on main street approach | 0 = no<br>1 = yes |
| RTCROSS | Number of traffic lanes for cyclists to cross to make a right turn | 0, 1, 2, … |
| RTLANES | Number of right turn traffic lanes on main street approach | 0, 1 |
| SIGNAL | Traffic signal at intersection | 0 = no<br>1 = yes |
| TURNVEH | Presence of turning vehicle traffic across the path of through cyclists | 0 = no<br>1 = yes |

## Bicycle Level-of-Service


### *Interrupted flow:*

- ✖ LOS reported separately for each mode
  - + Purpose, length, and expectation differs
- ✖ Travel speed
- ✖ Intersection delay
- ✖ Bicyclist perception

| Factors in bicyclist LOS score (interrupted flow): | |
|---|---|
| Motorized vehicle volume | Median |
| % heavy vehicles | Curb |
| % occupied parking | Access |
| # lanes | Pavement condition |
| Outside lane width | Motorized vehicle speed |

### *Off-Street Bicycle Facilities*

| Factors in bicyclist LOS score (shared-use & exclusive paths): | |
|---|---|
| Meetings per minute | Presence of centerline |
| Active passings per minute | Path width |
| Delayed passings | |

Source: *Highway Capacity Manual*, 2010.

## Levels of Traffic Stress (LTS)

- ✖ LTS 1: Suitable for almost all cyclists, including children trained to safely cross intersections (paths, low volume streets).
- ✖ LTS 2: Suitable to most adult cyclists but demanding more attention than expected from children (bike lanes, sharrows).
- ✖ LTS 3: More traffic stress than LTS 2, but less stress than integrating with multilane traffic (bike lanes/sharrows on arterials).
- ✖ LTS 4: Strong and fearless.

| Levels of Traffic Stress | | | |
|---|---|---|---|
| LTS 1 | LTS 2 | LTS 3 | LTS 4 |
| • Physically separated from traffic or low-volume, mixed-flow traffic at 25 mph or less<br>• Bike lanes 6 ft wide or more<br>• Intersections easy to approach and cross<br>• Comfortable for children | • Bike lanes 5.5 ft wide or less, next to 30 mph auto traffic<br>• Unsignalized crossings of up to 5 lanes at 30 mph<br>• Comfortable for most adults<br>• Typical of bicycle facilities in Netherlands | • Bicycle lanes next to 35 mph auto traffic, or mixed-flow traffic at 30 mph or less<br>• Comfortable for most current U.S. riders<br>• Typical of bicycle facilities in U.S. | • No dedicated bicycle facilities<br>• Traffic speeds 40 mph or more<br>• Comfortable for "strong and fearless" riders (vehicular cyclists) |

Source: Mekuria, Furth, and Nixon, "Low-Stress Bicycling and Network Connectivity", Mineta Transportation Institute, May 2012.

## Road Safety Audit

A RSA is a formal safety performance evaluation of an existing or future road or intersection by an independent, multidisciplinary team. RSA programs have been established in most states and FHWA has guidelines regarding the RSA process. RSAs are an effective tool because they engage a diverse team to identify issues by riding the road. FHWA developed a Bicycle Road Safety Audit Guidelines and Prompt Lists document to help guide stakeholders through the process of identifying and addressing issues.

For more information: http://safety.fhwa.dot.gov/rsa/


Since bicycle crashes tend to be widely dispersed, mapping of crash locations may not yield a strong indication of problem locations. Therefore it is also important to use other methods to identify risk factors when evaluating safety for all road users. One way to get a general understanding of factors that affect bicyclists' safety is to use a bikeability checklist, such as the one available through the Pedestrian and Bicycle Information Center. Conducting a Bicycle Road Safety Audit (RSA) can also be useful for identifying roadway improvements and other strategies that may improve the safety of bicyclists.

## Master Prompt List

| RSA Zones | | | | |
|---|---|---|---|---|
| **A. Street or Path** | **B. Structures** | **C. Intersections, Crossings, and Interchanges** | **D. Transitions** | **E. Transit** |
| **1. Presence & Availability** | | | | |
| Are cyclists accommodated? | | | | |
| **2. Design & Placement** | | | | |
| Are design features present that adversely impact the use of the facility by cyclists? | Are bridges/tunnels designed with adequate bicycle accommodations on both sides?<br><br>Does the gradient of the cycling accommodations impact the use of the facility? | Are intersection/interchange accommodations designed to reduce conflicting movements and communicate proper bicycle positioning through the crossing? | Are transition areas designed with logical termini or do they end abruptly, potentially contributing to sudden and difficult merges, midblock crossings, or behaviors such as wrong-way riding? | Are transit facilities designed and placed to minimize conflicts with other modes? |
| **3. Operations** | | | | |
| Are there suitable provisions for cyclists given the characteristics of the roadway or path (speed, volume, traffic, and functional classification)?<br><br>Do access management practices detract from cycling safety? | | Do traffic operations (especially during peak periods) create a safety concern for cyclists? | Do shared roadway geometrics change substantially or frequently? | Are transit facilities designed and placed to minimize conflicts with other modes? |
| **4. Quality & Conditions** | | | | |
| Is the riding surface smooth, stable, and free of debris and is drainage adequate?<br><br>Are drainage grates designed for cyclists? | Is the grating/bridge surface designed for cyclists?<br><br>Is drainage adequate to accommodate bicyclists?<br><br>Are there longitudinal or transverse joints that may cause cyclists problems? | Are there any obstacles at crossings?<br><br>Are the manhole covers properly designed? | Is there an abrupt change in riding surface? | Are transit stops maintained during periods of inclement weather? |
| **5. Obstructions** | | | | |
| Are there any horizontal or vertical obstructions (temporary or permanent) along the facility? | Is there adequate horizontal and vertical clearance? | If bollards or other physical terminal devices are used, is the risk of occasional motorized vehicles greater than the risk of a fixed object within the travel way? | | Is the waiting area free of temporary/permanent obstructions that constrict its width or block access to the bus stop? |
| **6. Roadside** | | | | |
| Is the clear zone for cyclists' operating space adequate? | Are railings, guardrail, and/or parapets and other structures installed at an appropriate height and shy distance? | If bollards or other physical terminal devices are used, is the risk of occasional motorized vehicles greater than the risk of a fixed object within the travel way? | | Are bicycle accommodations connected and convenient for transit users? |
| **7. Continuity & Connectivity** | | | | |
| Are bicycle accommodations continuous?<br><br>Do bicycle accommodations provide adequate connectivity to major destinations? | Are bicycle accommodations continuous, or do they end abruptly at bridge/tunnel crossings? | Are bicycle accommodations continuous, or do they end abruptly at crossings/intersections/interchanges? | Is there a safe way for cyclists from both directions to access connections or continue to other destinations along the street network? | Are crossings convenient and free of potential hazards for cyclists? |
| **8. Lighting** | | | | |
| Is the riding surface adequately lit? | Are bridges and tunnels adequately lit? | Are the intersection/transition and paths leading to the transition adequately lit? | | Are transit access ways and facilities adequately lit? |

| | | | | |
|---|---|---|---|---|
| **8. Lighting** | | | | |
| Is the riding surface adequately lit? | Are bridges and tunnels adequately lit? | Are the intersection/transition and paths leading to the transition adequately lit? | | Are transit access ways and facilities adequately lit? |
| **9. Visibility** | | | | |
| Is the visibility of cyclists using the facility adequate from the perspective of all road users? | Can cyclists see approaching vehicles/pedestrians, and vice versa? | Can cyclists see approaching vehicles/pedestrians at all legs of an intersection/crossing, and vice versa? | Is the visibility of cyclists as they make the transition from one facility or roadway geometry to another adequate from the perspective of all road users? | Is the visibility of cyclists using the facility adequate from the perspective of all road users? |
| **10. Signs & Pavement Markings** | | | | |
| Are signs and markings along the riding surface visible, well-maintained, easily understood, and adequate? | Are adequate warning signs posted at entrances? | Do signs and markings along the cycling facility clearly indicate the cyclist path and right-of-way at intersections? | Are signs and markings at transition areas appropriate? | Are signs and markings at designated areas for cyclists using transit appropriate? |
| **11. Signals** | | | | |
| If bicycle traffic signalization and detection are present, are they properly positioned, functioning, and effective? | | | | |
| Does the traffic signal design accommodate all users? | | | | |
| **12. Human Factors / Behavior** | | | | |
| What are all roadway users (vehicles, bicyclists, pedestrians, transit, etc.) doing with regards to bicycle traffic, and vice versa? | | | | |

## Prompt List

### A. Street or Path

| **A.2: Are design features present that adversely impact the use of the facility by cyclists?** | |
|---|---|
| **Sub-Prompt** | **Description** |
| **A.2.1: Do accommodations for cyclists conform to the state of practice, guidelines, and relevant standards, or are there more advanced designs that would better support and enhance conditions for cycling?** | While an RSA is not a standards check, it is critical that some RSA team members have an understanding of design requirements for cycling facilities as well as an understanding of the relative safety benefits that various design features may provide.<br><br>Guidance documents include, but are not limited to:<br>• *AASHTO's A Policy on Geometric Design of Highways and Streets* ("Green Book").<br>• *Manual on Uniform Traffic Control Devices* (MUTCD).<br><br>Successful practices may be found in:<br>• *AASHTO's Guide for the Development of Bicycle Facilities.*<br>• *FHWA's Designing Sidewalks and Trails for Access, Parts 1 and 2.(28) (29)*<br>• *NACTO Urban Bikeways Design Guide.*<br><br>Knowledge of the information contained in these resources will help RSA team members check for conditions that may present a safety issue for cyclists, especially under challenging conditions (e.g., night, adverse weather, high vehicle speeds, multiple conflicts, etc.). Chapter 1 provides a more complete list of resources. |
| **A.2.2: Are there adequate cycling provisions on both sides / directions of the roadway?**<br>  | On-road accommodations: accommodations for cyclists are needed on both sides of a two-way roadway and certain one-way roadway pairs of streets to accommodate desire lines of cyclists. Aside from issues of continuity and connectivity (see A.7), conflicts arise when two-way accommodations for cyclists are not present (see photo, left).<br><br>The roadway in the photo has a shoulder on one side of the road only, which raises several potential issues associated with this cross-section:<br>• Cyclists are encouraged to ride against traffic.<br>• Cyclists and pedestrians traveling opposite directions are subject to conflicts on the shoulder.<br>• Some cyclists approach intersections and driveways from the right, creating an expectancy conflict with motor vehicle traffic.<br>• Connectivity to destinations on the opposite side of the road is not provided, potentially resulting in unpredictable maneuvers by cyclists. A.2.9 shows two-directional travel for bicycles maintained with a counterflow bicycle lane.<br><br>Off-road accommodations: facilities should allow for two-way travel that considers conflicts with other road users and desire lines of cyclists. Separated bicycle facilities may take the form of two, one-way paths or two-way paths. Priority should be carefully considered at side street crossings, especially for two-way paths. Continuity and connectivity (see A.7) with other types of facilities are also potential safety concerns. |

Source: http://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa12018/

## *Bikeability Checklist*

Go for a ride and use this checklist to rate your neighborhood's bikeability.

# How bikeable is your community?

**Location of bike ride (be specific):** **Rating Scale:** 1 (awful) 2 (many problems) 3 (some problems) 4 (good) 5 (very good) 6 (excellent)

### 1. Did you have a place to bicycle safely?

a) On the road, sharing the road with motor vehicles?

☐ Yes ☐ Some problems (please note locations):
- ☐ No space for bicyclists to ride
- ☐ Bicycle lane or paved shoulder disappeared
- ☐ Heavy and/or fast-moving traffic
- ☐ Too many trucks or buses
- ☐ No space for bicyclists on bridges or in tunnels
- ☐ Poorly lighted roadways

Other problems:

_____

_____

b) On an off-road path or trail, where motor vehicles were not allowed?

☐ Yes ☐ Some problems:
- ☐ Path ended abruptly
- ☐ Path didn't go where I wanted to go
- ☐ Path intersected with roads that were difficult to cross
- ☐ Path was crowded
- ☐ Path was unsafe because of sharp turns or dangerous downhills
- ☐ Path was uncomfortable because of too many hills
- ☐ Path was poorly lighted

Other problems:

_____

_____

**Overall "Safe Place To Ride" Rating:** (circle one)
1 2 3 4 5 6

### 2. How was the surface that you rode on?

☐ Good ☐ Some problems, the road or path had:
- ☐ Potholes
- ☐ Cracked or broken pavement
- ☐ Debris (e.g. broken glass, sand, gravel, etc.)
- ☐ Dangerous drain grates, utility covers, or metal plates
- ☐ Uneven surface or gaps
- ☐ Slippery surfaces when wet (e.g. bridge decks, construction plates, road markings)
- ☐ Bumpy or angled railroad tracks
- ☐ Rumble strips

Other problems:

_____

_____

**Overall Surface Rating:** (circle one)
1 2 3 4 5 6

### 3. How were the intersections you rode through?

☐ Good ☐ Some problems:
- ☐ Had to wait too long to cross intersection
- ☐ Couldn't see crossing traffic
- ☐ Signal didn't give me enough time to cross the road
- ☐ Signal didn't change for a bicycle
- ☐ Unsure where or how to ride through intersection

Other problems:

_____

_____

**Overall Intersection Rating:** (circle one)
1 2 3 4 5 6

Continue the checklist on the next page...

Source: Excerpt from http://www.pedbikeinfo.com/pdf/bikeability_checklist.pdf

# SELECTING COUNTERMEASURES

## Design Guidelines

**Memorandum**
U.S. Department of Transportation
Federal Highway Administration

**Subject:** Bicycle and Pedestrian Facility Design Flexibility

**From:**
Gloria M. Shepherd
Associate Administrator for Planning,
Environment and Realty

**Date:** August 20, 2013

**Reply to:** HEPH-10

Walter C. (Butch) Waidelich, Jr.
Associate Administrator for Infrastructure

Jeffrey A. Lindley
Associate Administrator for Operations

Tony T. Furst
Associate Administrator for Safety

**To:**
Division Administrators
Directors of Field Services

This memorandum expresses the Federal Highway Administration's (FHWA) support for taking a flexible approach to bicycle and pedestrian facility design. The American Association of State Highway and Transportation Officials (AASHTO) bicycle and pedestrian design guides are the primary national resources for planning, designing, and operating bicycle and pedestrian facilities. The National Association of City Transportation Officials (NACTO) *Urban Bikeway Design Guide* and the Institute of Transportation Engineers (ITE)*Designing Urban Walkable Thoroughfares* guide builds upon the flexibilities provided in the AASHTO guides, which can help communities plan and design safe and convenient facilities for pedestrian and bicyclists. FHWA supports the use of these resources to further develop nonmotorized transportation networks, particularly in urban areas.

**AASHTO Guides**

AASHTO publishes two guides that address pedestrian and bicycle facilities:

- *Guide for the Planning, Design, and Operation of Pedestrian Facilities*, July 2004, (AASHTO Pedestrian Guide) provides guidelines for the planning, design, operation, and maintenance of pedestrian facilities, including signals and signing. The guide recommends methods for accommodating pedestrians, which vary among roadway and facility types, and addresses the effects of land use planning and site design on pedestrian mobility.

- *Guide for the Development of Bicycle Facilities 2012, Fourth Edition* (AASHTO Bike Guide) provides detailed planning and design guidelines on how to accommodate bicycle travel and operation in most riding environments. It covers the planning, design, operation, maintenance, and safety of on-road facilities, shared use paths, and parking facilities. Flexibility is provided through ranges in design values to encourage facilities that are sensitive to local context and incorporate the needs of bicyclists, pedestrians, and motorists.

**NACTO Guide**

NACTO first released the *Urban Bikeway Design Guide* (NACTO Guide) in 2010 to address more recently developed bicycle design treatments and techniques. It provides options that can help create "complete streets" that better accommodate bicyclists. While not directly referenced in the AASHTO Bike Guide, many of the treatments in the NACTO Guide are compatible with the AASHTO Bike Guide and demonstrate new and innovative solutions for the varied urban settings across the country.

The vast majority of treatments illustrated in the NACTO Guide are either allowed or not precluded by the Manual on Uniform Traffic Control Devices (MUTCD). In addition, non-compliant traffic control devices may be piloted through the MUTCD experimentation process. That process is described in Section 1A.10 of the MUTCD and a table on the FHWA's bicycle and pedestrian design guidance Web page is regularly updated (FHWA Bicycle and Pedestrian Design Guidance), and explains what bicycle facilities, signs, and markings are allowed in accordance with the MUTCD. Other elements of the NACTO Guide's new and revised provisions will be considered in the rulemaking cycle for the next edition of the MUTCD.

**ITE Guide**

In 2010, FHWA supported production of the ITE Guide *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*. This guide is useful in gaining an understanding of the flexibility that is inherent in the AASHTO "Green Book," *A Policy on Geometric Design of Highways and Streets*. The chapters emphasize thoroughfares in "walkable communities" - compact, pedestrian-scaled villages, neighborhoods, town centers, urban centers, urban cores and other areas where walking, bicycling and transit are encouraged. It describes the relationship, compatibility and trade-offs that may be appropriate when balancing the needs of all users, adjoining land uses, environment and community interests when making decisions in the project development process.

**Summary**

FHWA encourages agencies to appropriately use these guides and other resources to help fulfill the aims of the *2010 US DOT Policy Statement on Bicycle and Pedestrian Accommodation Regulations and Recommendations* - "...DOT encourages transportation agencies to go beyond the minimum requirements, and proactively provide convenient, safe, and context-sensitive facilities that foster increased use by bicyclists and pedestrians of all ages and abilities, and utilize universal design characteristics when appropriate."

Accompanying this memo are the latest versions of the: 1) AASHTO Bike Guide, 2) NACTO Bike Guide; and 3) the ITE *Designing Walkable Urban Thoroughfares* Guide.

The attachments provide two examples that demonstrate the use of treatments illustrated in the NACTO Guide (i.e., buffered bike lanes and green colored pavement for bicycle lanes) by State or local DOTs, and a list of FHWA staff that can help with questions about pedestrian and bicycle design issues.

*Attachments*

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Source: http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_flexibility.cfm

### *New Design Guidelines*

- FHWA, *Separated Bike Lanes Planning and Design Guide*, 2016
  http://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/
- FHWA, Achieving Multimodal Networks: Applying Flexibility and Reducing Conflicts, 2016
  Available soon.

## BikeSafe

Bicycle Safety Guide

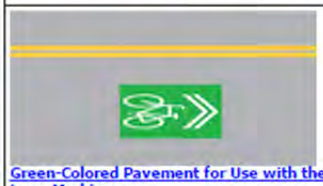
- Background—Understand what is needed to create a viable bicycle network
- Statistics—Learn about the factors related to the bicycle crash problem
- Analysis—How crash typing can lead to the most appropriate countermeasures
- Implementation—Needed components for treatements

Countermeasure Selection System

- Selection Tool—Find countermeasures based on desired objectives
- Selection Matrices—Find countermeasures based on crash types and performance objectives
- Countermeasure List—A comprehensive list of all countermeasures

Note that BikeSafe is currently undergoing an update, and new information will be included.
Source: http://www.pedbikesafe.org/bikesafe/

## Traffic Control Devices

| Subject to Experimentation | Available through Interim Approval | Interpretations |
|---|---|---|
|  Two-Stage Turn Box |  Green-Colored Pavement |   Use of R4-11 Sign on Roads with Speed Limits Above 35mph |
|  Bicycle Box |   Alternate Design for the U.S. Bicycle Route (M1-9) Sign |   Modified Bicycle Destination Sign |
|  Dashed Bicycle Lanes |  Bicycle Signal Faces |   Installation of Advance Turn and Directional Assemblies for Bike Route Signs |
|   Destination Guide Signs for Shared-Use Paths | |   Pavement Markings for Designated Bicycle Routes |
|  Green-Colored Pavement for Use with the Shared-Lane Marking | | |

Source: http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/mutcd/index.cfm

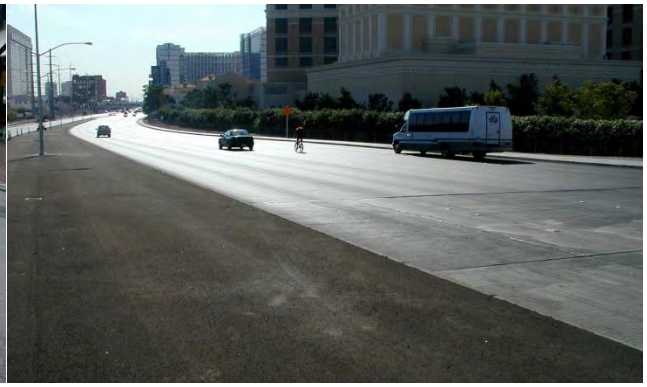
| Additional Resources | |
|---|---|
| **Allowable through the 2009 MUTCD** | • Continuation of Bicycle Lanes up to Intersections<br>• Extensions of Bicycle Lanes through Intersections<br>• Counter-flow Bicycle Lanes<br>• Buffer-Separated Bicycle Lanes<br>• Bicycle Lanes on the Left-Hand Side of One-Way Streets<br>• Two-stage turn box Jughandle movement at a T-intersection<br>• Shared-Lane Markings<br>• Shared-lane markings in exclusive turn lanes<br>• Rotated bicycle symbols in bicycle lanes or separated bikeways at intersections and driveways oriented towards turning or entering motorists |
| **Disallowed** | • Combined bicycle lane/turn lane where the lane attempts to establish a bike lane<br>• Green channelizing devices, delineators, posts, or retroreflective elements thereof<br>• Yield bar pavement markings without a standard, regulatory yield sign<br>• Alterations of the shared lane marking symbol, including its chevrons |
| **Other treatments that are not traffic control devices, so no MUTCD restriction on their use** | • Separated bikeways<br>• Convex mirrors at conflict points to improve visibility<br>• Bicycle networks<br>• Median or refuge island for bikeway crossings |
| Additional Information | |

# CORE SAFETY CONCEPTS

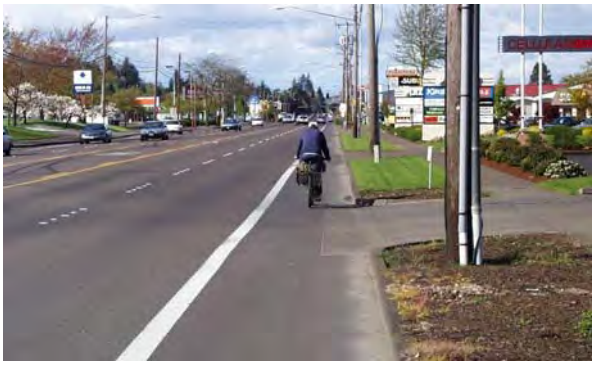
## Key Safety Factors

- ✖ Speed
- ✖ Number of lanes
- ✖ Visibility
- ✖ Traffic volume & composition
- ✖ Conflict points
- ✖ Proximity
- ✖ Bike control
- ✖ Connectivity


Low Risk



High Risk



Provide space on the street…

…or slow down traffic.

Don't ask, "Where can we put bicyclists?"

Instead ask, "How can we design roads to better include bicyclists?"