Transit Stop Improvements

DPS 201

PEDESTRIAN & BICYCLIST
FOCUSED APPROACH TO SAFETY

U.S. Department of Transportation
Federal Highway Administration

ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE

1

Module Overview

- Types of transit
- Common transit considerations
- Resources/sources for guidance
- Selected transit modules

- ❑Bus (local)
- ❑Bus rapid transit (BRT)
- ❑Light rail
- ❑Commuter rail
- ❑Streetcars

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Local Bus Service

- Most common transit type and focus of previous course
- Typically lower average travel speeds
- Operates with general traffic
- Frequent stops (.10 - .50 miles apart)
- Stops along the curb (primarily)

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Other Transit Types

Streetcars

Bus Rapid Transit

Light Rail

Commuter Rail

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Streetcars

- Operate on rails within the street, sometimes with traffic, at urban automobile traffic speeds (7-12 mph)
- Connects multiple local destinations with fixed route and local service
- Frequent stops based on passenger calls (similar to local buses)
- Convenient for short trips and transit connections
- Sense of permanence from use of rails, compared to local bus service

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Bus Rapid Transit

- Lower infrastructure costs vs. light rail transit
- Level boarding
- Exclusive running way
- Off-board fare collection
- Increased station spacing
- Transit signal priority

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Bus Rapid Transit

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- Level boarding
- Exclusive running way
- Off-board fare collection
- Increased station spacing
- Transit signal priority

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Light Rail

- Operates on fixed rail guideways, often separate from automobile traffic
- Operates a higher speeds (20 mph average) than streetcars
- Fixed stations and off-board fare collection
- Provides relatively frequent and reliable service

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Commuter Rail

- Exclusive rail right-of-way corridors
- Primarily used for commuting
- Greater station spacing
- Greater capacity
- Reduced service frequency

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General Considerations for Transit Accessibility

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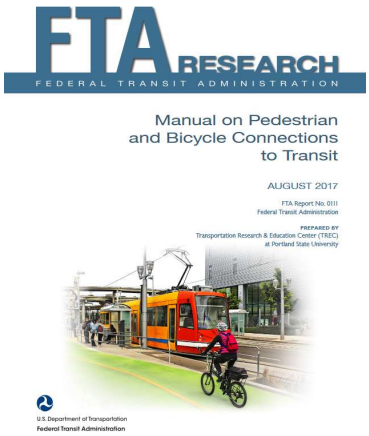
Connecting People to Transit

- Transit systems are only as good as the connections allowing people to use them
- Federal Transit Administration guide outlines principles for improving multimodal connections to transit facilities and designing multimodal facilities with each road user in mind.



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The Goal of transit

- The primary goal of transit is to carry passengers between residences, employment, and other destinations in a safe, efficient, and reliable manner.
- The physical safety of ALL passengers is vital to the success of any transit system- not only to retain riders, but to encourage new riders.

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…There are numerous competing needs

- Increases in ridership
- Crashes
- Amenities
- TCDs
- Conditions
- Vehicle needs
- Stop characteristics
- Capacity
- Security concerns
- Real time information
- Customer information
- Roadwork/Construction
- Transit plans
- Enforcement
- Private development
- Driver needs
- Special needs
- Funding

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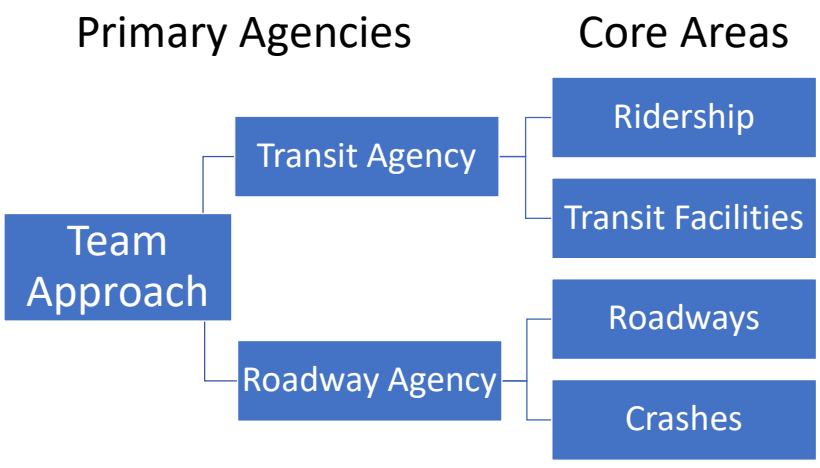
Agency Considerations



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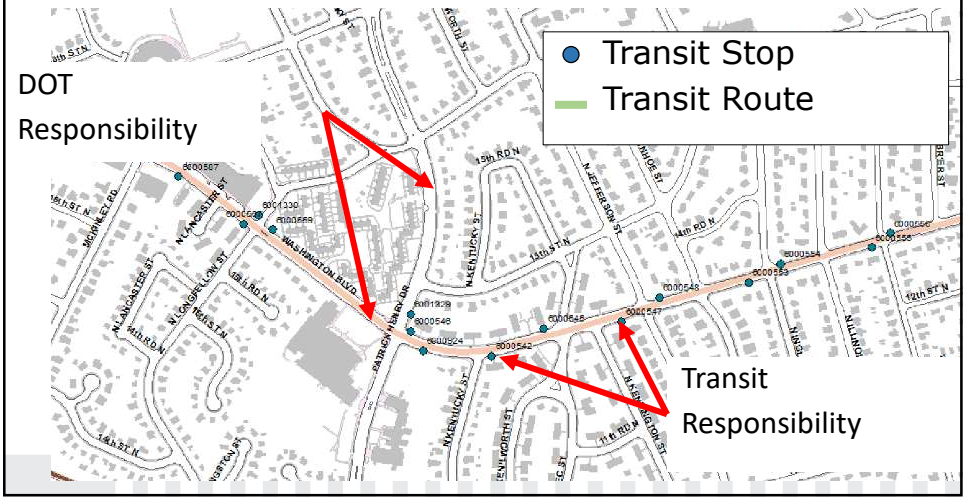
Agency Considerations

Transit vs.DOT Responsibility:



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Agency Considerations

Focus resources on areas of need

- High-Use Locations (ridership)
  - Busy Corridors
  - Busy Stops near key generators or high transfer activity
- Infrastructure Gaps/Needs
  - Sidewalks
  - Crossings
  - ADA compliance
- Safety
  - High incident locations

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High-Use Locations
Passenger demand

- Waiting space should meet passenger demand
- This may change as routes change and land use changes

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High-Use Locations
Key generators

- Understand activities and locations that generate demand
- Understand pedestrian paths

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High-Use Locations Transfer Activity

Understand passenger travel patterns and the effect on pedestrian paths

Source: RTD Denver

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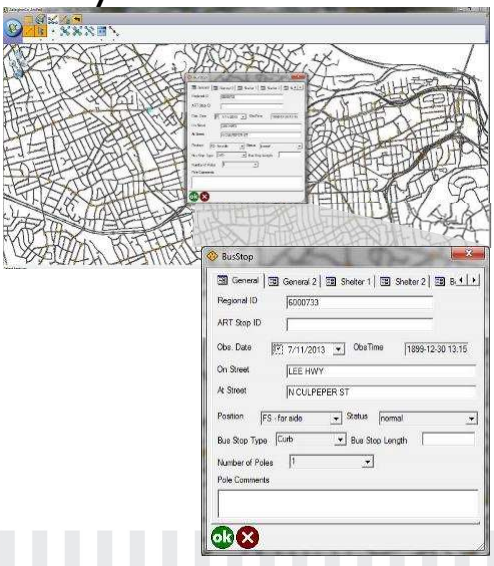
Infrastructure needs Transit Stop Inventory

- Tool to identify needs at transit stops and transit corridors
- Immediate transit stop characteristics inventoried and evaluated
- Includes surrounding ped/bike connections
- Ped/bike facilities at the stop



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Infrastructure needs
ADA Compliance

Before and After → ADA Access

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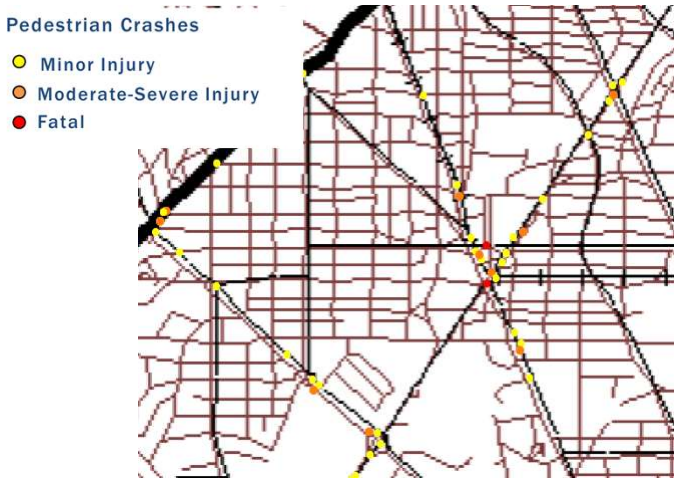
Pedestrian crashes



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Combine all elements

- Transit ridership
- Transit stop inventory (ADA compliance and other design elements)
- Crashes

23

Combine all elements

- Transit ridership
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24

Combine all elements

- Transit ridership
- Transit stop inventory (ADA compliance and other design elements)
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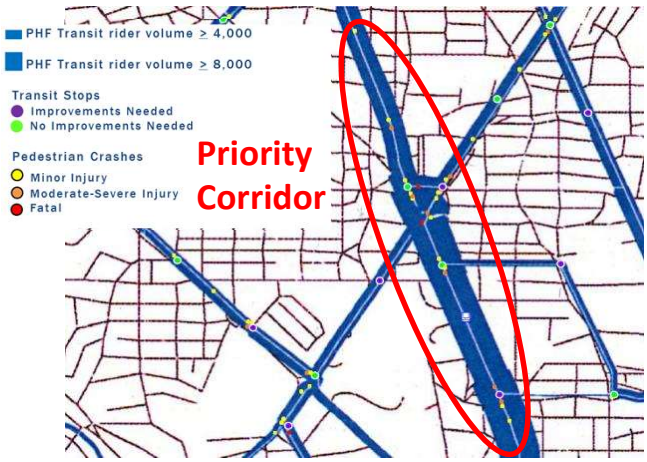

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Combine all elements

- Transit ridership
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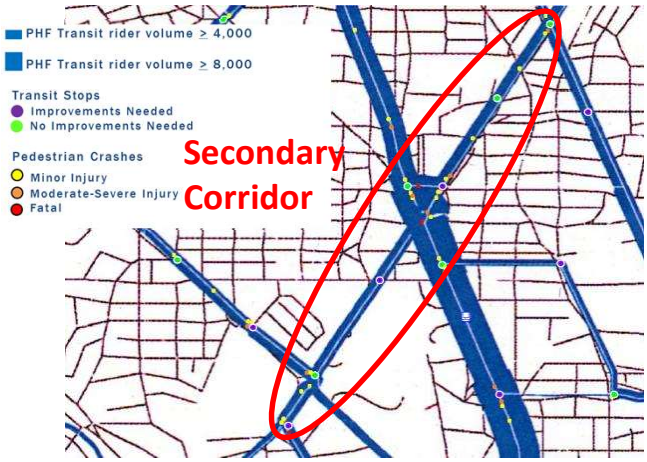

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Combine all elements

- Transit ridership
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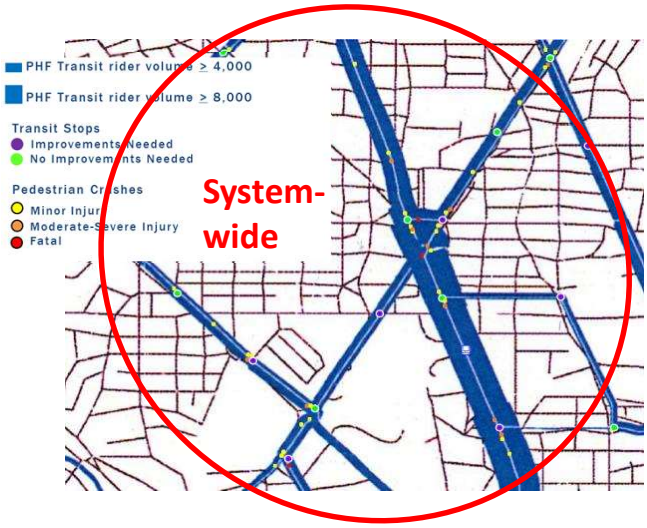
- Crashes



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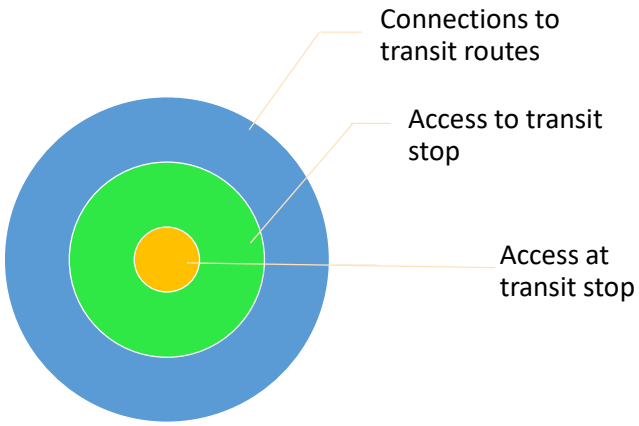
Access to transit

Access to transit exists on multiple levels:



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Catchment Area

- The catchment area is defined as the area served by transit
- Transit access considers elements within catchment area
- In general, people are willing to:
  - Walk up to ¼ Mile to access Local Bus transit
  - Walk up to ½ Mile to access BRT or Rail transit
  - Bike between 1-3 Miles to access Rail transit
  - Drive 15 miles

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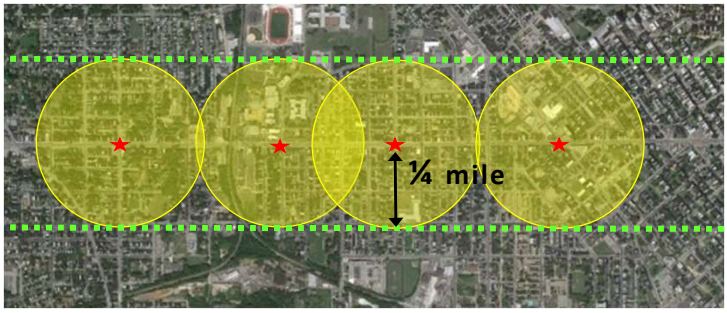
Catchment Area



★ - Bus Stop
- Bus Stop Catchment Area
..... - Corridor Catchment Area

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Catchment Area

Land Use Around Transit
Buffer of 1 mile

0 0.15 0.3 0.45 0.6 Miles

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Catchment Area

Larger areas are more diverse

- Land Use
- Street types
- Access mode

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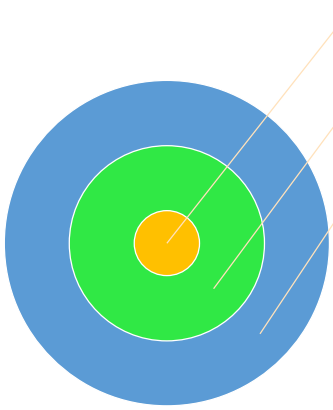
Common pedestrian safety issues

Major safety concerns/considerations occur at these levels:



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Common pedestrian safety issues

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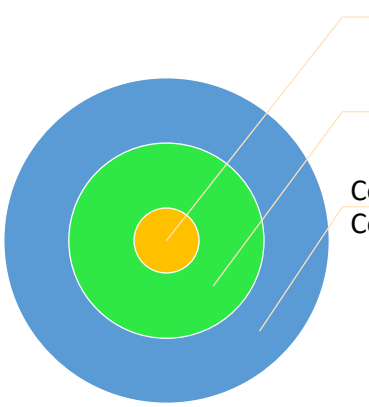

- Desire lines
- Demand
- Accessibility
- Convergence of modes
- Visibility
- Lighting
- Available information/guidance

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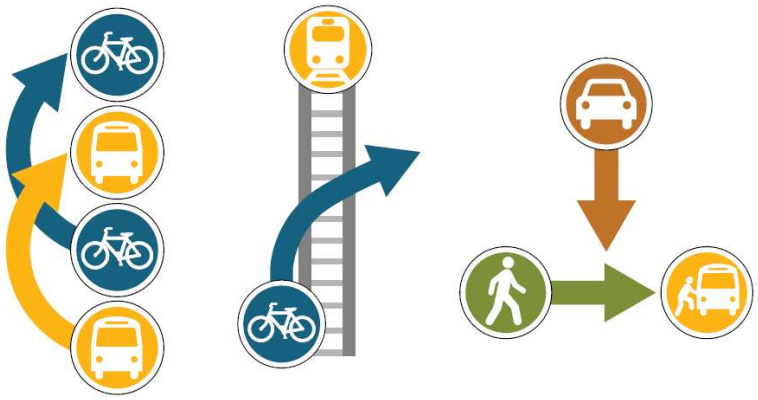
Common transit conflicts



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Example: La Metro Plan

- Seeks to improve transit connections by:
  - Decreasing point-to-point distances through increased (and safer) road crossing opportunities and pedestrian shortcuts
  - Supporting multimodal transfers (bike-share to transit, transit to car-share, etc.)
  - Improving pedestrian facilities within existing areas through street lighting, sidewalk repairs, curb ramps, etc.

FIRST LAST MILE
STRATEGIC PLAN

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MUTCD

Provides standards for pavement markings and traffic signals

- Part 2 - Signs
- Part 4 – Highway Traffic Signals
- Part 8 – Traffic Control for Railroad and Light Rail Transit Grade Crossings

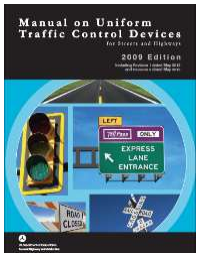
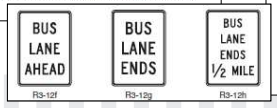
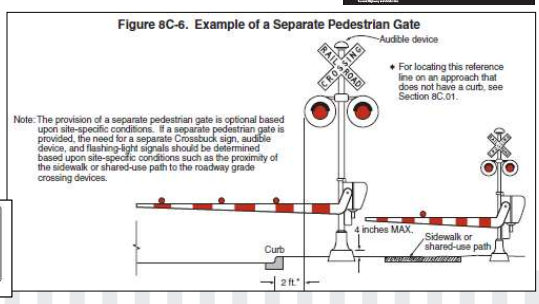


Table 4C-3. Warrant 9, Adjustment Factor for Percentage of High-Occupancy Buses

% of High-Occupancy Buses* on Minor-Street Approach	Adjustment Factor
0%	1.00
2%	1.09
4%	1.19
6% or more	1.32

* A high-occupancy bus is defined as a bus occupied by at least 20 people.





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Accessibility

- ADA Standards for Transportation Facilities
  - Part 1190 – Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG)
- Title 49 of the Code of Federal Regulations (Transportation)
  - Part 27 – Nondiscrimination on the basis of disability in programs or activities receiving Federal financial assistance
  - Part 37 – Transportation services for individuals with disabilities
  - Part 38 – Americans with disabilities act accessibility specifications for transportation vehicles
  - Part 39 – Transportation for individuals with disabilities: passenger vessels

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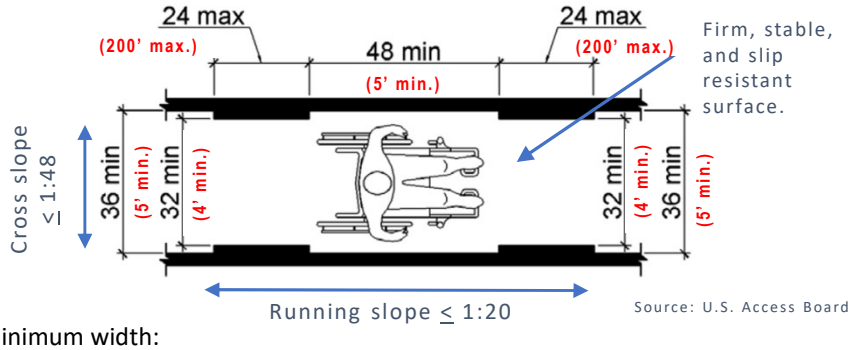
Accessibility

ADA Standards – Accessible routes



Minimum width:

- 36" for a maximum length of 2'.
- Within public right-of-way: 48" (4') for a maximum length of 200'.
- *Passing zones must be provided within public right-of-way.*

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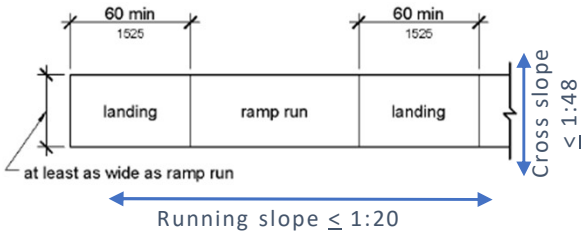
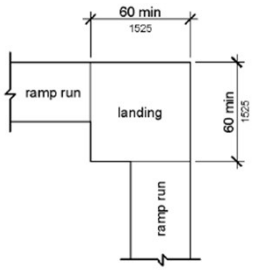
Accessibility

ADA Standards – Ramps



Change in direction:



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Accessibility

BUS STOP CHECKLIST — PART B: PEDESTRIAN ACCESS FEATURES

B9	How wide is the sidewalk?					
	No sidewalk ☐	less than 3' ☐	3'-5' ☐	5' or greater ☐	N/A ☐	
B10	Are there physical barriers that constrict the width of the sidewalk within the block on which the bus stop is located?					Yes ☐ No ☐
	If YES, what is the narrowest useable width:					
	Less than 3' ☐		3' or greater ☐			
B11	Rank the condition of the sidewalk:					
	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	
	1=hazardous – large breaks, cracks, root uplifting, someone could get hurt from normal use or use of a wheelchair would be difficult					
	2=in poor shape though not hazardous – very rough, some root uplifting, cracks, breaks					
	3=fair – minor root uplifting, minor cracks or breaks					
	4=good – not perfect but no immediate repair					
	5=cosmetically excellent; new					
B12	Does the landing pad connect to the sidewalk?					Yes ☐ No ☐
	If YES, what does the sidewalk connect to:					
	One of the trip generators listed in Question B8 ☐		The nearest intersection ☐			
B13	Where is the nearest street crossing opportunity?					
	The nearest intersection ☐		Mid-block crosswalk ☐			
B14	What pedestrian amenities are at the nearest intersection (or other crossing opportunity)?					
	Curb cuts all corners/ both sides ☐		Pedestrian crossing signal ☐		Traffic Light ☐	
	Visible crosswalk ☐		Audible crosswalk signal ☐		Crossing guard assistance ☐	
					Tactile warning strip on curb	
	Curb cuts at some corners/one side					

Date

Toolkit for the Assess

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Transit Agency Documents

- Design Documents
  - Stop location and design
- Planning documents
  - Corridor studies
  - System plans
    - Transit Development Plans
    - Long-range Transit Plans

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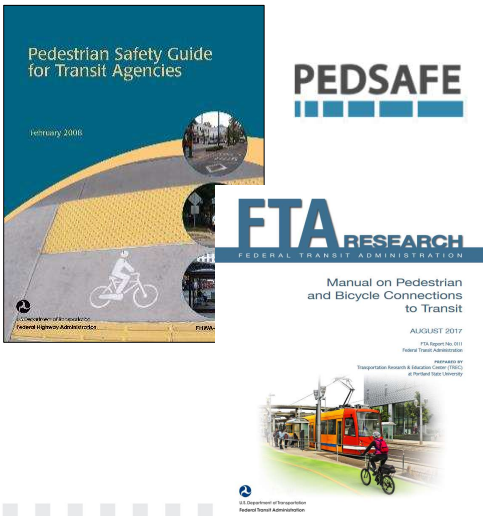
Other Documents

- Pedestrian Safety Guide for Transit Agencies (FHWA, 2008)
- Manual on Pedestrian and Bicycle Connections to Transit (FTA, 2017)
- PEDSAFE



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Design Considerations for Different Transit Types

Select the Modes you want to Cover

- Buses
- Bus Rapid Transit (BRT)
- Light Rail
- Commuter Rail
- Streetcars

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Buses: Topics

- Design criteria
- Major safety considerations:
  - Bus stop location
  - Bus stop design
  - Accessibility
  - Lighting
- Areas of Caution:
  - Desire lines
  - Passenger demand
  - Complex/unfamiliar designs and signals

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Bus design criteria

- ADA Standards
  - Stops
  - Vehicle Accessibility
    - Lifts
    - Ramps
- Local Standards
- Vehicle Improvements

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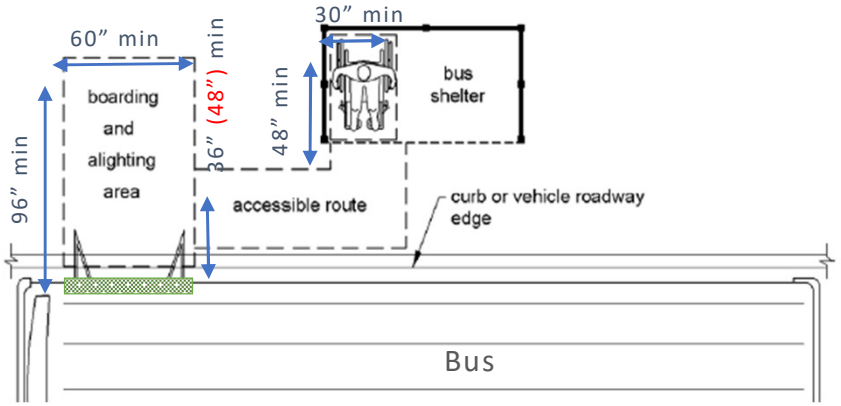
Accessibility

ADA Standards – Boarding & alighting, shelters



Source: U.S. Access Board

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Accessibility

ADA Standards – Boarding & alighting, shelters

- Bus stop boarding and alighting areas:
  - A clear length of 96 inches, measured perpendicular to the curb or vehicle roadway edge, and a clear width of 60 inches, measured parallel to the vehicle roadway (ADA Section 810.2.2).
- Bus Shelters
  - Shall be level(slopes < 1:48),
  - Have a minimum clear floor or ground space (30”x 48”)
  - Be positioned for either forward or parallel approach
  - Be connected by a accessible route to the boarding and alighting area. (ADA Sections 810.3 and 305, PROWAG Section R302)
  - *Note: At bus stops where a shelter is provided, the bus stop pad can be located either within or outside of the shelter.*

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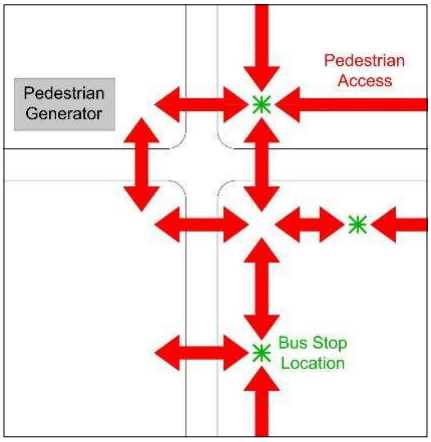
Siting bus stops: the big picture

- Maximize ridership:
  - Place near intersecting street for better access.
  - Place near pedestrian generators.
- Reliable operations:
  - Spacing between stops for efficient service
  - Locations based on demand



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Siting Bus Stops

Location of bus stops depends on many factors including:

- Ridership
- Routing
- Number of buses stopping
- Transfer activity
- Traffic operations
- Parking
- Key generators
- Property owners

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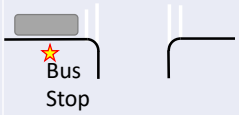
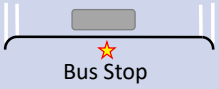
Bus Stop location review

Stop Location		Advantages	Disadvantages
Far-Side Stop		- Encourages peds to cross behind bus	- Sight distance issues for crossing vehicles and pedestrians
Near-side Stop		- Allows passengers to access bus closest to crosswalk	- Sight distance issues for veh to right of bus and crossing peds - Obscures curb signals and peds
Mid-Block Stop		- Min sight distance problems for vehicles and pedestrians - May reduce congestion at passenger waiting areas	- Encourages midblock crossing. - Increases walking distance for peds crossing at intersections

Source: Transit Cooperative Research Program Report 19: Guidelines for the Location and Design of Bus Stops, TRB, 1996

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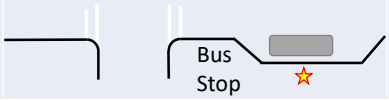
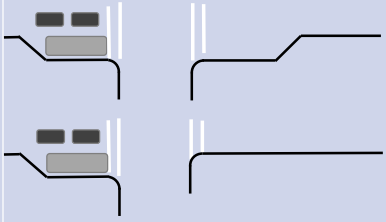
Bus Stop Type review

Bus Stop Type		Considerations	101
Bus Bulb/ Nub		- Can be applied near or far side - Far side should have two lanes - Should be length of bus	Y
Bus Bay		- Ability of bus to re-enter traffic - Effect of open bus bay - Sidewalk space (width)	Y
Queue Jumper		- Two types: with acceleration lane and without accel. Lane (see TCRP Synthesis 83) - Used to give transit priority through intersection (transit signal priority-TSP) - Potentially confusing signal phasing	N

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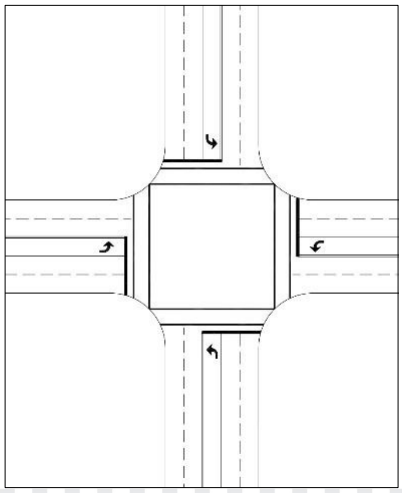
Locating BUS STOPs

At intersections, consider traffic conditions:

- Transfers
- Proximity of pedestrian crossing facilities
- Geometry (bus access and vehicle access)
- Driveways



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Bus STOP LOCATIONS

Key Elements: Bus rider destination and transfers

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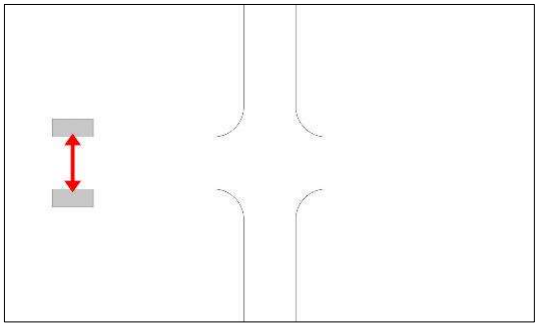
Bus STOP LOCATIONS

Mid block bus stops may create false demand and encourage mid-block crossings



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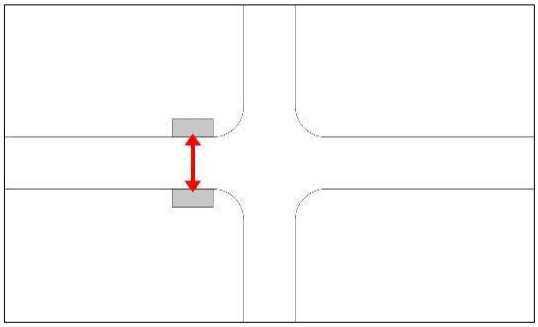
Bus STOP LOCATIONS

Locating the bus stops to the intersections would encourage crossings at the intersection



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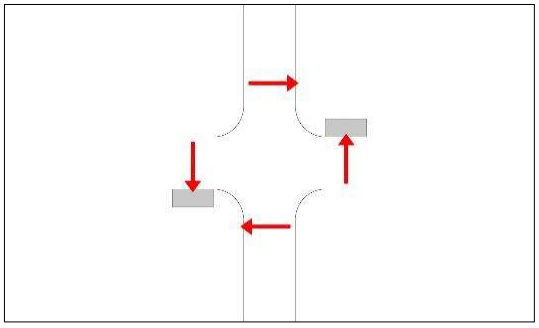
Bus STOP LOCATIONS

Placing the stops diagonally would more evenly distribute the crossings needed to access the stop



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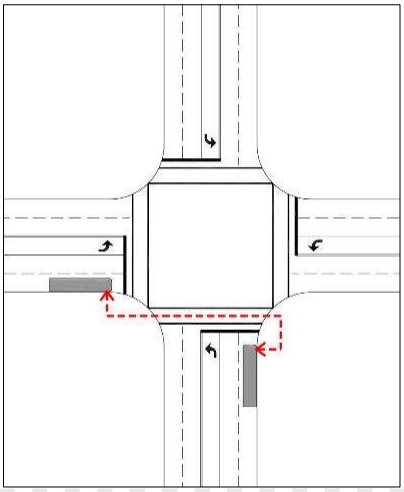
BUS STOP locations: transfers

This bus transfer location forces pedestrians to cross the street



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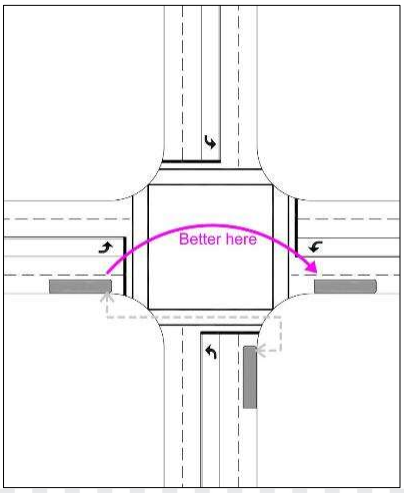
BUS STOP locations: transfers

The bus transfer location would be better in the same quadrant of the intersection



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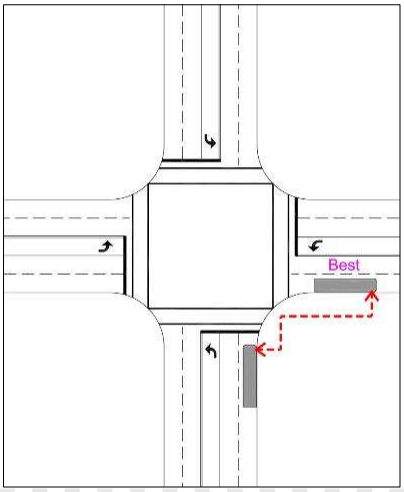
BUS STOP locations: transfers

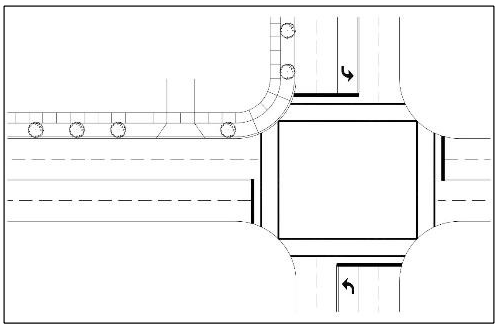
This bus transfer location allows pedestrians to transfer without crossing the street or entering the intersection



62

BUS STOP locations: driveways

Driveways

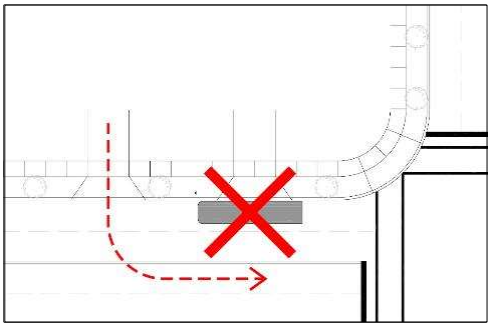


- Driveways are common along roadways in urban areas.
- Placement of bus stop should avoid driveway entrances.

63

BUS STOP locations: driveways

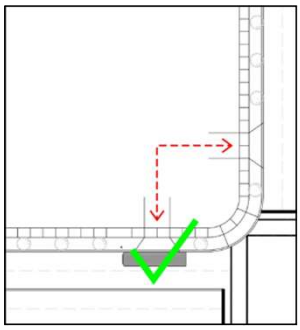
Driveways



- In some instances, driveways may be unavoidable.
- Consider possible driveway movements and sight distance considerations.

64

BUS STOP locations: driveways



- In some instances, driveways may be unavoidable.
  - Consideration of access points to a site, service frequency, and traffic volumes may enable placement of a stop near/at a driveway.

65

Bus stop Design

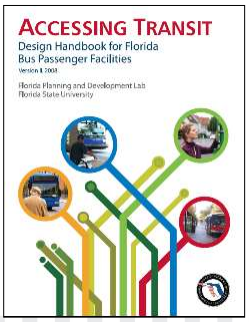
Design of the bus stop can depend on a number of factors

- Accessibility
- Travel Patterns/Flows
  - Traffic
  - Bus
  - Pedestrian
- Vehicle Type

66

Bus Stop design

- The accessibility needs of a bus stop may dictate the type of design.
- Accessibility also needs to be considered when placing bus stop amenities – amenities should never become obstructions.



67

Bus stop Design

Amenities

- Dependent on usage (typically)
- Space considerations
- ADA considerations
- Interactions between bus loading/unloading and pedestrian traffic
- Resources
  - Easter Seals Project ACTION
  - FDOT
  - TCRP
  - Local Agencies

68

BUS STOP DESIGN

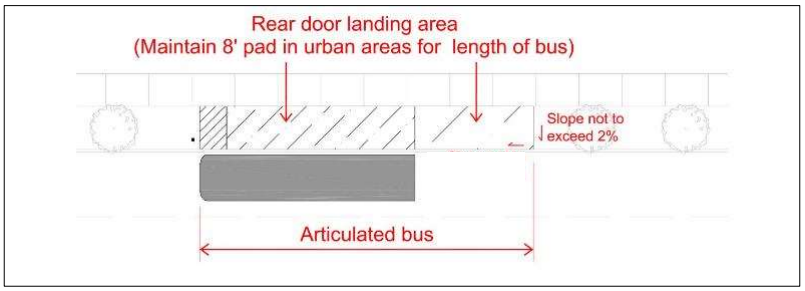
ADA Landing Pad/Passenger Waiting Area

- Connected to the curb
- 5’ wide (parallel to the roadway) by 8’ deep (perpendicular to the roadway)
- Free from obstructions

69

BUS STOP DESIGN

Expanded Landing Pad

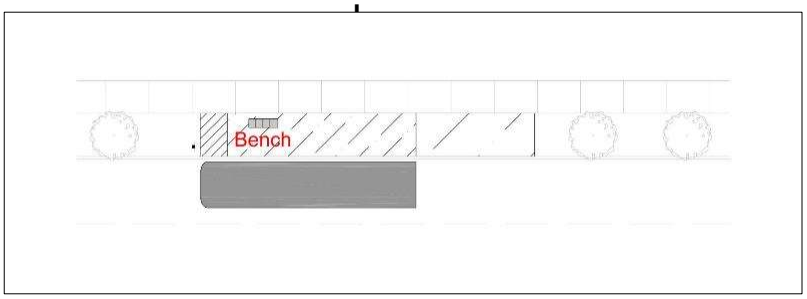


- Minimum 40’ for standard bus
- Minimum 62’ for articulated bus
- 8’ deep pad should be maintained for length of bus

70

BUS STOP DESIGN

Benc

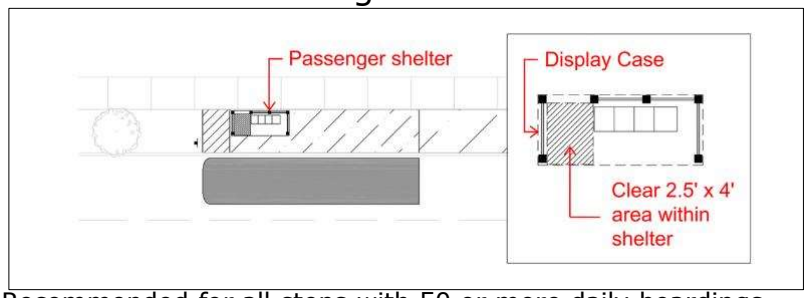


- Can be freestanding or part of a shelter design
- Recommended where headways are longer than 15 minutes
- Should be away from 5’ x 8’ landing pad

71

BUS STOP DESIGN

Passenger Shelter

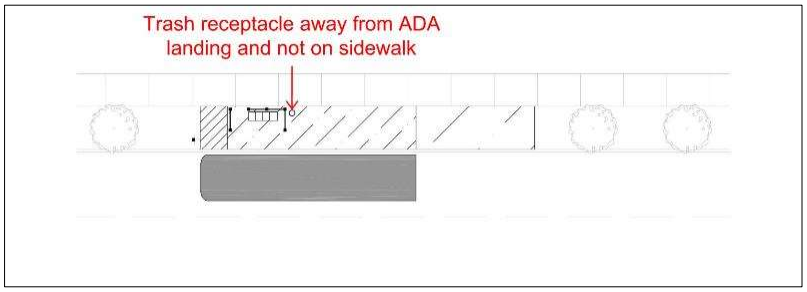


- Recommended for all stops with 50 or more daily boardings
- Shall contain a clear area (2.5’ x 4’) – if seating is provided, clear space shall be located either at end of seat or shall not overlap the area within 1.5’ from front edge of seat.
- The 5’ x 8’ landing pad can be located either within or outside of the shelter
- The shelter should not obstruct sidewalk

72

BUS STOP DESIGN

Trash Receptacles

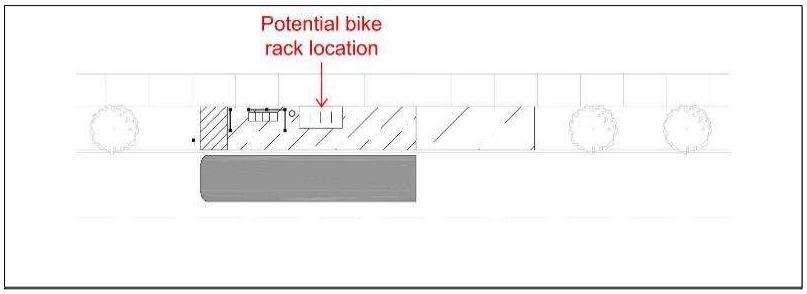


- Should be provided at stops served by enhanced bus service and stops in proximity to fast food establishments
- Should resemble other publicly owned and maintained trash receptacles along the corridor

73

BUS STOP DESIGN

Potential Bike Rack Locations

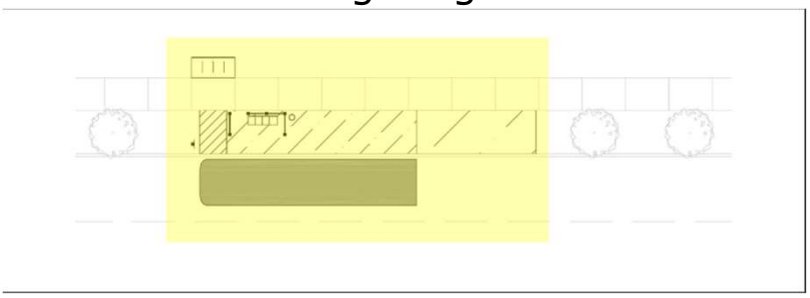


- Potential locations:
  - Right of passenger shelter
  - In front or rear of expanded landing pad
  - Behind sidewalk opposite the 5’ x 8’ landing pad
- Should be away from 5’ x 8’ landing pad

74

BUS STOP DESIGN

Lighting



Provide adequate lighting for safety and security

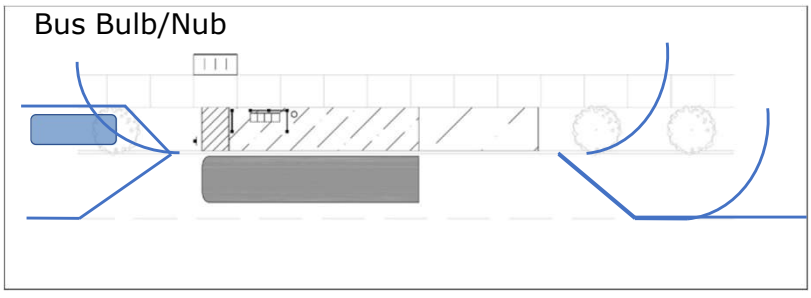
75

BUS STOP DESIGN

These features can be incorporated at various bus stop types:

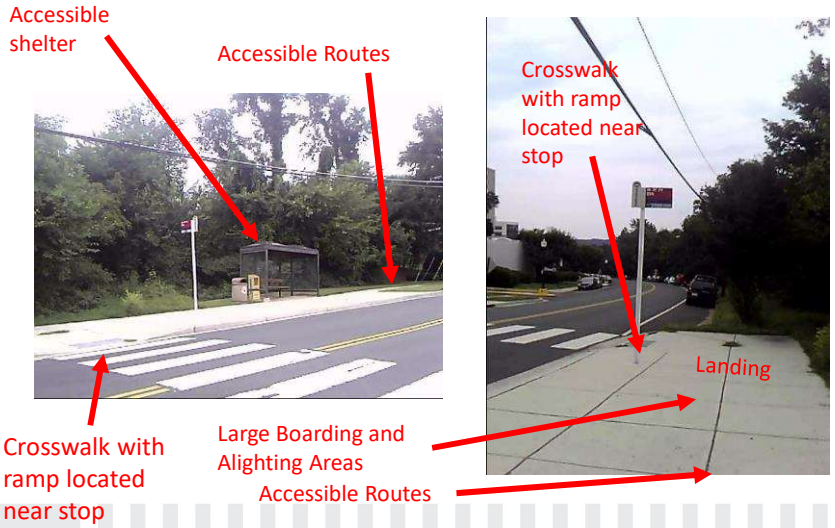
Queue Jumper Bus Bay

Bus Bulb/Nub



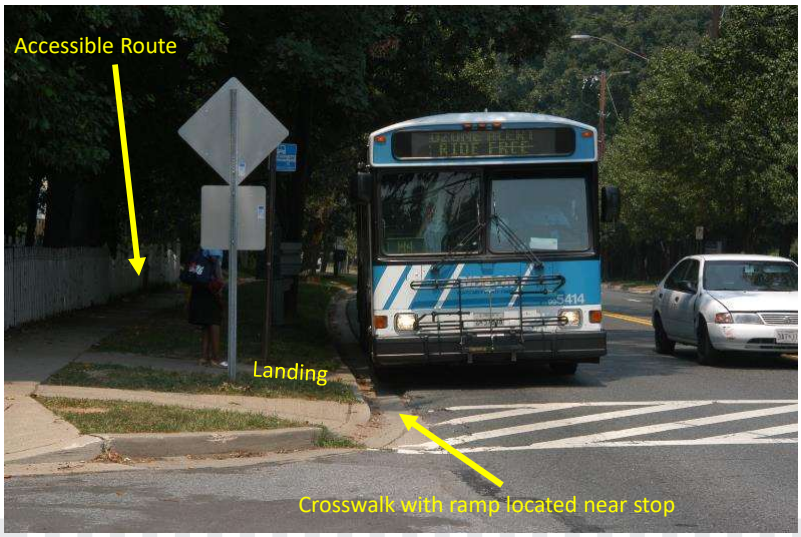
76

Bus stop Design: putting it together



77

Bus stop Design: putting it together



78

Bus stop Design: putting it together

79

Bus Areas of Caution

- Desire lines
- Passenger demand
- Complex/ unfamiliar designs and signals

80

Bus Areas of Caution
Desire lines

- Off-street facilities can be key generators
- Provide direct routes including crossing enhancements

81

Bus Areas of Caution
Desire lines

- Bus stacking can create additional desire lines
- Degree of concern depends on context
  - Provide wayfinding, use channelization, and consider relocating stops to mitigate midblock crossings on high-speed roadways

82

Bus Areas of Caution passenger demand

- Can exceed designated space
- Consider effects on following:
  - Pedestrian zone
  - Position of bus
  - Loading time
- Define zones
- Driver training

83

Bus Areas of Caution passenger demand

Additional effects include diverting pedestrians, sight distance obstruction, and unexpected conditions

84

Bus Areas of Caution passenger demand

Additional effects include diverting pedestrians, sight distance obstruction, and unexpected conditions

85

Bus Areas of Caution complex/unfamiliar designs

Transit Signal Priority- buses get an advance signal and passing opportunity

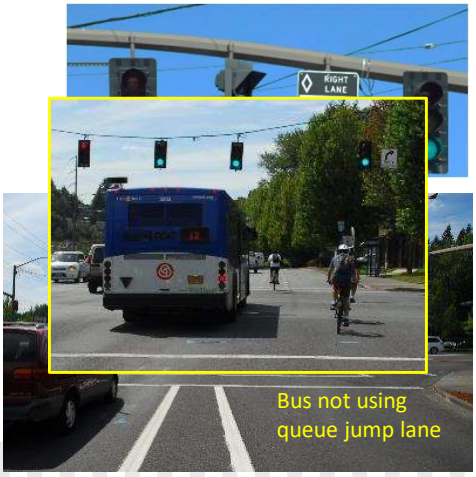
- May create conflicts with pedestrians leaving curb early
- Conflicts with cyclists as well if facility is not consistently used
- Pedestrian crossing on far side

86

Bus Areas of Caution complex/unfamiliar designs

Transit Signal Priority- buses get an advance signal and passing opportunity

- May create conflicts with pedestrians leaving curb early
- Conflicts with cyclists as well if facility is not consistently used
- Pedestrian crossing on far side

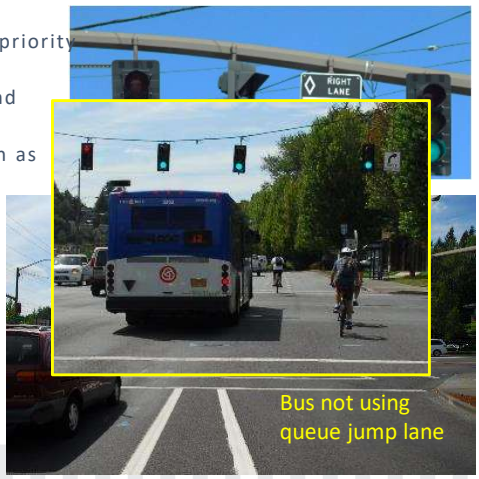


87

Bus Areas of Caution complex/unfamiliar designs

Transit Signal Priority- buses get an advance signal and passing opportunity

- Additional signage to alert users of priority condition
- Review need for queue jump lane and driver training for consistent use
- Far side crossing enhancements such as bulb out



88

Bus Areas of Caution complex/unfamiliar designs

Bus lanes and bus/bike lanes

- Misuse by vehicles and pedestrians (using lanes as refuge when buses are not using)

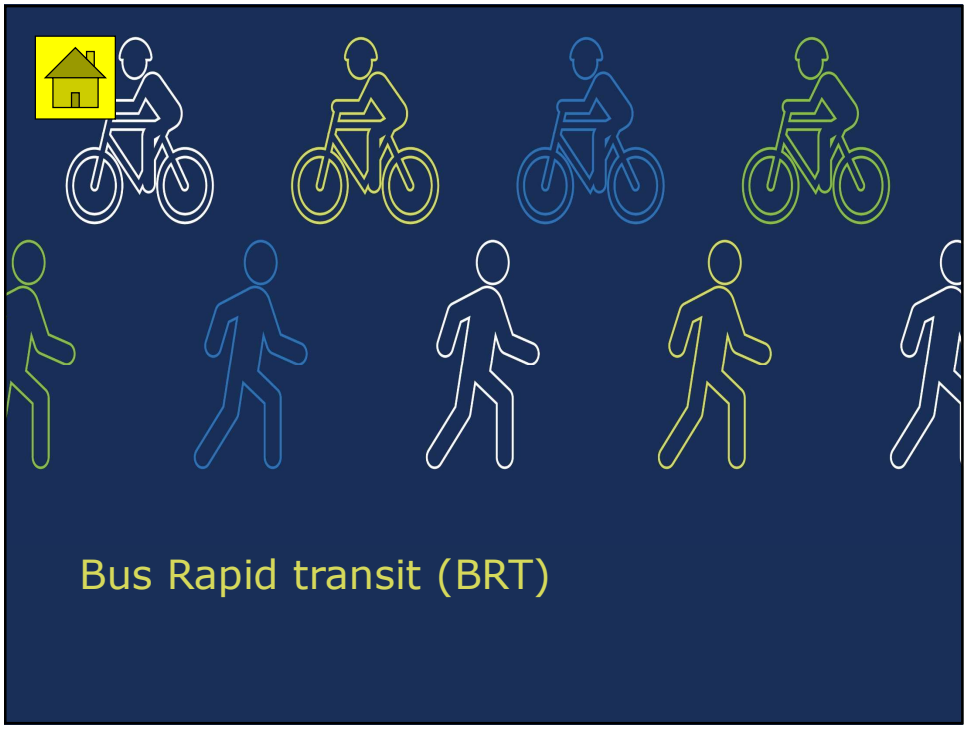
89

Bus Stop Summary

You should be able to:

- Describe key factors in siting bus stops
- Describe considerations in finding specific locations for bus stops
- Illustrate how the different elements fit into the design of a bus stop
- Describe the specific areas of caution when planning bus stops
  - Desire lines, bus stacking, passenger demand, complex and unfamiliar designs

90



91

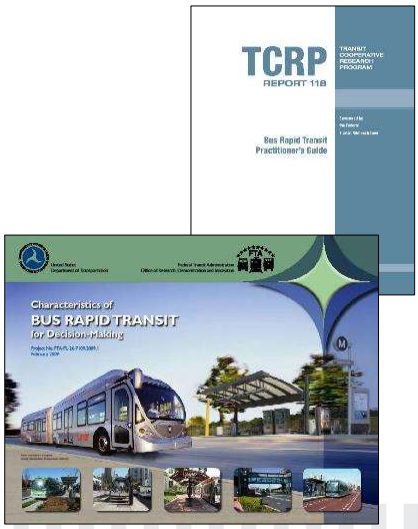
BRT: Topics

- Resources
- Local bus service vs. BRT
- Platform location and design
- Areas of Caution:
  - Platform access
  - Speed differential
  - Crossing away from marked crossings
  - Transfer activity
  - Transit signal priority

92

BRT Resources

Design Criteria
- ADA
  - Vehicle
  - Stop
- Standards and guidance
  - TCRP Reports 90 and 118
  - Characteristics of Bus Rapid Transit for Decision Making
- MUTCD
  - Part 2 - Signs
  - Part 8 – Traffic Control for Railroad and Light Rail Transit Grade Crossings
- American Public Transit Association
- Local Agency



93

BRT Stops

- BRT stops may look like a curb side stop served by a local bus route.
- These stops need to be designed on local bus route principles.

94

BRT Stops

- However, BRT stops may differ from local bus service in that:
- Fare collection space is needed.
- Pedestrian facilities at stops may be separated, once the off-board fare is collected.
- Boarding area may be elevated to expedite boarding/alighting process.

95

BRT Stops

- However, BRT stops may differ from local bus service in that:
- Fare collection space is needed.
- Pedestrian facilities at stops may be separated, once the off-board fare is collected.
- Boarding area may be elevated to expedite boarding/alighting process.

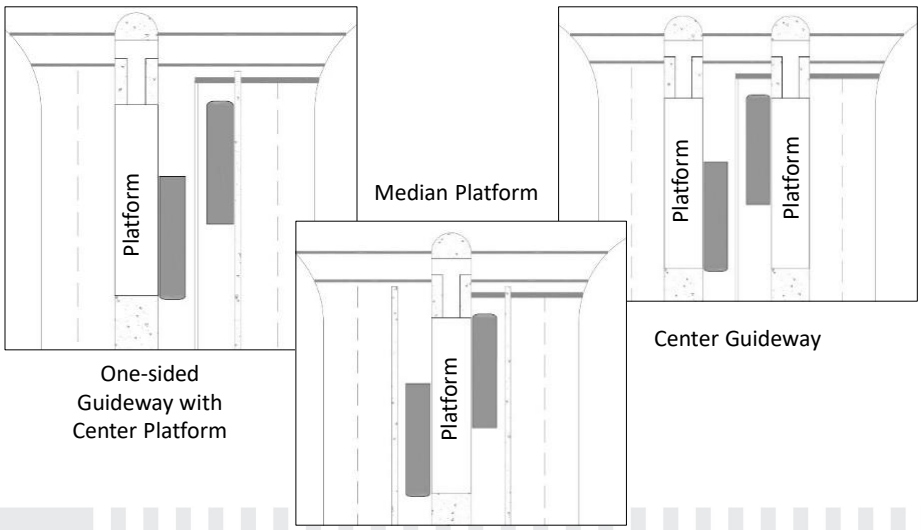
96

BRT Stops

- Such stops are often referred to as platforms.
- These will be the focus of this module.

97

BRT Platforms



98

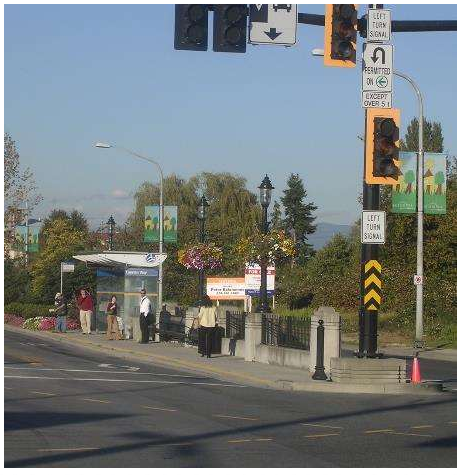
BRT Platforms

- Considerations for at-grade median stops:
  - Traffic speed
  - Location type
  - Traffic control
  - Turning movements
  - Pedestrian refuge
  - Platform connection to crosswalk
  - Pedestrian control devices
  - Barriers/physical separation from traffic

99

BRT Platforms

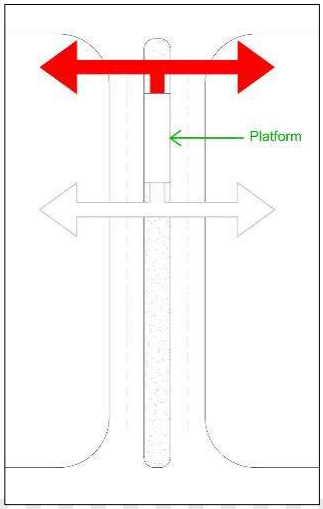
- Considerations for at-grade median stops:
  - Traffic speed
  - Location type
  - Traffic control
  - Turning movements
  - Pedestrian refuge
  - Platform connection to crosswalk
  - Pedestrian control devices
  - Barriers/physical separation from traffic



100

BRT
Platform Location

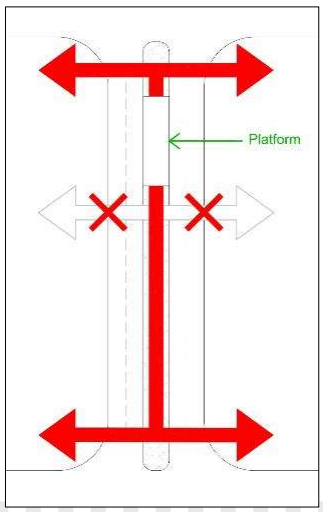
- When locating platforms the potential crossing locations should be considered.



101

BRT
Platform Location

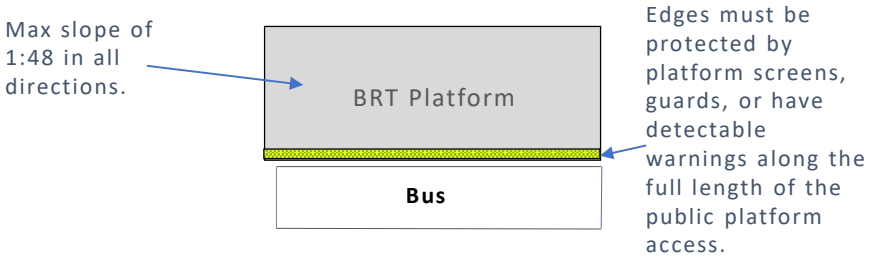
- When locating platforms the potential crossing locations should be considered.
- Crossings should follow the principles discussed in earlier modules.
- Uncontrolled midblock crossings should be discouraged.



102

BRT platform design

ADA Standards –Platforms

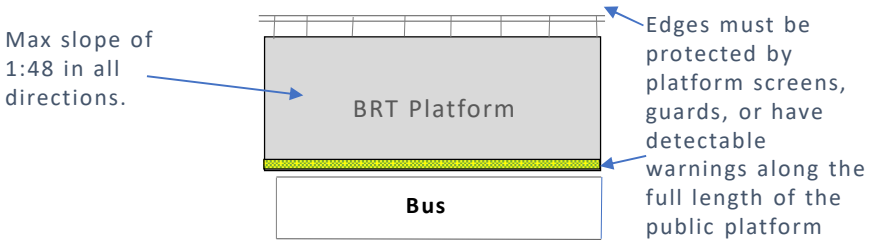


Source: U.S. Access Board

103

BRT platform design

ADA Standards –Platforms



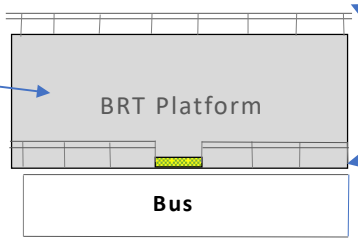
Source: U.S. Access Board

104

BRT platform design

ADA Standards –Platforms

Max slope of 1:48 in all directions.



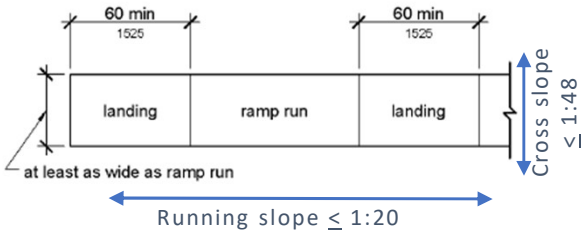
Edges must be protected by platform screens, guards, or have detectable warnings along the full length of the public platform access.

Source: U.S. Access Board

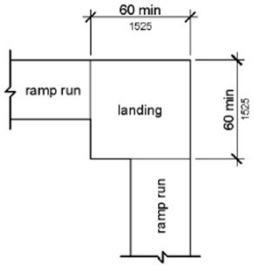
105

BRT platform design

ADA Standards – Ramps



Change in direction:



106

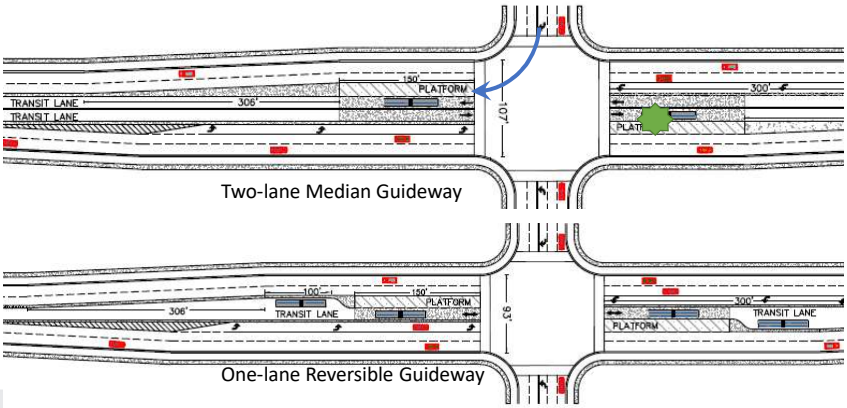
BRT Platform Design

- BRT platforms need to accommodate users with all types of abilities.
- Elements to consider include ramps and protection from raised curbing.

107

BRT Running Way

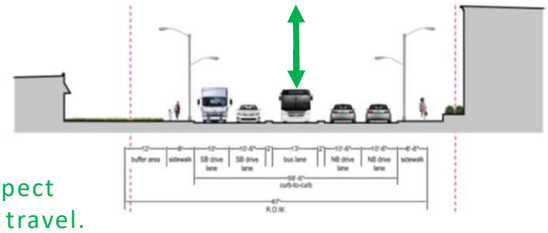
Running way location (median or curb), the number of lanes (one or two lanes), and direction of flow (concurrent or contra) impact safety considerations.



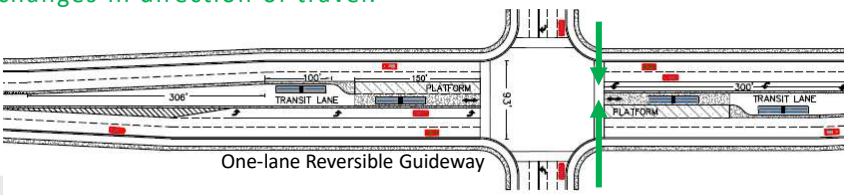
108

BRT Running Way

Running way location (median or curb), the number of lanes (one or two lanes), and direction of flow (concurrent or contra) impact safety considerations.



Pedestrians may not expect changes in direction of travel.



One-lane Reversible Guideway

109

BRT Areas of Caution

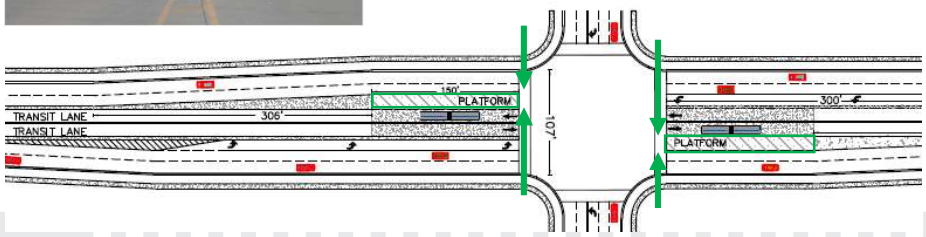
- Platform Access
- Speed differential
- Crossing away from marked crossings
- Other considerations similar to local bus
  - Desire lines/transfer activity
  - Transit signal priority

110

BRT Areas of Caution
Platform Access

Median platforms may be center or split design and require passengers to cross from either side of the street to access the platform.

Pedestrians must cross from either side of the street to access the platform.

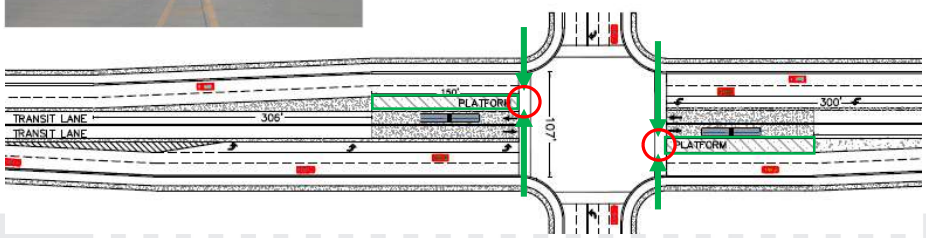


111

BRT Areas of Caution
Platform Access

Median platforms may be center or split design and require passengers to cross from either side of the street to access the platform.

These areas should provide pedestrian refuge for pedestrians to wait to cross or if signalized, access a push button.

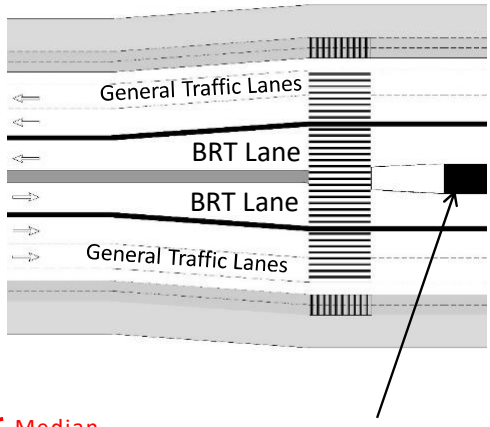


112

BRT Areas of Caution
Platform Access

Median platform crossing with no refuge

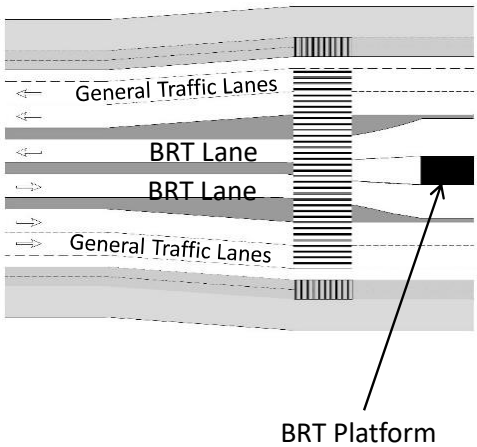
- Greater distance to cross
- Change in direction of travel
- Speed differential between general traffic and buses may be confusing to pedestrians.



113

BRT Areas of Caution
Platform Access

- Median platform crossing with refuge *(Better)*
  - Allows for multi-stage crossing
  - Separation of speed differential
  - Still allows for direct crossing



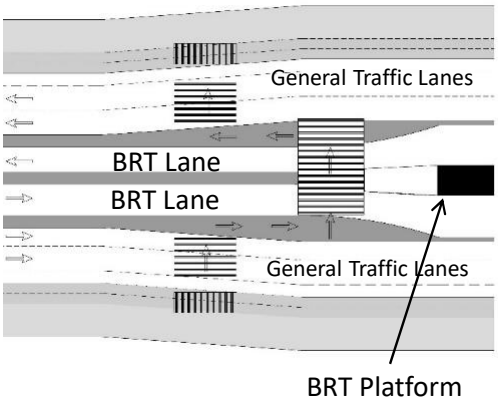
114

BRT Areas of Caution
Platform Access

Median platform

Z-crossing *(Better)*

- Allows for multi-stage crossing
- Separation of speed differential
- Channelizes pedestrians and orients pedestrians to approaching traffic/transit lanes



115

BRT Areas of Caution
Platform Access

Treatments should direct pedestrians to cross the street and busway where intended.

116

BRT Areas of Caution
Platform Access

Channel pedestrians to crossing

Not a Z-crossing

Remember to use high-visibility crosswalk markings!

117

BRT Areas of Caution
Platform Access

Plantings used to channelize crossing. Should use low-lying vegetation.

118

BRT Areas of Caution
Platform Access

Crossing away from marked crosswalks.

- Due to platform length, pedestrians may cross midblock.

Signage with limited effectiveness

119

BRT Areas of Caution
Platform Access

Pedestrian pushbutton to allow pedestrian to call for ped phase.

Fencing and bollards used to restrict undesired pedestrian movements.

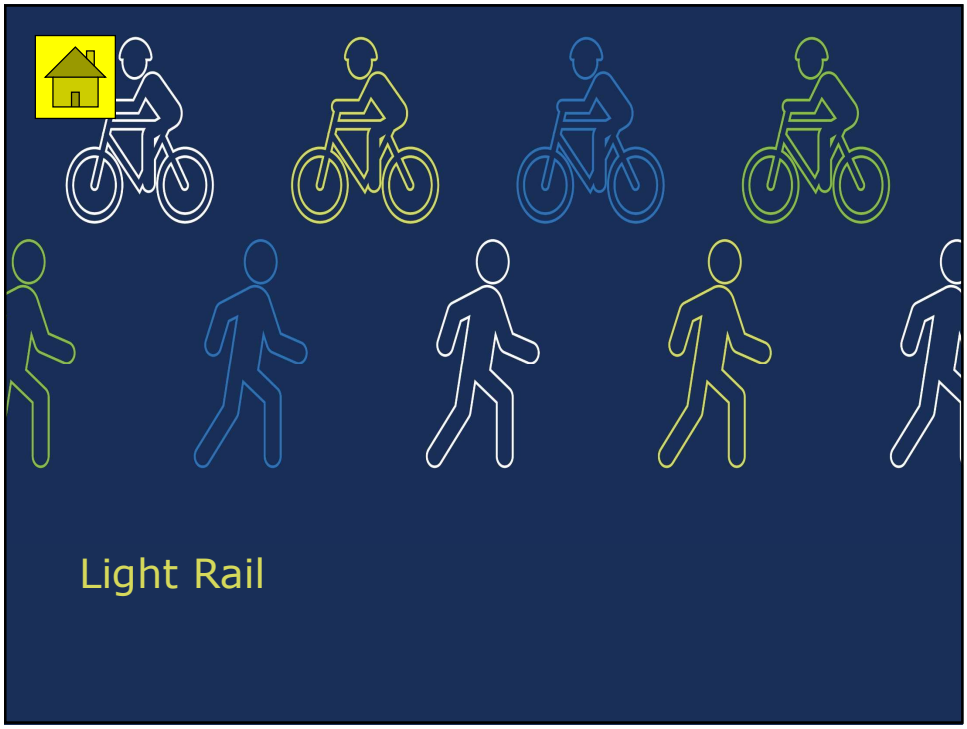
120

BRT Summary

You should be able to:

- Identify the differences in local bus service and BRT
- Describe methods to access BRT platforms
- Describe design features of BRT that should be considered to address pedestrian safety
- Understand the critical areas of caution with respect to designing for pedestrians

121



122

Light Rail topics

- Resources
- Design Details
- Safety Considerations:
  - Platform location and design
  - Accessibility
  - Crossings
- Areas of Caution:
  - Intersections
    - Vehicle & LRT conflicts
    - Vehicles & pedestrians crossing against signals
  - Crossing the Tracks
    - Crossing away from marked crosswalks

123

Light Rail Resources

- Safety
  - Research
- Design Criteria
  - MUTCD
    - Part 8
  - ADA Standards
  - FRA Standards
    - Provide a min. of 20 seconds of warning time with active devices deployed fully for 5 second before arrival
  - *Safety Criteria for Light Rail Pedestrian Crossings* - TriMet
  - TCRP Reports 17, 69, & 137

TABLE 3-3 Use of Warning Devices at Pedestrian Crossings

Pedestrian Crossing Location	Typical Devices	
	Visual[a]	Audible
Isolated Pedestrian or Bicycle Path	LRV-Activated LRT Warning Signs	Bell
Parallel to Roadway along Sidewalk (Semi-Exclusive, Type b.1)	Red Flashing Light Signals[b]	Bell
Across Roadway in Marked Crosswalk — Adjacent to an Intersection (Semi-Exclusive, Type b.2)	Pedestrian Signals[c]	Audio Pedestrian Device[d]

a) Alternative visual device is a Second Train Approaching sign for two or more tracks.
b) The LRV-activated LRT warning sign (the W10-7 sign as depicted in Figure 3-37) is an alternate to using red flashing light signals at LRT-only crossings. At crossings with both LRT and railroad, the W10-7 sign may be installed as a supplement to red flashing light signals and illuminated when LRVs approach.
c) The LRV-activated LRT warning sign (W10-7) may be used to supplement standard pedestrian signals to warn pedestrians of the increased risk associated with violating the primary regulatory device (the pedestrian signals).
d) "Chirp-chirp" or "coo-coo" sound provided during WALK indication.

Source: TCRP Report 69 Light Rail Service: Pedestrian and Vehicular Safety, TRB, 2001

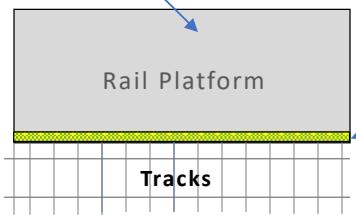
124

Accessibility

ADA Standards – Rail platforms & crossings

Track Crossings:

Max slope of 1:48 in all directions.



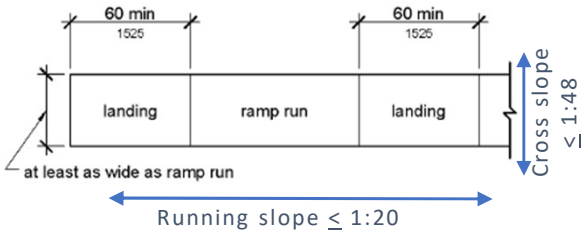
Edges must be protected by platform screens, guards, or have detectable warnings along the full length of the public platform access.

Source: U.S. Access Board

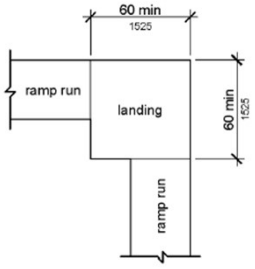
125

Accessibility

ADA Standards – Ramps

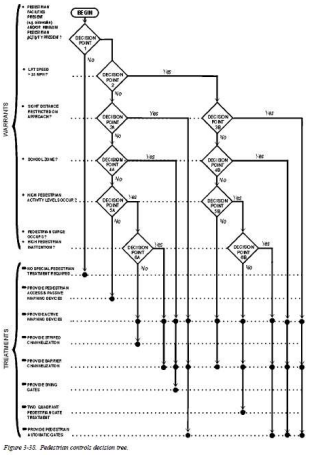


Change in direction:



126

Light Rail Design Considerations

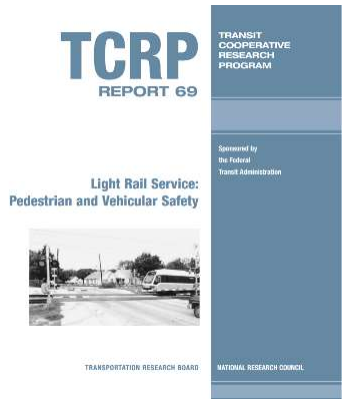


Source: TCRP Report 69 Light Rail Service: Pedestrian and Vehicular Safety, TRB, 2001

- Location & Operation
  - Alignment
  - Speed
  - Station area characteristics
- Crossings
  - Signs & Markings
  - Tactile warnings
  - Gates & other crossing controls
- Accessibility

127

Light Rail Design Considerations



- Location & Operation
  - Alignment
  - Speed
  - Station area characteristics
- Crossings
  - Signs & Markings
  - Tactile & Audible warnings
  - Gates & other crossing controls
- Accessibility

128

Light Rail Station Area Characteristics

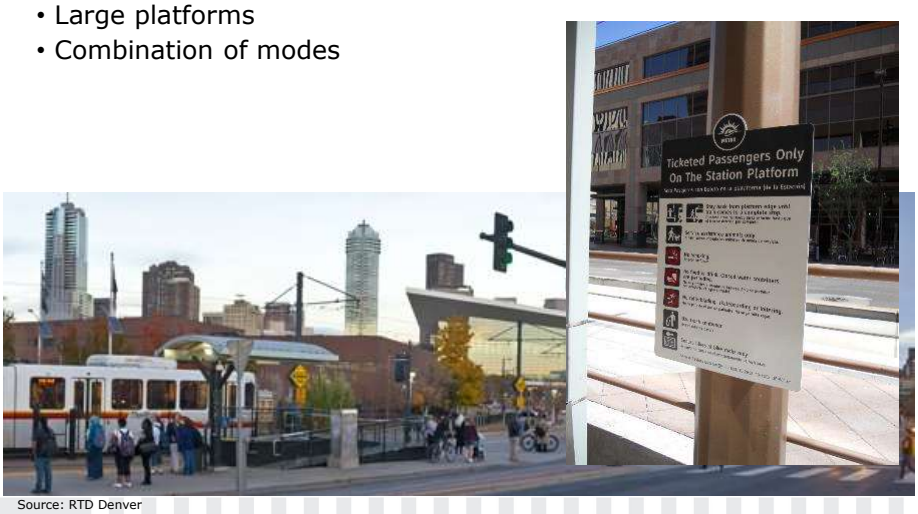
- Large platforms
- Combination of modes

Source: RTD Denver

129

Light Rail Station Area Characteristics

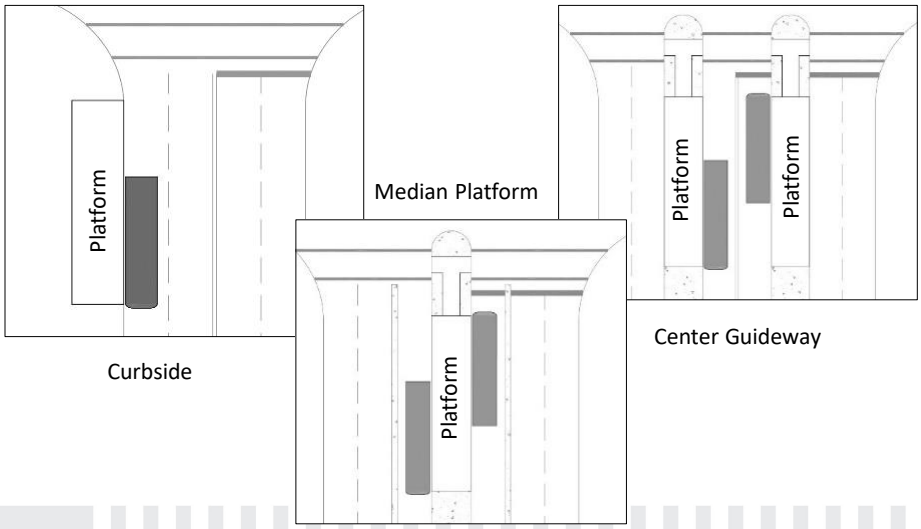
- Large platforms
- Combination of modes



Source: RTD Denver

130

Light Rail Platforms



131

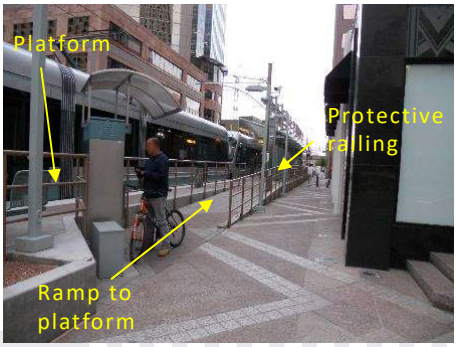
Light Rail Location & Operation

Pedestrian crossings should be clearly marked with pedestrian signals linked to the signals for the light rail and general traffic.

132

Light Rail Location & Operation

LRT Platforms should not block general pedestrian activity and should be well defined with a sufficiently sized waiting area and paths that access the waiting area.



133

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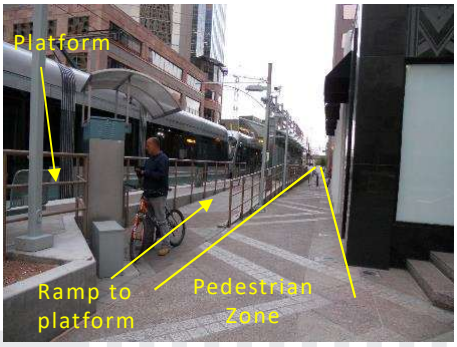


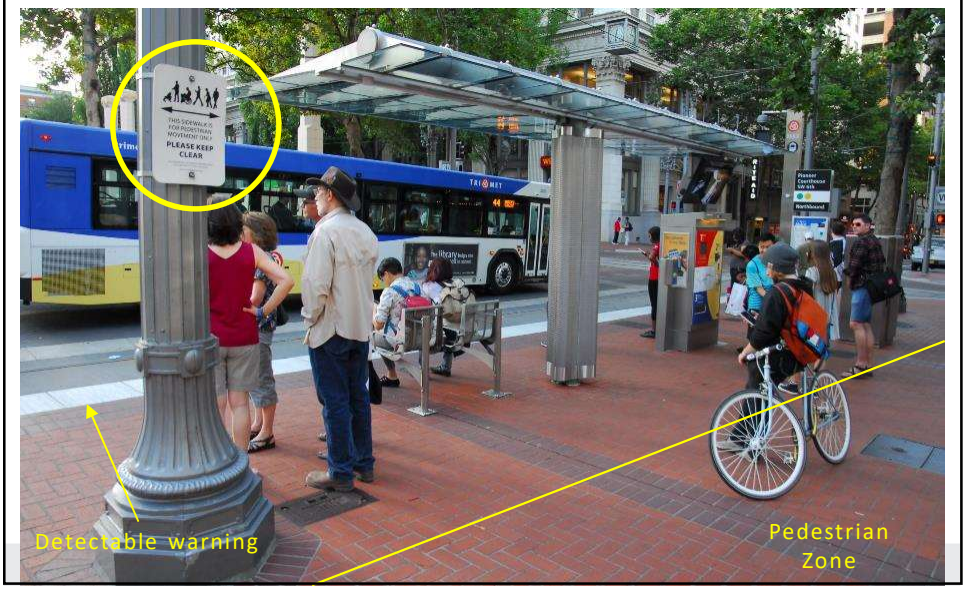
134

Light Rail Location & Operation

LRT Platforms should not block general pedestrian activity and should be well defined with a sufficiently sized waiting area and paths that access the waiting area.

135

Light Rail Location & Operation



136

Light Rail accessibility

LRT platforms need to accommodate all types of users with all types of abilities.

137

Light Rail accessibility

LRT platforms need to accommodate different modes. Sometimes different waiting areas are assigned to provide accessibility.

138

Light Rail Accessibility

It is important to consider how users will access platforms and also how to load them on to LRT vehicles.

139

Light Rail crossings

Signs can provide warnings to pedestrians about LRT crossings.

140

Light Rail crossings

Signs can provide warnings to pedestrians & bicyclists about LRT crossings.

141

Light Rail crossings

Flashers or gates may be used to warn pedestrians and bicyclists of approaching trains or to prevent crossings.

142

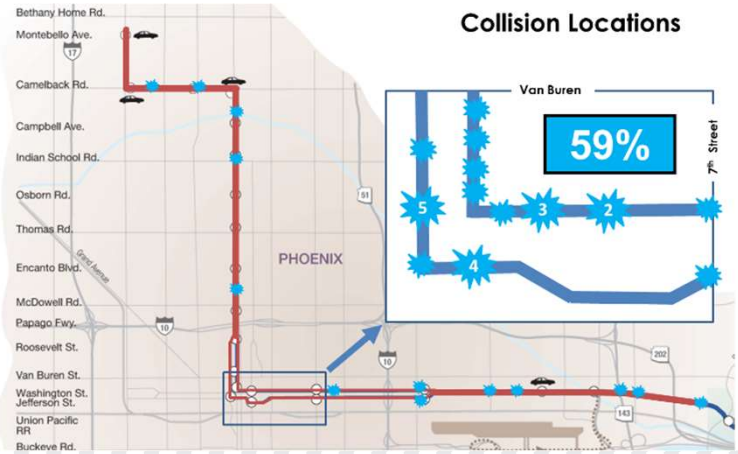
Light Rail Area of Caution

- Intersections
  - Vehicle & LRT conflicts
  - Vehicles & pedestrians crossing against signals
- Crossing the Tracks
  - Crossing away from marked crosswalks

143

Light Rail Areas of Caution: Intersections

Phoenix Case Study

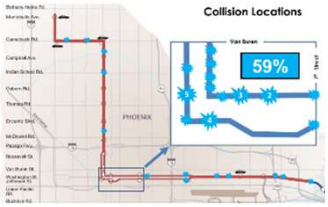


144

Light Rail Areas of Caution: Intersections

Collisions with Light Rail Trains:

- 87% of vehicles were travelling in the same direction as Light Rail Train.
- 86% were caused by drivers turning against a red traffic signal arrow
- Approximately 44% involved motor vehicles turning right. One-third of the collisions involved vehicles turning left.



145

Light Rail Areas of Caution: Intersections

- Issues with Protected Turns parallel to LRT TRACKS
  - Less time for pedestrians to cross
  - Long pedestrian delays
  - High pedestrian violations
  - Motorist delay and frustration
  - Motorists run the red light

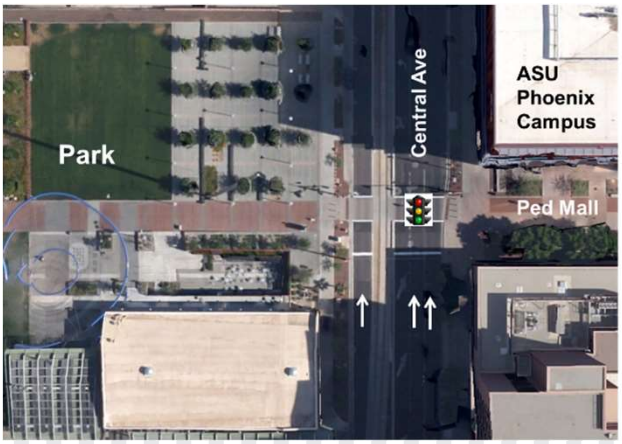
SOLUTION: **All-Red** phase called when the train arrives:

- More ped crossing opportunities
- Improved pedestrian behavior
- Fewer red-light violations
- LPI created where turn conflicts exist

146

Light Rail Areas of Caution: Intersections

Pedestrians crossing against traffic signals



147

Light Rail Areas of Caution: Intersections

- Pedestrians crossing against traffic signals
- "**Hot Button**" pedestrian signal for most of the day, except:
  - When LRT approaches (12 minute intervals)
  - During afternoon peak (4-6 PM)
- Few crossings during afternoon peak
- **Minimum** green time between actuations

148

Light Rail Areas of Caution: Crossings

Crossing away from marked crosswalks

149

Light Rail Areas of Caution: crossings

Crossing away from marked crosswalks

150

Light Rail Areas of Caution: crossings

Crossing away from marked crosswalks

151

Light Rail Areas of Caution: crossings

Crossing the Tracks

- Larger platforms mean pedestrians may cross midblock
- Low-speed environments- pedestrians cross with infrequent conflicts
- High-speed environments- crossing reinforcements may be used to provide pedestrians guidance about where to cross.

152

Light Rail Areas of Caution: crossings

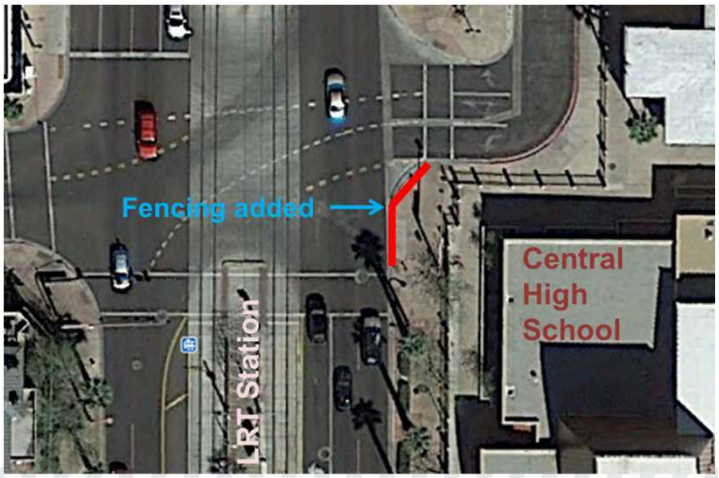
Crossing the Tracks

- Larger platforms mean pedestrians may cross midblock
- Crossing reinforcements may be used to provide pedestrians guidance about where to cross.

153

Light Rail Areas of Caution: crossings

Crossing away from marked crosswalks



154

Light Rail Areas of Caution: crossings

Crossing away from marked crosswalks

155

Light rail summary

You should be able to:

- Describe design features of pedestrian access to light rail
- Describe the design elements of light rail access
- Describe the areas of caution for pedestrians accessing light rail

156

157

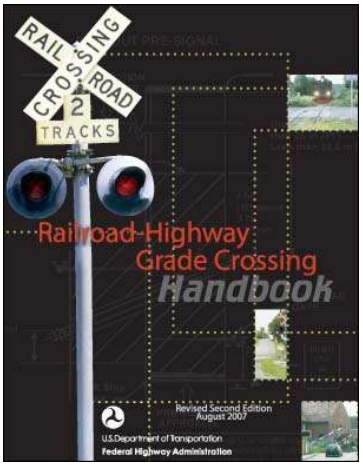
Commuter Rail topics

- Resources
- Platform Accessibility and Design
- Major design considerations:
  - Station access
  - Convergence of modes
  - Rail crossings
- Areas of Caution:
  - Lighting
  - Pedestrian Surges
  - Distractions

158

Commuter Rail Resources

- Safety
  - Research
    - 2008 – Illinois Commerce Commission looked at 33 pedestrian incidents between 2000-04
      - 66% involved disregard of warning devices
    - Commuter Rail Safety Study, FTA, 2006
- Design
  - FHWA Railroad-Highway Grade Crossing Handbook
  - TCRP Report 17
  - MUTCD
  - AREMA Communications and Signal Manual
  - CFR 49 Part 234
  - State and Local



159

Commuter Rail
Design considerations

- Station catchment area typically large
- Characterized by a convergence of modes
- Most have parking facilities at or near stations
- Pedestrians may have to cross tracks at grade-separated or at grade locations

160

Commuter Rail Access

Station Area Characteristics

101 Planning Principles	
• Access Management • Street Connectivity • Land Use	• Site Design • Level of Service

These elements will impact the types of behaviors and expectations for travelers and will dictate the strategies to improve safety.

161

Commuter Rail Station Access

Station Access

- Need a good understanding of how many people want to access the station and how they are accessing the station.
- Pedestrian and bike facilities should be located so that they minimize conflicts with other vehicles.

162

Commuter Rail Station access

Station Access
- How are people accessing the station?
- Is the street appropriate given ped/bike activity?
- Provide connectivity to surrounding network, particularly within the catchment area.

Bus

Commuter Rail

163

Commuter Rail station Parking

- Parking should be located so that pedestrian paths avoid conflicts with other modes (including parking vehicles).
- Pedestrian path should be clearly marked and should follow desire lines.
- Bike parking should be provided to provide convenient access to the station.

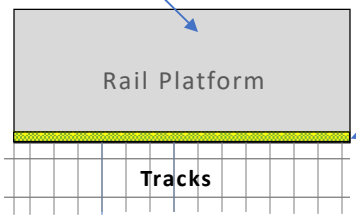
164

Accessibility

ADA Standards – Rail platforms & crossings

Track Crossings:

Max slope of 1:48 in all directions.



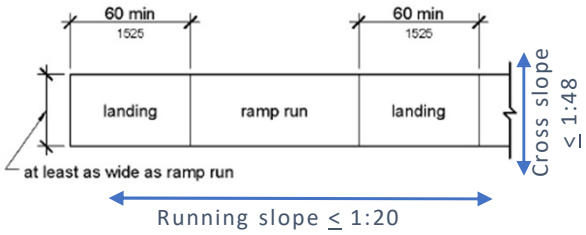
Edges must be protected by platform screens, guards, or have detectable warnings along the full length of the public platform access.

Source: U.S. Access Board

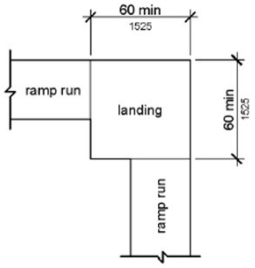
165

Accessibility

ADA Standards – Ramps



Change in direction:



166

Accessibility

Both commuter rail stations and the routes to stations should be accessible.

167

Commuter Rail Crossings – At-grade

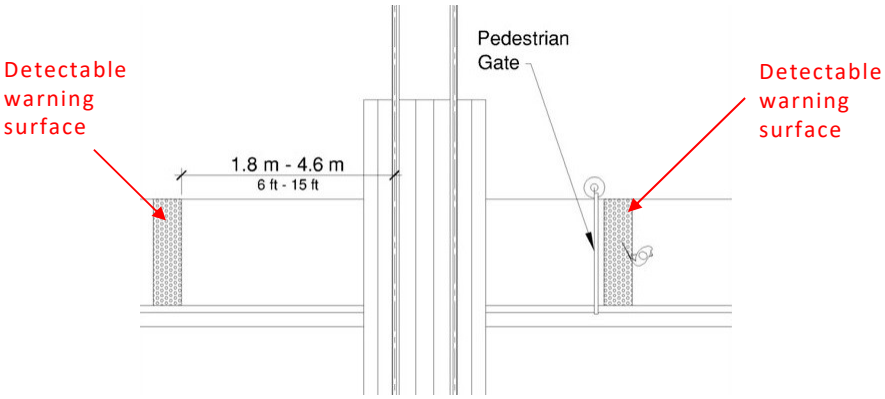
At-Grade

- Land Use– a crossing near a pedestrian generator may warrant additional safety treatments.
- Similarly, pedestrian paths with higher activity may warrant more robust treatments.

168

Commuter Rail Crossings – At-grade

At-Grade crossings not located within a street or highway (PROWAG).



169

Commuter Rail Crossings – Grade Separated

Grade Separated

- Do not have many of the same safety considerations for design that **at-grade** crossing do because the conflict between rail and pedestrian have been removed
- Desired pedestrian crossing locations and demand should be considered when deciding where to locate grade-separated crossings. Visibility of the station maintained.
- Adequate lighting, safe connections between both ends of the crossing, and connectivity to other pedestrian facilities provide a sense of safety for the pedestrian and can improve facility use.

170

Commuter Rail Area of Caution – At-grade Crossings

- Pedestrians darting or crossing tracks.
  - Gates (automatic or swing) can physically prevent pedestrians from crossing tracks in high risk areas.
- Pedestrians not realizing that a second train may be approaching.
  - Active signs.
- Pedestrians failing to look both ways.
  - Z crossing channelization used where pedestrians were likely to cross unimpeded. Used to turn pedestrians toward on-coming trains.

171

Commuter Rail Area of Caution

- Lighting – many people using commuter rail do so during hours of darkness. Paths to stations should be illuminated.
- Pedestrian Surges – the facilities need to accommodate large pedestrian surges (e.g., sidewalk width, crosswalk width, etc.).
- Distractions - inattention and distraction at rail crossings is a concern for many agencies. Engineering and educational measures have been instituted to raise awareness about crossing train tracks.

172

Commuter Rail Summary

You should be able to describe:

- Accessibility requirements for commuter rail
- Station area access features
  - Large catchment area, convergence of modes, parking facilities at stations, pedestrians tracks crossings
- Commuter rail areas of caution
  - Lighting, pedestrian surges, distractions

173

174

Streetcar topics

- Major safety considerations:
  - Alignment
  - Track crossings
- Areas of Caution:
  - Crossings
    - Track and Cyclist Interaction
  - Accessibility
  - Warning Devices
  - Distractions

175

Streetcars

- Safety
  - Research
- Design Criteria
  - MUTCD
  - ADA Standards
  - APTA

Source: Washington Post

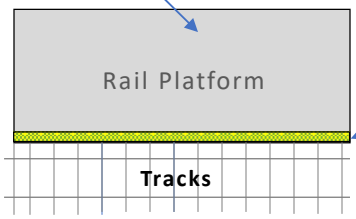
176

Accessibility

ADA Standards – Rail platforms & crossings

Track Crossings:

Max slope of 1:48 in all directions.



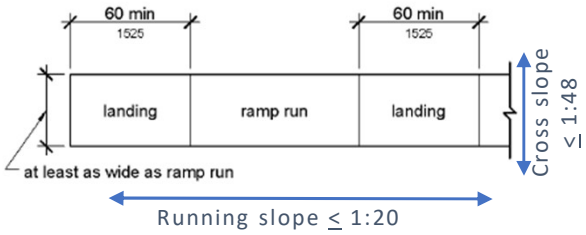
Edges must be protected by platform screens, guards, or have detectable warnings along the full length of the public platform access.

Source: U.S. Access Board

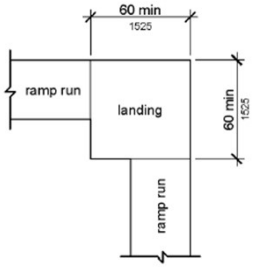
177

Accessibility

ADA Standards – Ramps



Change in direction:



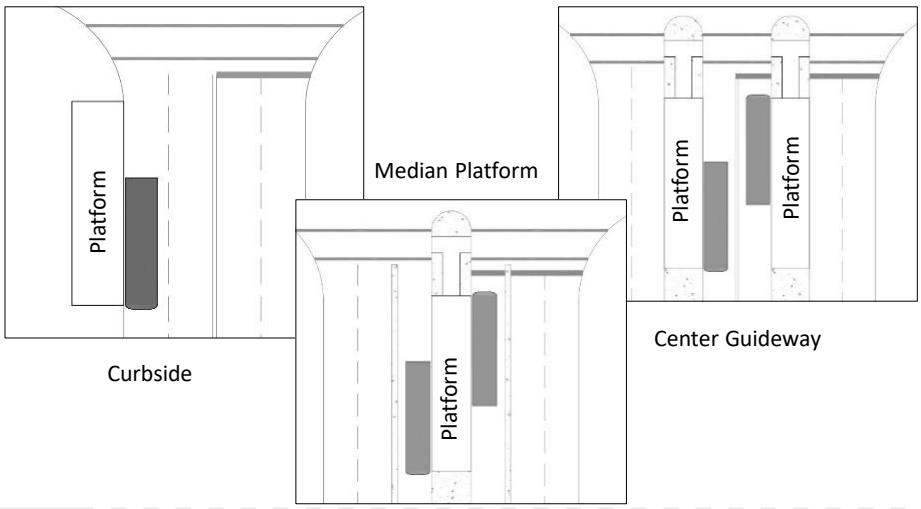
178

Streetcars
Design considerations

- Location
  - Typically operated within the street
  - Slower Speeds (7-12 mph)
  - Tracks and stations can clearly delineate streetcar areas from pedestrian areas
  - Interaction between vehicle and platform design
- Accessibility
  - Presence of platform
  - Tracks present challenges to cyclists and wheelchairs
  - Separate whenever possible
  - Provide 90⁰ crossings where feasible
  - Type of vehicle

179

STREETCAR Platforms



180

Platform design

Similarities to local bus, BRT, and light rail

Protective railing

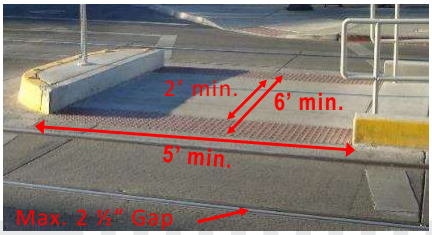
Edges have detectable warnings along the full length of the public platform access.

Platform

Ramp to platform

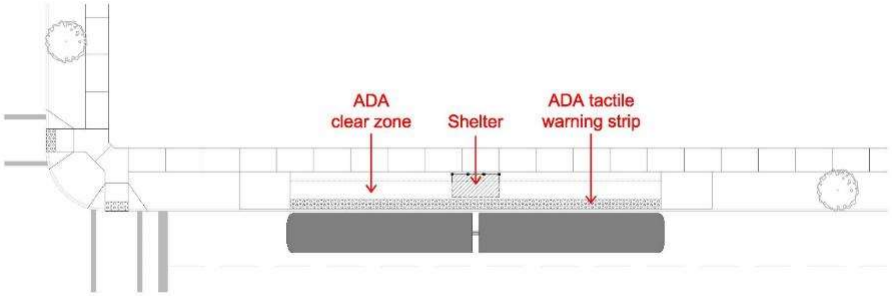
181

Streetcar platform access



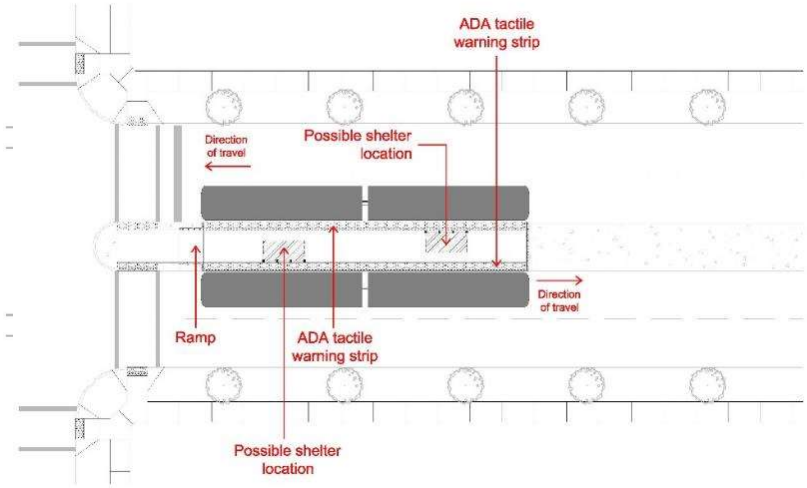
182

Curbside Platform design



183

Median Platform design



184

Streetcar Areas of Caution

- Crossings
  - Track and Cyclist Interaction
- Accessibility
- Construction of platform
- Warning Devices
- Distractions

185

Streetcar Areas of CAUTION

- Pedestrian crossings should be clearly marked with pedestrian signals linked to the signals for the light rail and general traffic.
- Streetcar platforms should not block general pedestrian activity and should be well defined with a sufficiently sized waiting area and paths that access the waiting area.

186

Streetcar Areas of CAUTION

Crossing reinforcements may be used to provide pedestrians guidance about where to cross.

187

Streetcar Areas of CAUTION

Signs can provide warnings to pedestrians & bicyclists about streetcar crossings.

188

Streetcar summary

You should be able to:

- Understand the differences and similarities of streetcars and other forms of transit
- Describe the platform design elements
- Describe the streetcar areas of caution

189

190

Legal Cases

- Bonnano v. Central Contra Costa Transit Authority
  - Rider was struck by a car when crossing the street in a marked crosswalk at an unsignalized intersection.
  - Transit authority was found partially liable as they control the bus stop and were aware of the dangerous conditions.
- Southeastern Pennsylvania Transportation Authority
  - Passenger was struck crossing the street to transfer between a trolley and bus.
  - Transit agency held liable because according to PA law, a person "standing or walking outside of a vehicle can still qualify as a vehicle occupant if there is a connection between the injury sustained and the use of the vehicle".
- Niagara Frontier Transportation Authority
  - Passenger struck when crossing traffic to access a destination after exiting bus.
  - No court ruling or admission of wrongdoing was found but transit agencies should work with local government and property owners when determining stop locations.

Source: Pedestrian Safety Guide for Transit Agencies, FHWA, 2008

191

Transit Summary

You should be able to:

- Understand pedestrian safety within catchment area
- Determine if stops are properly placed
- Determine if stops are properly designed

192

Transit Summary

You should be able to:

- Understand pedestrian safety within catchment area
- Determine if stops are properly placed
- Determine if stops are properly designed

- You should also know:
- The differences between local bus service and other forms of transit.
- Methods and countermeasures to address these differences.

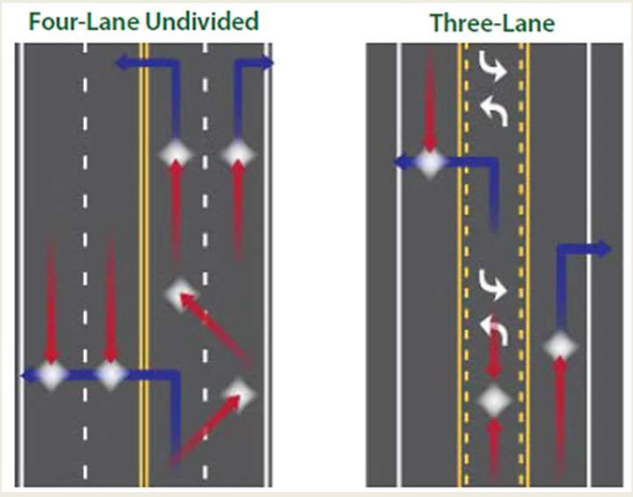
193

ROAD DIET / LANE REDUCTION

DPS 201

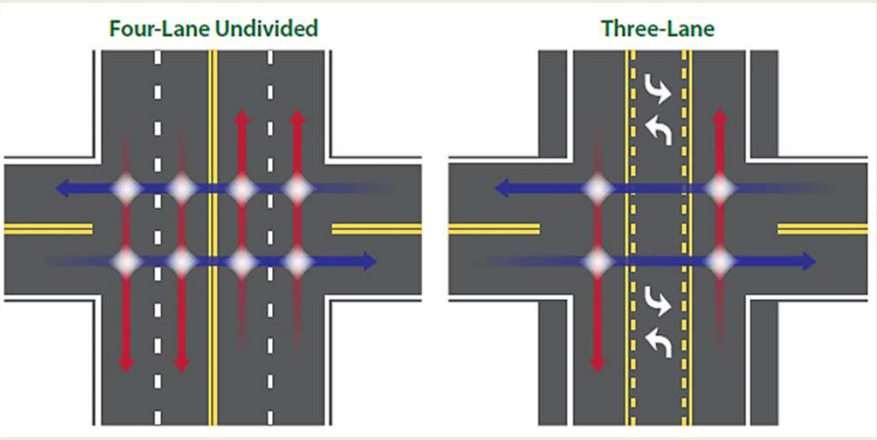
1

WHY



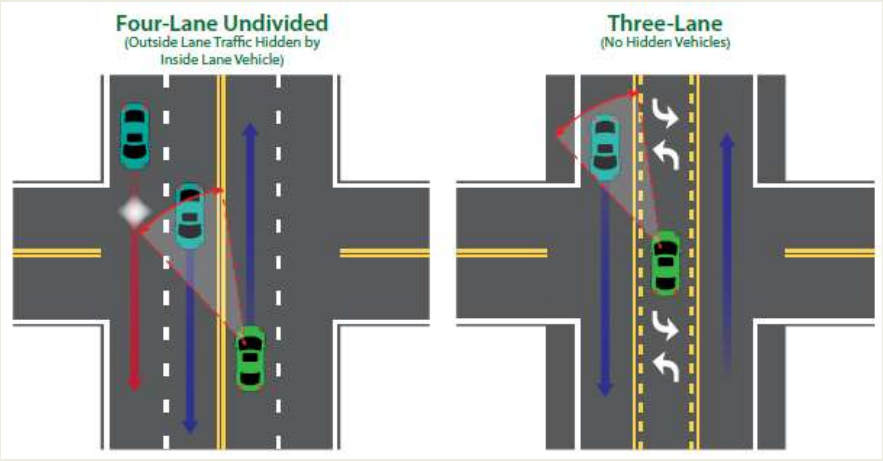
2

WHY


Four-Lane Undivided
Three-Lane

3

WHY


Four-Lane Undivided
(Outside Lane Traffic Hidden by Inside Lane Vehicle)
Three-Lane
(No Hidden Vehicles)

4

PEDESTRIAN BENEFITS

Components of road diet projects associated with increased pedestrian safety:

- Decreases number of vehicle lanes to cross
  - Reduces the multiple-threat situation
- Provides room for a pedestrian crossing island
- Improves speed limit compliance and decrease crash severity
- Creates a buffer between pedestrians and vehicular traffic through addition of on-street bike lanes or on-street parking.

5

Exhibit 4-5. Typical multimodal roadway design characteristics by context zone.

Design Characteristic	Typical Multimodal Roadway Design Characteristics by Context Zone			
	Urban Core	Urban	Suburban	Rural Town
Design Speed	20 mph–30 mph	25 mph–35 mph	30 mph–45 mph	25 mph–45 mph
Target Operating Speed *	20 mph–30 mph	25 mph–35 mph	25 mph–40 mph	25 mph–35 mph
Vehicle Lane Widths	10–11 ft.	10–11 ft.	11–12 ft.	11–12 ft.
Dedicated Turn Lanes	• Can have negative impacts on pedestrians/bikes • Often eliminated on lower-volume streets	• Can have negative impacts on pedestrians/bikes • Often eliminated on lower-volume streets	• Can have negative impacts on pedestrians/bikes • Special designs may be needed to minimize pedestrian/bike conflicts	• Can have negative impacts on pedestrians/bikes • Often eliminated on lower-volume streets
Medians	• Not typically used due to limited right-of-way • Used on boulevard sections	• Not typically used due to limited right-of-way • Used on boulevard sections and for some pedestrian crossings	• Used often for arterial roadways • Sometimes used for collector boulevards and at some pedestrian crossings	• Rarely used unless for pedestrian crossings
On-Street Parking	• Frequently used • Parallel is typical, angle or reverse-angle in some settings	• Selectively used at lower speed ranges • Generally not used for streets with speeds 35 mph and higher	• Rarely used due to safety considerations of speed differentials	• Frequently used if land use includes building fronts on or near right-of-way line
Curb and Gutter	• Typical	• Typical	• Typical in developed areas	• Typical if land use includes building fronts on or near right-of-way line

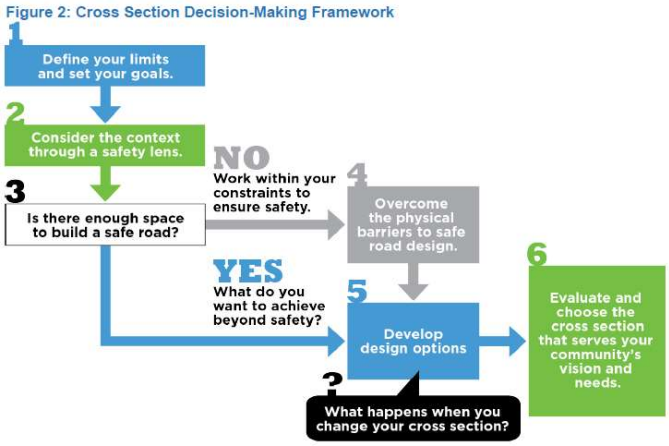
NCHRP Report 880 provides guidance for applying flexibility and understanding context when designing for lower-speed, multimodal roadways

1-6

Considering context when designing streets

6

NCHRP Report 1036 provides a framework for decision-making around cross-section reallocation to help agencies navigate trade-offs and overcome barriers to safe road design.



1-7

National Academies of Sciences, Engineering, and Medicine. 2022. Roadway Cross-Section Reallocation: A Guide. Washington, DC: The National Academies Press. https://doi.org/10.17226/26788.

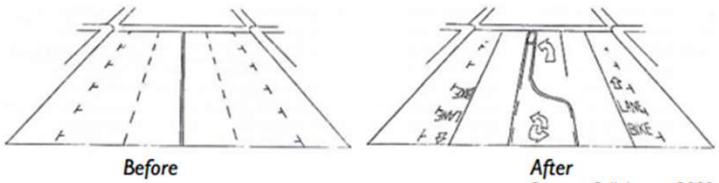
7

CASE STUDY: ROAD DIET (SAN FRANCISCO, CA)

Why a Road Diet?

- Community recognized need to accommodate other road users
- Large number of pedestrian attractors led to conflicts
- Bicycle community wanted dedicated bicycle lanes

Figure 1 – Drawings of Valencia Street Before and After the Bike Lanes



Source: Sallaberry, 2000, p. 20

8

CASE STUDY: ROAD DIET (SAN FRANCISCO, CA)

Problem/Background

- Valencia Street part of San Francisco's Mission District
- 1.8 miles long
- 4-lane road with 22,000 ADT
- High pedestrian, bicycle, bus activity but lacked supporting infrastructure

Before

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CASE STUDY: ROAD DIET (SAN FRANCISCO, CA)

Details

- In 1999, 4 lanes restriped to 2 lanes + bicycle lanes and center turn-lane
  - Trial basis
- Speed limit lowered from 30 to 25 mph
- Signal timing altered to minimize loss of capacity
- Made permanent after year trial
- Initial cost: $130,000
  - Paint and sign work, & labor spent writing an impact report

Before

After

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CASE STUDY: ROAD DIET (SAN FRANCISCO, CA)

Results

- Success
  - No real change in ADT
  - Large increase in cycling & pedestrian activity
  - Reduction in collisions
  - Aided revitalization of area
- Four years after, a survey of business owners along Valencia Street found general support*
  - 65% felt bicycle lanes had positive impact on their business, only 4% said it had negative impact
  - 65% would support more traffic calming

**Source: Emily Drennen, "Economic Effects of Traffic Calming on Urban Small Business"*

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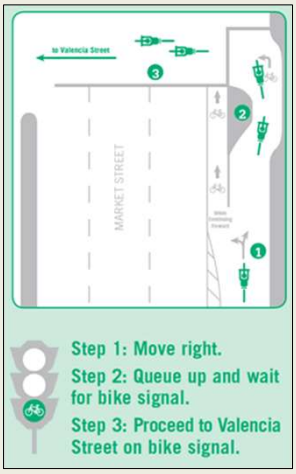
CASE STUDY: ROAD DIET (SAN FRANCISCO, CA)

Results

- City implemented more changes in 2010:
  - sidewalks and bike-lanes widened
  - bulb outs, streets trees, lighting, and public art added
- Became place to try new treatments such as bicycle "green wave" and bicycle bays

Sign indicating the street is set for "green wave" speeds



Sign illustrating a bicycle bay

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CASE STUDY: ROAD DIET (GENNESSEE COUNTY, MI)

Why Road Diets?

- Complete Streets program launched in 2009
- Systemwide assessment of every four-lane road in the County

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CASE STUDY: ROAD DIET (GENNESSEE COUNTY, MI)

Details

- Initially targeted volumes of 6,000 to 8,000 vehicles per day (low-hanging fruit)
- Eventually moved toward volumes up to 15,000 vehicles per day
- Simple re-striping during trial period to keep costs low and test application
- Comprehensive stakeholder engagement and public involvement phase

The GCMPC stated that...

"Road Diets are seen as treatments that can be used to keep a downtown area 'current' and follow the national [livability] trends."

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CASE STUDY: ROAD DIET (GENNESSEE COUNTY, MI)

Results

- Evaluation of seven projects demonstrated reduction numerous crash types (using data from 1996 to 2007)

Average Annual Crash Reduction Rates After Road Diets in Genesee County								
Crash Type	Davison Rd	Dupont St	Flushing/Fifth Ave	ML King Jr Blvd	Miller Rd	University Ave	Vienna Rd	OVERALL
Head-on	-17%	-31%	-100%	129%	-43%	-100%	-62%	-32%
Head-on Left Turn	-28%	-74%	-100%	-41%	-37%	-100%	-24%	-58%
Rear End	-16%	-54%	-29%	-46%	-29%	-53%	-21%	-35%
Rear End Left Turn	92%	-79%	-100%	-17%	-37%	-100%	-13%	-36%
Side Swipe Same Side	-18%	-56%	-48%	-42%	-15%	-31%	-20%	-33%
Side Swipe Opposite Side	-31%	-5%	-100%	-17%	-33%	-100%	-55%	-39%
All Non-alcohol & Non-deer	-16%	-47%	-42%	-38%	-23%	-35%	-26%	-32%

**Source: FHWA "Road Diet Case Studies"*
https://safety.fhwa.dot.gov/road_diets/case_studies/roaddiet_cs.pdf

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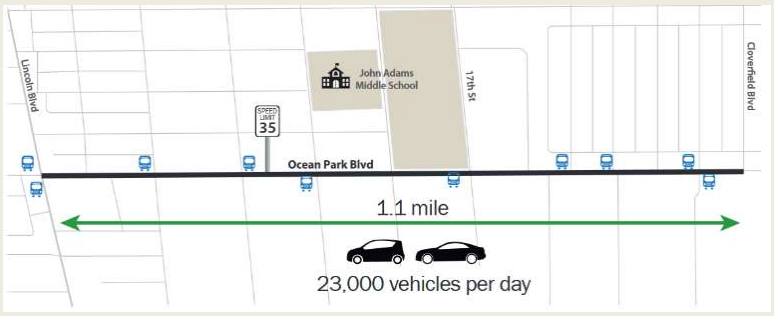
CASE STUDY: ROAD DIET (SANTA MONICA, CA)

Why Road Diet?

- Safety concerns related to crossings and high speeds, proximity to school
- Past efforts had little impact on speed reduction

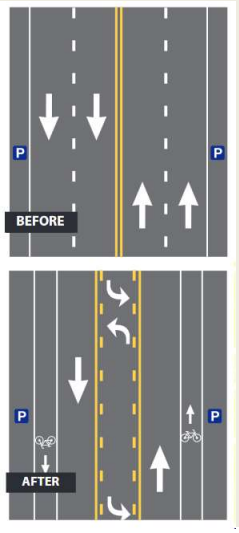


16

CASE STUDY: ROAD DIET (SANTA MONICA, CA)

Details

- Challenging site due to high volume and presence of a transit route
- Goal to maintain on-street parking as part of conversion
- Speed limit is 35 mph (lowered to 25 mph when children are present)
- High concentration of pedestrians due to elementary school and middle school



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CASE STUDY: ROAD DIET (SANTA MONICA, CA)

Results

- Nine-month evaluation showed a 65% reduction in crashes. Injury collisions went down by 60%.

Ocean Park Boulevard looking east at 16th Street

Ocean Park Boulevard looking east at 18th Street marked crosswalk and bicycle lane

**Source: FHWA "Road Diet Case Studies"*
https://safety.fhwa.dot.gov/road_diets/case_studies/roaddiet_cs.pdf

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ROAD DIET / LANE REDUCTION: SAFETY

- One of the FHWA Proven Safety Countermeasures
- Road diets can:
  - Reduce rear-end and left-turn crashes
  - Reduce right-angle crashes
  - Reduce crossing distance for pedestrians
  - Create space for other treatments (e.g. refuge islands, bike lanes, parking)
  - Calm traffic and reduce speeds

https://highways.dot.gov/safety/proven-safety-countermeasures/road-diets-roadway-configuration

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ROAD DIET / LANE REDUCTION: SAFETY

- Narrowing the roadway cross section from four lanes to three lanes (two through lanes with center turn lane) has been associated with a 29% decrease in all crashes.

Countermeasure: Road diet (Convert 4-lane undivided road to 2-lanes plus turning lane)

CMF	CRF(%)	Quality	Crash Type	Crash Severity	Roadway Type	Area Type
0.71 [B]	29	★★★★★	All	All	Minor Arterial	Urban

Research

- Harkey, D., Srinivasan, R., Baek, J., Council, F. M., Eccles, K., Lefler, N., ... & Bonneson, J. A. (2008). Crash Reduction Factors for Traffic Engineering and ITS Improvements. *Final Report National Cooperative Highway Research Program (NCHRP) Project*, 17-25.

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ROAD DIET / LANE REDUCTION: SAFETY

- Converting roadway cross-section from four lanes to three lanes (two through lanes with center turn lane) has been associated with a 37% decrease in all crashes.
  - Urban areas

Countermeasure: Narrow cross section (4 to 3 lanes with two way left-turn lane)

CMF	CRF(%)	Quality	Crash Type	Crash Severity	Roadway Type	Area Type
0.63	37	★★★☆☆	All	All	Not specified	Urban

Research

- Gates, T. J., Noyce, D. A., Talada, V., and Hill, L., "The Safety and Operational Effects of "Road Diet" Conversion in Minnesota." 2007 TRB 86th Annual Meeting: Compendium of Papers CD-ROM, Vol. TRB#07-1918, Washington, D.C., (2007)

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ROAD DIET / LANE REDUCTION: SAFETY

- Converting roadway cross-section from four lanes to three lanes (two through lanes with center turn lane) has been associated with a 53% decrease in all crashes.
  - Suburban roadways

CMF	CRF(%)	Quality	Crash Type	Crash Severity	Area Type	Reference
0.47	53	★★★★☆	All	All	Suburban	Persaud et. al, 2010

Research

- Persaud, B., Lana, B., Lyon, C., and Bhim, R. "Comparison of empirical Bayes and full Bayes approaches for before–after road safety evaluations." Accident Analysis & Prevention, Vol. 42, Issue 1, pp. 38-43 (2010)

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COLLISION REDUCTIONS FROM SEATTLE ROAD DIETS

Data on Street Conversions - Seattle, Washington

ROADWAY SECTION	DATE CHANGE	ADT (BEFORE)	ADT (AFTER)	CHANGE	COLLISION REDUCTION
Greenwood Ave. N, from N 80th St. to N 50th St.	April 1995	11872	12427	4 lanes to 2 lanes plus TWLTL plus bike lanes	24 to 10 58%
N 45th Street in Wallingford Area	December 1972	19421	20274	4 lanes to 2 lanes plus TWLTL	45 to 23 49%
8th Ave. NW in Ballard Area	January 1994	10549	11858	4 lanes to 2 lanes plus planted median with turn pockets as needed	18 to 7 61%
Martin Luther King Jr. Way, north of I-90	January 1994	12336	13161	4 lanes to 2 lanes plus TWLTL plus bike lanes	15 to 6 60%
Dexter Ave. N, East side of Queen Anne Area	June 1991	13606	14949	4 lanes to 2 lanes plus TWLTL plus bike lanes	19 to 16 59%
24th Ave. NW, from NW 85th St. to NW 65th St.	October 1995	9727	9754	4 lanes to 2 lanes plus TWLTL	14 to 10 28%
Madison St., from 7th Ave. to Broadway	July 1994	16969	18075	4 lanes to 2 lanes plus TWLTL	28 to 28 0%
W Government Way/Gilman Ave. W, from W Ruffner St. to 31st. Ave. W	June 1991	12916	14286	4 lanes to 2 lanes plus TWLTL plus bike lanes	6 to 6 0%
12th Ave., from Yesler Way to John St.	March 1995	11751	12557	4 lanes to 2 lanes plus TWLTL plus bike lanes	16 to 16 0%
				Total	185 to 122 34%

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COLLISION REDUCTIONS FROM VIRGINIA ROAD DIETS

- Evaluation of 36 segment and 39 intersection sites where road diets had been implemented between 2009-2018
- Segment findings:
  - CMF of 0.62 (62 percent reduction) for total crashes
  - CMF of 0.36 (36 percent reduction) for fatal and injury crashes
- Intersection findings:
  - CMF of 0.65 (65 percent reduction) for total crashes
  - CMF of 54 (54 percent reduction) for fatal and injury crashes

Lim, L., & Fontaine, M. D. (2022). Development of Road Diet Segment and Intersection Crash Modification Factors. Transportation Research Record, 2676(5), 660–671. https://doi.org/10.1177/03611981211069074

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LONG-TERM PERFORMANCE AND IMPACT OF ROAD DIETS IN VIRGINIA

- Virginia DOT compiled an inventory of its road diet projects and assessed their broader impact on transportation and safety.
- Inventory reflected 66 road diet projects implemented since 2010, representing 39 miles of roadway.
- Survey of agencies involved in the projects found that:
  - Road diets were incorporated into larger safety and transportation initiatives (e.g. complete streets).
  - The projects did not, generally, create traffic congestion problems.

Ohlms, P., Dougald, L., and MacKnight, H. (2022). How's That Diet Working: Performance of Virginia Road Diets. Virginia Transportation Research Council. Federal Highway Administration. Report Number FHWA/VTRC 20-R19.

25

MORE RESULTS FROM ROAD DIET EVALUATIONS

Rhode Island

- Empirical Bayes before/after evaluation
- 29% reduction in total crashes
- 37% reduction in fatal and injury crashes

Zhou, Y., Himes, S., Le, T., Gooch, J., Northup, K., & Pavao, P. (2022). Safety Effectiveness of the Road Diet Treatment in Rhode Island. Transportation Research Record, 2676(7), 24–31. https://doi.org/10.1177/03611981221076433

Knoxville, Tennessee

- 50 to 55% decrease in crashes involving vulnerable road users
- 16% decrease in peak hour traffic volume
- Five-fold increase in land value for parcels along one road diet corridor.

Aryal, S., Cherry, C., Brakewood, C., Han, L., Sexton, E., Nelson, J., and Cate, M. (2021). Evaluating Performance and Benefits of Road Reconfigurations in Tennessee. Tennessee Department of Transportation. RES2020-16.

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BEFORE AND AFTER CRASH DATA

Table 1. Study sites and crashes used in the analysis.

CITY	NUMBER OF SITES		NUMBER OF CRASHES	
	Road Diet	Comparison*	Road Diet	Comparison*
Bellevue, WA	1	2	134	307
Mountain View, CA	1	2	20	134
Oakland, CA	2	5	443	2,067
San Francisco, CA	2	5	450	1,339
Seattle, WA	5	9	969	4,485
Sunnyvale, CA	1	2	52	224
TOTAL	12	25	2,068	8,556

* Each road diet had one or more comparison sites.

Source: Summary Report: Evaluation of Lane Reduction "Road Diet" Measures and Their Effects on Crashes and Injuries FHWA-HRT-04-082

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BEFORE AND AFTER CRASH DATA

Table 2. Summary of findings.

ANALYSIS CATEGORY	COMPARISON			
	Road Diets Before vs. After	Comparison Sites Before vs. After	Before Period Road Diets vs. Comparison Sites	After Period Road Diets vs. Comparison Sites
Crash frequency	Reduction in after period	No change	No difference	Road diets lower
Crash rates	No change	No change	Road diets lower	Road diets lower
Crash severity	No change	No change	No difference	No difference
Crash type	No change	No change	Difference: 1. Road diets had a higher percentage of angle crashes. 2. Road diets had a lower percentage of rear-end crashes.	Difference: 1. Road diets had a higher percentage of angle crashes. 2. Road diets had a lower percentage of rear-end crashes.

Source: Summary Report: Evaluation of Lane Reduction "Road Diet" Measures and Their Effects on Crashes and Injuries FHWA-HRT-04-082

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WHEN

- The roadway has a moderately high density of driveways and other uncontrolled access
- Crash severities are high
- Speeding contributes to safety problems
- Pedestrians and others crossing/accessing the main corridor are affected by the higher exposure of crossing
- Multiple lanes exist on each approach
- No center turn lane exists
- Frequent crash types exist that are most amenable to reduction through a road diet (opposing left-turn, sideswipe, pedestrian, rear-end)
- Complete streets policy direction with focus on active transportation comfort

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ROAD DIET IMPLEMENTATION CONSIDERATIONS

Road Diet Implementation Considerations

	Maximum Volume, ADT	Maximum Peak Volumes, DHV	Minimum Lane Width, ft			Crash History	Vehicle Speed	Number of Lanes	Turning Volumes	Freight Usage	Presence of Transit	Presence of Bicycles	Travel Time or LOS	Accessibility
			Through	Left/Right	Bicycle									
Chicago DOT	●	●	●	●	●	●			●					
Seattle DOT	●					●	●	●		●	●		●	●
City of Lansing, MI	●		●	●	●									
Michigan DOT						●			●		●		●	●
Delaware Valley Regional Planning Commission	●								●				●	
City of Las Vegas, NV							●					●		●
Genesee County (MI) Metropolitan Planning Commission	●		●			●	●							

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UNDERSTANDING TRADEOFFS

- Consider how the road diet reconfiguration may impact other street functions in both positive and negative ways
- Table taken from the Road Diet Desk Reference (FHWA)

Summary: Road Diet Installation Observations

Road Diet Feature	Primary/Intended Impacts	Secondary/Unintended Impacts	
		Positive	Negative
Bike Lanes	• Increased mobility/safety for bicyclists, higher bicycle volumes • Increased comfort level for bicyclists	Increased property values	Could reduce parking, depending on design
Fewer Travel Lanes	Reallocate space for other uses	• Pedestrian crossings are easier, less complex • Can make finding a gap easier for cross-traffic	• Transit vehicles/mail trucks can block traffic when stopped • May reduce capacity • Potential to negatively affect maintenance budgets if agency's funding is tied to lane-miles
Two-Way Left Turn Lane	Remove left-turning traffic from through lane	Makes efficient use of limited roadway area	Could be difficult for drivers to access left turn lane if demand for left turns is too high
Pedestrian Refuge Island	Increased mobility and safety for pedestrians	Prevents illegal use of the TWLTL to pass slower traffic or access and upstream turn lane	May create issues with snow removal
Buffers (grass, concrete median, delineators)	Provide barriers and space between travel modes	• Increases comfort level for bicyclists • Barriers can prevent users entering a lane reserved for another mode	Grass and delineator buffers will necessitate ongoing maintenance

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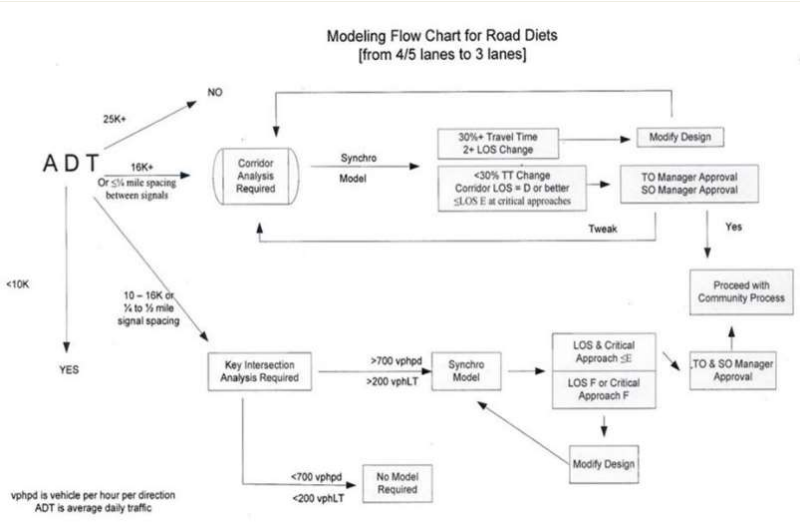
CITY OF SEATTLE



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RESEARCH

- **Road Diet Conversions: A Synthesis of Safety Research**
  - May 2013 Libby Thomas, Senior Associate, UNC HSRC
  - FHWA DTFH61-11-H-00024
- Each potential road diet should be vetted on a case by case basis.
- Case study and modeling results suggest
  - Caution warranted when volumes approach 1,700 vehicles in the peak hour or range of 20,000 to 24,000 ADT
  - (HSIS, 2010; Knapp and Giese, 2001; Welch, 1999).

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GUIDELINES

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SAFE TRANSPORTATION FOR EVERY PEDESTRIAN (STEP)

- Road diets are one of several countermeasures included in the STEP guidance
- Candidate treatment for four-lane roads without median

https://www.fhwa.dot.gov/innovation/everydaycounts/edc_4/step.cfm

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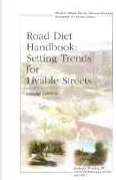
ROAD DIET HANDBOOK: SETTING TRENDS FOR LIVABLE STREETS

- Jennifer A. Rosales, P.E.
- A comprehensive guide for planners, engineers, & designers to help make decisions on applicability of road diets.
- Contains information on:
  - Planning
  - Analysis
  - Design
  - Implementation
  - Results of previous research
  - Significant gaps in the field
  - Analyses of safety and traffic operations
  - Livability considerations
  - Case study evaluations
  - Lessons learned from experience
  - Guidelines for identifying & evaluating potential road diet sites & typical cross-sections
  - Overall guidelines for implementation.



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KENTUCKY TRANSPORTATION CENTER GUIDELINES FOR ROAD DIET CONVERSIONS

- Looks at operational and safety aspects to assist in preliminary determination whether a road diet is appropriate
- Cross-section designs
- Transition to and from the road diet section
- Flow chart for determining appropriate action
- Identified gap in Rosales Road Diet guidelines
  - Did not provide specific guidance regarding volumes or left-turn percentages indicating when such a project could result in improved operational and safety conditions

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KENTUCKY TRANSPORTATION CENTER GUIDELINES FOR ROAD DIET CONVERSIONS

Typically, road diet conversions will operate at acceptable levels as long as the signalized intersections do not present any operational problems (Welch 1999)

Table 1 Level of service and maximum sum of critical lane volumes at signalized intersections

Level of Service	Traffic Flow Condition	Volume to Capacity Ratio	Critical Lane Volumes (vph)		
			Two-Phase	Three-Phase	Multiphase
A	Stable	<.6	900	855	825
B	Stable	<.7	1050	1000	965
C	Stable	<.8	1200	1140	1100
D	Unstable	<.85	1275	1200	1175
E	Capacity	<1.0	1500	1425	1375

Source: Messer and Fambro, 1977

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KENTUCKY TRANSPORTATION CENTER GUIDELINES FOR ROAD DIET CONVERSIONS

DELAY COMPARISON 3-4 LANES WITH SIDE STREET VPH

Table 2 Range of delay differences by side street volume

Side Street (vph)	Min (sec)	Max (sec)	Avg (sec)
300	-2.4	3.4	0.98
700	-4.5	3.6	0.50
1300	-9.5	15.5	0.94

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KENTUCKY TRANSPORTATION CENTER GUIDELINES FOR ROAD DIET CONVERSIONS

MAIN STREET SIDE STREET SIGNALIZED INTERSECTION GUIDELINES

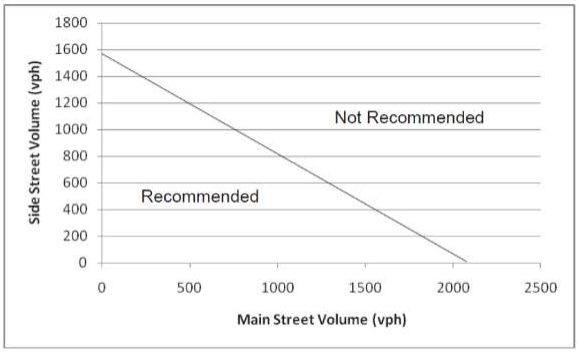

Figure 9 Guideline for operational performance at signalized intersections

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KENTUCKY TRANSPORTATION CENTER GUIDELINES FOR ROAD DIET CONVERSIONS

QUEUE DIFFERENCE 3-4 LANES WITH SIDE STREET VPH

Table 3 Range of average queue differences by side street volume

Side Street (vph)	Min (veh)	Max (veh)	Avg (veh)
300	-1	1	0.07
700	-2	2	0.03
1300	-3	3	0.30

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KENTUCKY TRANSPORTATION CENTER GUIDELINES FOR ROAD DIET CONVERSIONS

UNSIGNALIZED INTERSECTIONS

- Delay along major road very small
  - Less than 4.5 sec/veh
- 3-lane option slightly higher delays than 4-lane
  - Difference very small
    - Most < 2.5 sec/veh
    - 56% delay difference being < 1 sec/veh
- Significant differences in delays on side-street approaches
- Delays on side-street for 3-lane road diet conversion were **smaller** than 4-lane road

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ROAD DIET CANDIDATE GUIDELINES

- ADT (Road Diet Candidate)
  - 20,000 or less[1]
  - 23,000 or less[2]
- Peak hourly volume (Road Diet Candidate)
  - 1,700 or less[1]
  - 1,500 – 1750 or less depending on[2]:
    - Percentage of left turns at intersection
    - VPH on side street
- Case with higher ADT
  - Lake Washington Blvd. Kirkland, WA[3]
    - Initial volume of 23,000 vehicles per day
    - Increased nearly 26,000 after conversion
    - During one period about 30,000 vehicles per day

1. Rosales 2. Kentucky 3. Burden and Lagerwey (1999)

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PEAK HOURLY VOLUME

- Probably feasible at or below 750 vehicles per hour per direction (vphpd) during the peak hour
- Consider cautiously between 750 – 875 vphpd during the peak hour
- Feasibility less likely above 875 vphpd during the peak hour and expect reduced arterial LOS

Guidelines for the conversion of urban four-lane undivided road ways to three-lane two-way left-turn facilities. Sponsored by the Office of Traffic and Safety of the Iowa Department of Transportation, CTRE Management Project 99-54

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CONSIDERATIONS

- What are the non-intersection turning volumes and patterns
  - Driveway density
  - Left turns in and out
- Are there frequent-stop and slow-moving vehicles?
  - Buses
  - Mail
  - Double parked vehicles
  - Buggies
  - Delivery trucks
  - Agriculture
- Is there a lot of weaving?
- What are the speeds?

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CONSIDERATIONS

- Safety
  - Crash rate along corridor
  - What types of crashes are occurring?
- What's the level of pedestrian & bicycle activity?
- Commercial reinvestment areas
- Economic enterprise zones
- Historic streets
- Scenic roads
- Entertainment districts
- Main streets

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INTERSECTIONS

- Signal timing or phasing changes at intersections to optimize operations and safety benefits
- Roundabouts

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SIMULATION SOFTWARE

- Synchro (HCM)
- CORridor SIMulation (CORSIM)
- VISSIM
- Safety Surrogate Assessment Model (SSAM)

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DESIGN CONSIDERATIONS

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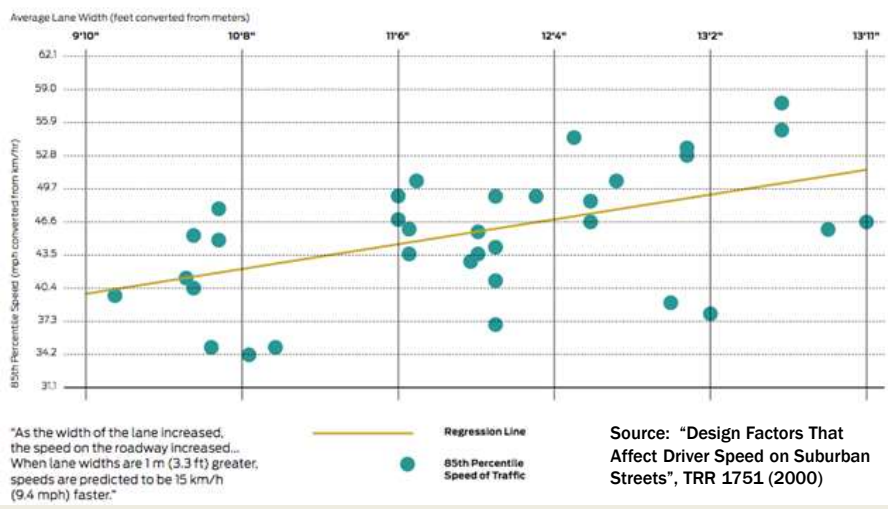
WIDER LANES = HIGHER SPEEDS



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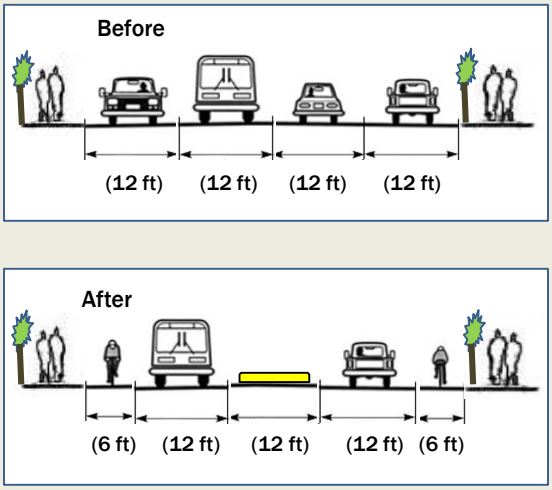
CROSS SECTIONS 48 FEET

- 48 feet curb-to-curb with no parking
- Sidewalks buffered in the Road Diet
- Space for pedestrian island



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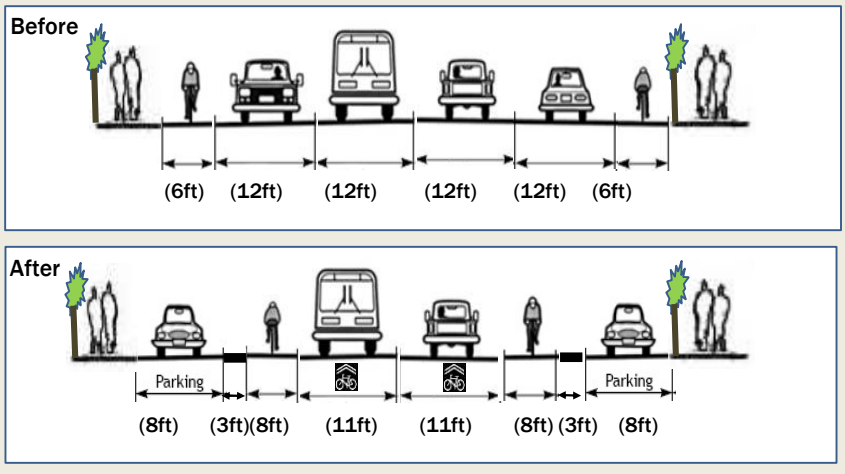
CROSS SECTIONS 60 FEET



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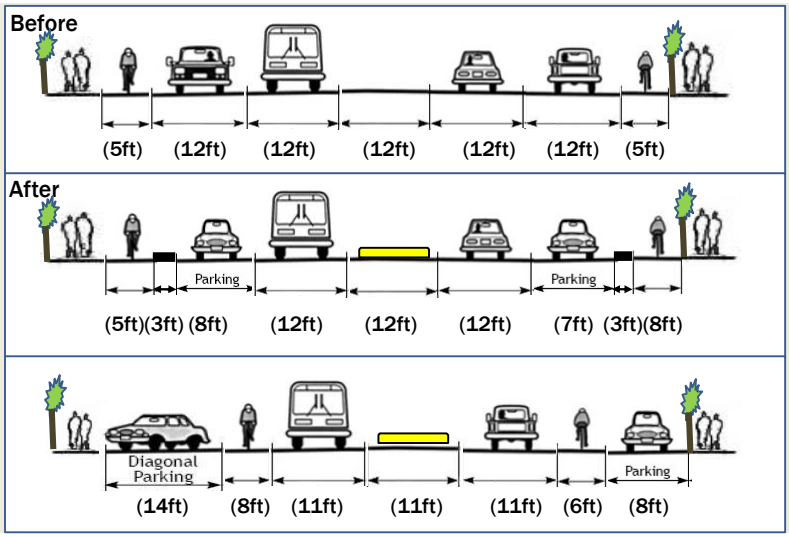
CROSS SECTIONS 70 FEET



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TYPICAL INTERSECTION TREATMENTS

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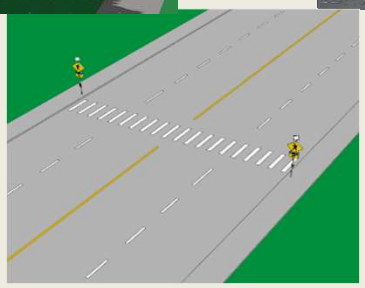
OPPORTUNITY TO ENHANCE CROSSWALKS



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OPPORTUNITY TO WIDEN SIDEWALKS

- Although higher cost sidewalks can be widened

Washington D.C
Sherman Ave. NW

- Lower cost option NYC Low Cost sidewalk widening with delineator posts

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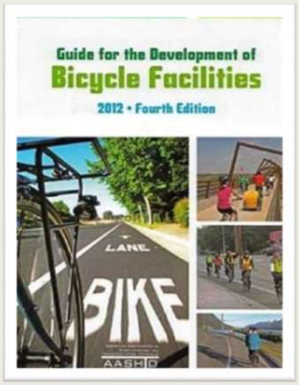
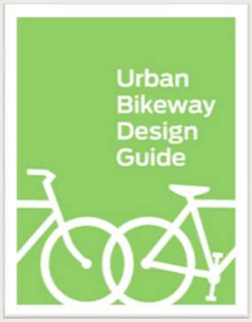
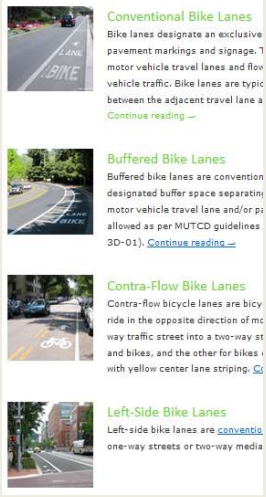
BIKE FEATURES





http://nacto.org/cities-for-cycling/design-guide/

Warning: Check traffic control against the MUTCD



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INTERSECTION CROSSING MARKINGS

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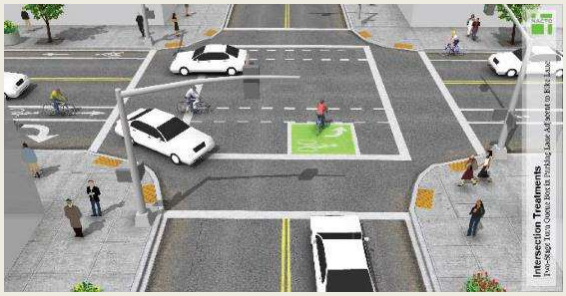
TWO-STAGE TURN QUEUE BOXES

Parking Lane Configuration



Interim Approval

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BACK IN ANGLED PARKING

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BACK-IN ANGLE PARKING

Pros

- Better visibility getting back into traffic
  - See cars and bicyclists
- More vehicle parking spaces than parallel
- Open car door(s) lead kids to sidewalk
- Loading items into trunk is safer

Cons

- Some people will need practice
- Furniture zone items might get hit
- Exhaust from running cars at sidewalk
  - Consider outdoor café's

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BACK-IN ANGLED PARKING PUBLIC EDUCATION AUSTIN TX

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COST

- Road diets can be low cost if planned in conjunction with reconstruction or simple overlay projects, since a road diet mostly consists of restriping
  - May involve other costs such as signal head relocation

63

BEST PRACTICE

- Know well in advance of when road reconstruction and overlay projects will be initiated to evaluate for Road Diet.
- Obtain input from the community stakeholders, and ensure the appropriate elements are included in the project.
- Classic four-to-three-lane Road Diet is very compatible with single-lane roundabouts

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PRIORITIZATION OF ROAD DIET PROJECTS

- Placeholder hidden slide
- To be filled in when someone can provide information for an agency that has a good established system for prioritizing road diets
- Also thinking of adding a systemic approach methodology

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CASE STUDY

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CASE STUDY
NICKERSON STREET, SEATTLE, WA

Nickerson Street Before:

Nickerson Street After:

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PROJECT GOALS

- Improve pedestrian safety
- Add marked crosswalks
- Reduce exposure to multiple threat collisions
- Increase driver compliance with the posted speed limit
- Reduce speed

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SPEED

85th Percentile Speed between 3rd Avenue W and 6th Avenue W *Speed in miles per hour*			
	Before	After	Change
Westbound	40.6	33.1	-18%
Eastbound	44.0	33.3	-24%

Speeders *Percent driving over the speed limit*			
	Before	After	Change
Westbound	88%	32%	-64%
Eastbound	91%	34%	-63%

Top End Speeders *Percent 10+ mph over the speed limit*			
	Before	After	Change
Westbound	17%	1.4%	-92%
Eastbound	38%	1.5%	-96%

69

COLLISIONS

- Two new marked crosswalks at Dravus St & 11th Ave W
- Preliminary collision statistics show a substantial reduction in collisions after the project was completed

Change in Number of Collisions on Nickerson from 13th Ave W to N Florentia St after Rechannelization		
5-Year Average	One Year Post-Project	Percent Change
10-18-2004 to 10-18-2009	10-18-2010 to 10-18-2011	
33.6	**26**	-23%

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ADT

- 2009 (Before)
  - Approximately 18,500 vehicles per weekday between 3rd Ave W and 6th Ave W.
- August 2011 (After)
  - Approximately 18,300 vehicles recorded in at the same location

Nickerson Traffic Volume			
	Before	After	Change
AM Peak	816	733	-10%
PM Peak	915	927	+1%
Average Weekday	18,563	18,364	-1%

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FREIGHT USE

- Freight vehicles of all types on Nickerson St rose slightly after the Road Diet
  - Trucks still account for about 5% of vehicles
- Large trucks account for about 2% of total traffic
  - Some large trucks continue to use Nickerson St both as a through route and to access the Queen Anne neighborhood via 3rd Ave W

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PROJECT OUTCOMES

- Add two marked crosswalks
  - Improved all marked and unmarked crosswalks on the corridor
- Collision reduction in the first year
  - 2009-2011: 23% reduction
- Significant speed reduction
  - Dramatically reduced percent of drivers traveling > 10 mph over speed limit
  - Percent drivers traveling over the speed limit reduced more than 60%
  - Top-end speeders reduced by 90%

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CASE STUDY: ROAD DIET (SEATTLE, WA)

Problem/Background

- 1.2 mile road
- High motorist speeds
- Connects regional trail to park
- 13,000 ADT
- Numerous bus routes
- 8 schools, 2 libraries and 2 parks within 5 blocks

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CASE STUDY: ROAD DIET (SEATTLE, WA)

Why a Road Diet?

- Uncontrolled, marked crosswalks needed to be changed due to new guidelines
- Aggressive speeders, high crash rates
- Seattle Bicycle Master Plan recommended climbing lanes and shared lane markings
- Repaving provided leveraging opportunity

Before

75

CASE STUDY: ROAD DIET (SEATTLE, WA)

Details

- Road restriped to provide 2 thru lanes, a two-way left turn lane & bike lanes
- Crosswalks were restored if they met guidelines

Before

After

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CASE STUDY: ROAD DIET (SEATTLE, WA)

Results

- Speeding reduced
- Total collisions declined 14%, injury collisions 33%
- Pedestrian collisions declined 80%
- Bicycle volume increased 35%
- Traffic did not divert to neighborhood streets
- Peak hour capacity maintained

After

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QUESTIONS / RESOURCES

- *Road Diet Handbook: Setting Trends for Livable Streets*
  - *(Rosales)*
- Guidelines for Road Diet Conversions
  - Kentucky Transportation Center
  - http://uknowledge.uky.edu/ktc_researchreports/16/
- Road Diet Information Guide
  - FHWA
  - https://safety.fhwa.dot.gov/road_diets/guidance/info_guide/
- PEDSAFE Case Studies
  - http://www.pedbikesafe.org/PEDSAFE/casestudies.cfm?op=C&subop=b&CM_NUM=19
- AASHTO Guide for the Development of Bicycle Facilities (2012 Edition)
  - https://bookstore.transportation.org/collection_detail.aspx?ID=116
- NACTO Urban Bikeway Design Guide
  - https://nacto.org/publication/urban-bikeway-design-guide/

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High speed multilane arterials

Designing for Bicyclist and Pedestrian Safety

PEDESTRIAN & BICYCLIST
FOCUSED APPROACH TO SAFETY

U.S. Department of Transportation
Federal Highway Administration

ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE

1

Module Objectives

- Characteristics of high speed multilane arterials
  - Defining high speed and multilane
  - Development and land use patterns
  - Complex intersections with long distance between crossings
- Common problems on multilane arterials
  - Symptoms of high speed multilane arterials
  - Safety risk factors for pedestrians, bicyclists, and motorists
- Design solutions and countermeasures
  - Access management and lane reduction
  - Enhancing crossings (Medians, RRFBs, PHBs, signals)
  - Lighting
  - Speed management

2

Defining "high speed" and "Multilane"

- For the purposes of this module:
  - High Speed: Posted or operating speeds exceeding 35 miles per hour
  - Multilane: More than three lanes, but primarily:
    - Four lane undivided or divided (median)
    - Five lane (with two-way left turn lane)
    - Six lane (divided with median)

3

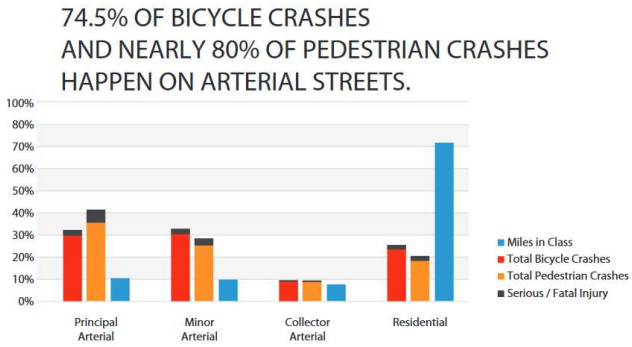
Importance of designing for nonmotorized road users

- High speed, multilane arterials are traditionally auto-focused
- Decisions prioritize level of service and capacity, not safety or comfort of peds or bikes
- These corridors account for sizable share of crashes, but can be areas where pedestrians and bicyclists are dismissed as secondary road users

4

Importance of designing for nonmotorized road users

- In Los Angeles, pedestrian crashes on arterials were seven times more deadly than those on non-arterials
- In Seattle, most crashes involving bikes and peds occur on arterials



Taken from Seattle's Bicycle and Pedestrian Safety Analysis

5

Designing for Context

- Street design isn't a one-size-fits-all approach
- Land use, user needs and other factors should drive decision-making, and design approaches should be flexible
- NCHRP 855 developed An Expanded Functional Classification System for Highways and Streets that builds upon existing AASHTO guidance, as well as other design guides from FHWA and NACTO

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NCHRP Report 885

- Expanded Functional Classification System (FCS) establishes a framework to consider all user needs based on roadway and context

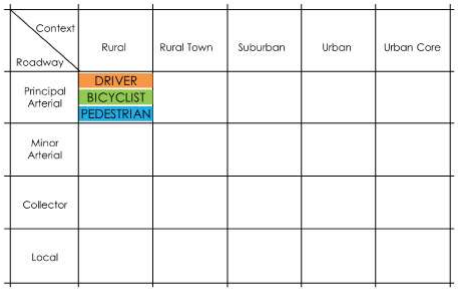


Figure 4. Expanded FCS framework user matrix.

7

NCHRP Report 885

- Expanded Functional Classification System (FCS) establishes a framework to consider all user needs based on roadway and context

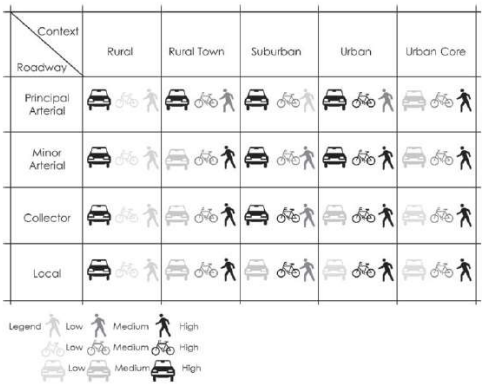
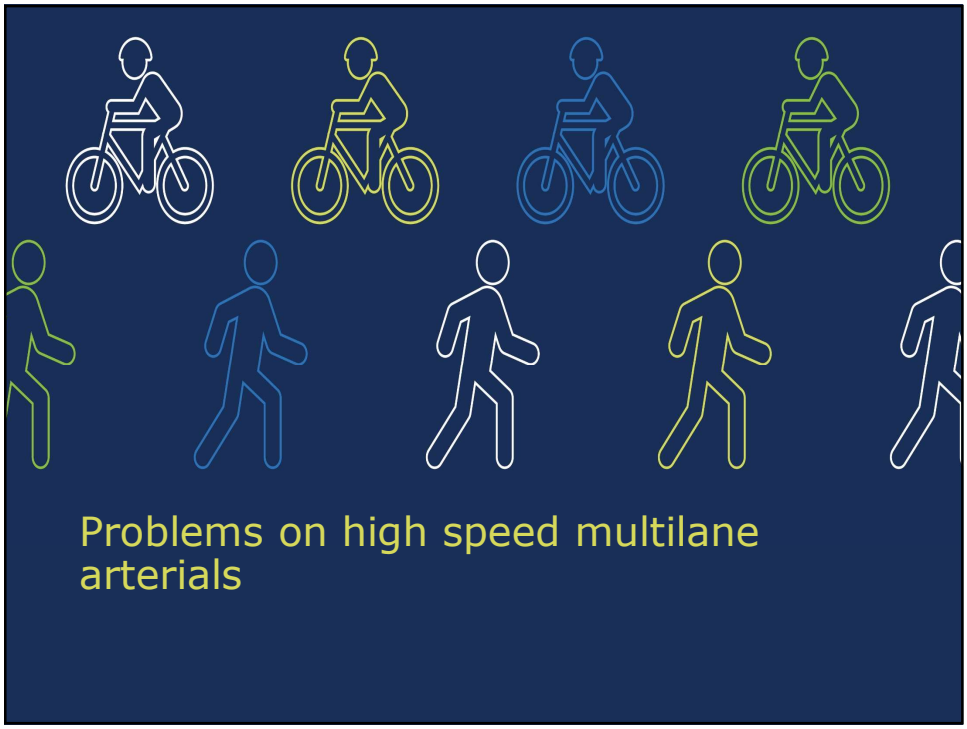


Figure 5. Typical user priorities in the Expanded FCS.

8



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LONG DISTANCE BETWEEN SIGNALS

Destinations are further apart, and signals are spaced according to vehicle needs

Resulting intersections handle more traffic and aren't spaced for bikes/peds

Decision to find a gap or walk/bike long distances to nearest intersection

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COMPLEX INTERSECTIONS

- Reduced signal density increases signal complexity
- Longer cycle lengths, more delay
- Complex crossing maneuvers for bicyclists, pedestrians

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FEW GAPS IN TRAFFIC

- Platooning of vehicles across multiple lanes means that pedestrians and bicyclists have a more difficult time finding gaps
- Crossings are especially difficult if there is no median to break crossing into two parts

12

CONFLICTS AT DRIVEWAYS

Development patterns lead to more driveways

Driveway designs de-emphasize sidewalk

Undivided roads with more driveways results in more opportunities for conflicts

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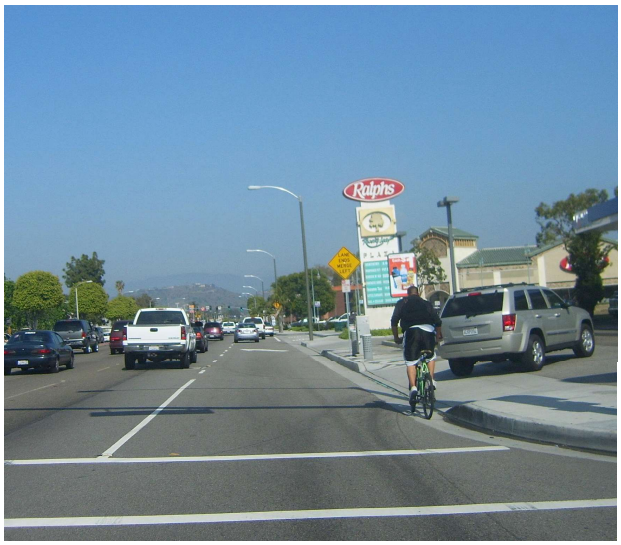
LITTLE SEPARATION FOR BICYCLISTS



These corridors often do not have bicycle facilities

Bicyclists are forced to ride far to the right or in the gutter pan

Many may resort to riding on the sidewalk

Not comfortable for most adults – LTS 4

Even bike lanes on these corridors are not comfortable – LTS 3

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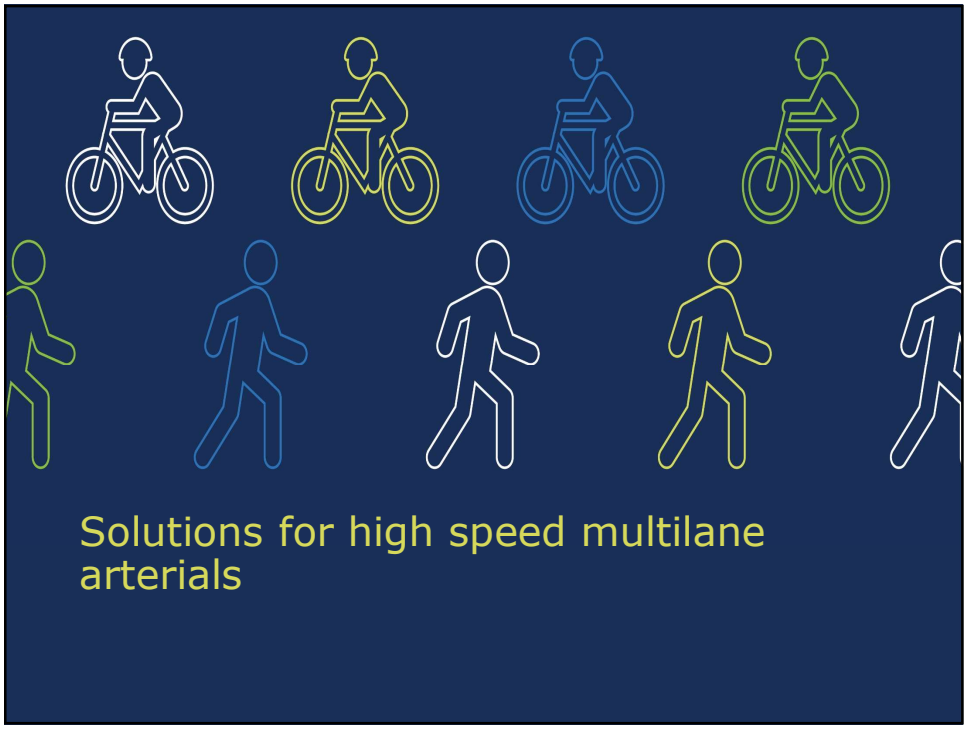

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Solutions for high speed multilane arterials

Speed Management

Bicycle Facilities

Crossing Enhancements

Lighting Improvements

Road Diets

Signal Improvements

16

Speed management

- Signal Timing
- Driver Speed feedback signs
- Automated Speed Enforcement (where permitted by State Law)
- Speed Feedback to Trigger Signals
- Roundabouts
- Other geometric improvements to reduce design speed

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SPEED MANAGEMENT

- Coordinated signals can be timed to manage progression speed of traffic
- More challenging as signal density decreases
- San Francisco and Portland have both had success lowering speeds through signal timing changes

Signal Timing

Driver Speed feedback Signs

Automated Speed Enforcement

Roundabouts

Other geometric improvements to reduce design speed

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SPEED FEEDBACK SIGNS

- Dynamic speed feedback signs can provide reminders to drivers
- Los Angeles uses speed feedback signs to trigger downstream red lights for speeding drivers

Signal Timing

Driver Speed Feedback Signs

Automated Speed Enforcement

Roundabouts

Other geometric improvements to reduce design speed

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AUTOMATED ENFORCEMENT

- Can be controversial, but effective in reducing speeds and crashes
- Scan of 90 studies found 20 to 25 percent reduction in injury crashes
- Be careful to roll programs out carefully and be transparent about where funding goes

Signal Timing

Driver Speed feedback signs

Automated Speed Enforcement

Roundabouts

Other geometric improvements to reduce design speed

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ROUNDABOUTS

- Reduce speeds and conflicts at intersections using roundabouts
- Especially useful at transition zones, such as ramps from interstates where speeds change quickly

Signal Timing

Driver Speed feedback signs

Automated Speed Enforcement

Roundabouts

Other geometric improvements to reduce design speed

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GEOMETRIC DESIGN

- A host of other geometric improvements have been shown to reduce speeds, such as:
  - Curb extensions and bulb-outs
  - Reduce curb radius

Signal Timing

Driver Speed feedback signs

Automated Speed Enforcement

Roundabouts

Geometric Design to Reduce Speeds

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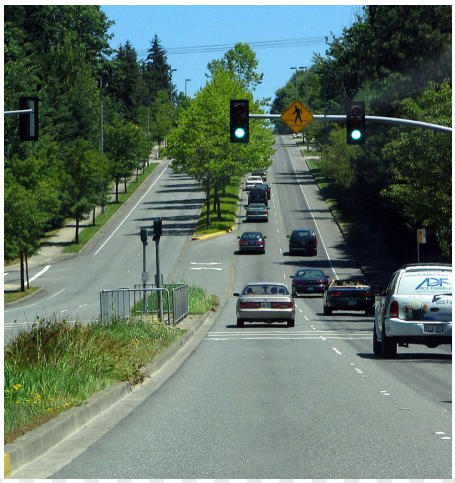
Crossing Enhancements

- Traffic signals & two-stage crossings
- PHBs & BikeHAWKs
- RRFBs
- Advance Stop/Yield Lines and Signs
- Medians and Refuge Islands
- Crossing Placement (Transit Stops)



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MEDIANS AND REFUGE ISLANDS

- Medians and refuge islands are proven to reduce crashes
- Needed where volumes, speeds, and number of lanes make crossings difficult

Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

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MEDIANS AND REFUGE ISLANDS

- Medians and refuge islands are proven to reduce crashes
- Needed where volumes, speeds, and number of lanes make crossings difficult

Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

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MEDIANS AND REFUGE ISLANDS

- Crossing islands can help shorten distances at intersections
- Proper design needed to manage slip lane traffic and move peds safely from curb to island

Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

26

TWO-STAGE CROSSINGS

- Where long distances exist between signals, incorporate two-stage crossings using median islands
- Allows for traffic to stop in one direction at a time to improve traffic flow

Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

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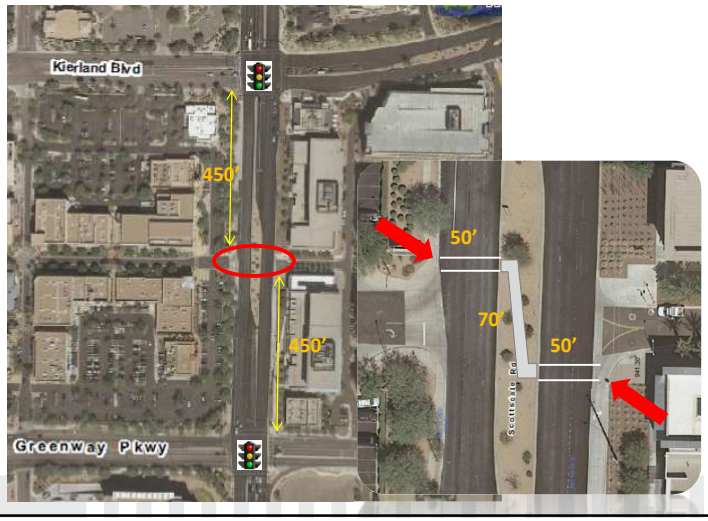
TWO-STAGE CROSSINGS

- Individual crossings enhanced w/ PHB or RRFB
- Example from Scottsdale, AZ:



Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

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PHBs AND BIKE HAWK

- Pedestrian Hybrid Beacons proven to decrease crashes and improve yielding
- Appropriate for locations where speeds, volumes and number of lanes exceed certain thresholds

Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

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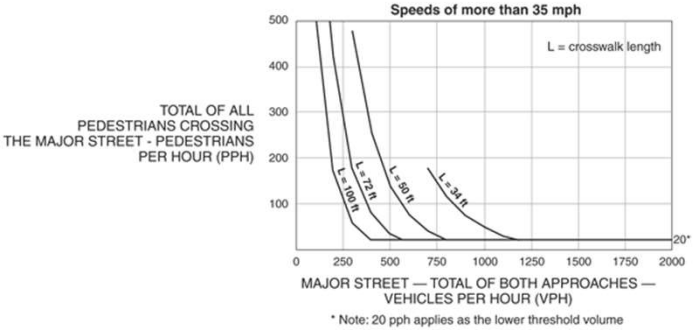
PHBs AND BIKE HAWK

- Use MUTCD guidelines for site selection
- Selection based on crossing length, pedestrian crossings, and vehicle volumes

Figure 4F-2. Guidelines for the Installation of Pedestrian Hybrid Beacons on High-Speed Roadways



Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

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PHBs AND BIKE HAWK

- PHB application for bicycle crossings at uncontrolled intersections
- R9-5 sign used to instruct bicyclists to use pedestrian signal

Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

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PHBs AND BIKE HAWK

- PHB application for bicycle crossings at uncontrolled intersections
- R9-5 sign used to instruct bicyclists to use pedestrian signal

Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

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RRFBs

- Improve yielding rates and reduce crashes
- Wide range of applications: trail crossings, uncontrolled midblock locations, uncontrolled intersections, roundabouts

Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

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RRFBs

- Two-stage crossing applications in Portland, OR
- Researchers found high rates of compliance with RRFB-equipped two-stage ("Z") crossings in Portland
- 4 travel lanes; 40mph posted speed limit

4 travel lanes; median island; 26,400 ADT volume; posted speed: 40 mph

Evaluating Driver and Pedestrian Behaviors at Enhanced Multi-lane Midblock Pedestrian Crossings: A Case Study in Portland, OR

Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

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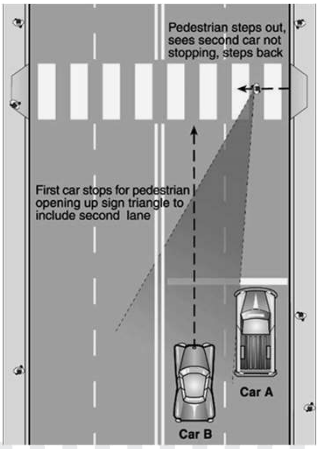
ADVANCE STOP/YIELD LINES

- Improve visibility by pulling vehicles back from crosswalk
- Proven reduction in crashes



Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

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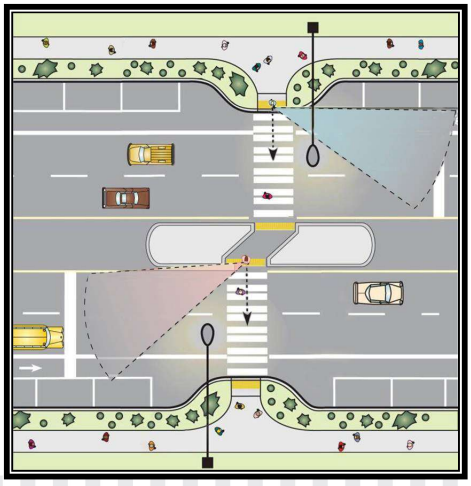
ADVANCE STOP/YIELD LINES

- Used in combination with other treatments already discussed



Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

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TRANSIT STOP PLACEMENT

- Transit stops are major generators of pedestrian trips
- High speed arterials are often transit corridors
- Use field observations to determine ideal placement

Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

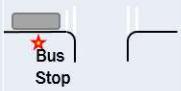
Advance Stop or Yield Lines

Crossing Placement and Transit Stops

37

TRANSIT STOP PLACEMENT

- Advantages and disadvantages for locating transit stops at:
  - Far-side of intersections
  - Near-side of intersections
  - Mid-block locations

Stop Location		Advantages	Disadvantages
Far-Side Stop		- Encourages peds to cross behind bus	- Sight distance issues for crossing vehicles and pedestrians
Near-side Stop		- Allows passengers to access bus closest to crosswalk	- Sight distance issues for veh to right of bus and crossing peds - Obscures curb signals and peds
Mid-Block Stop		- Min sight distance problems for vehicles and pedestrians - May reduce congestion at passenger waiting areas	- Encourages midblock crossing. - Increases walking distance for peds crossing at intersections

Source: Transit Cooperative Research Program Report 19: Guidelines for the Location and Design of Bus Stops, TRB, 1996

Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

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Signal Improvements

- Adding Traffic Signals
- Bicyclist Detection
- Bicyclist Clearance intervals
- Pedestrian countdown signals
- Leading Pedestrian Intervals

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ADDING TRAFFIC SIGNALS

- Increasing signal density can help manage progression of traffic and create more opportunities for crossings
- Can be expensive and difficult to justify many new signals

Adding Traffic Signals

Signal Timing Strategies

Pedestrian Signals

Leading Pedestrian Intervals

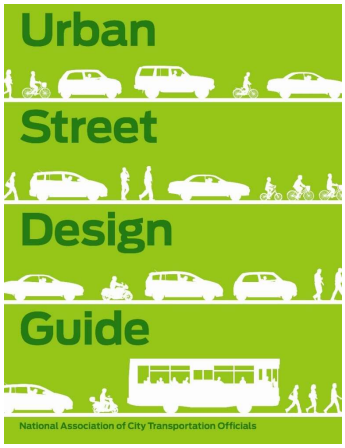
Bicycle Detection and Timing

40

SIGNAL TIMING STRATEGIES

Summarized from the NACTO Urban Street Design Guide:

- Coordinate signal timing to achieve desired progressions speeds
- Adjust peak and off-peak timing
- Fixed time is preferred over actuated signals
- Semi-actuated signals more common along major/minor intersections
- Shorten cycles and minimize phases to minimize wait times



Adding Traffic Signals

Signal Timing Strategies

Pedestrian Signals

Leading Pedestrian Intervals

Bicycle Detection and Timing

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PEDESTRIAN SIGNALS

- Belong at every signalized intersection
- Time signals to maximum 3.5 feet/second (can use slower speeds in areas with children or seniors)

Adding Traffic Signals

Signal Timing Strategies

Pedestrian Signals

Leading Pedestrian Intervals

Bicycle Detection and Timing

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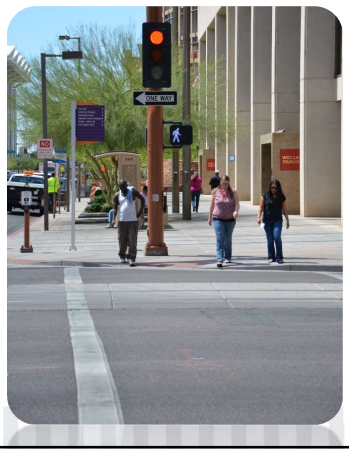
LEADING PEDESTRIAN INTERVAL

- Gives pedestrians 5-7 second head start
- Provide in areas with turning conflicts
- Must restrict RTOR when used



Adding Traffic Signals

Signal Timing Strategies

Pedestrian Signals

Leading Pedestrian Intervals

Bicycle Detection and Timing

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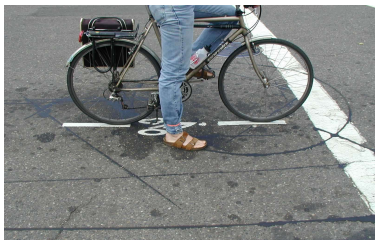
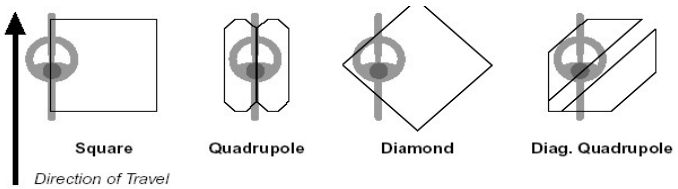
BICYCLE DETECTION AND TIMING

- Detection for bicyclists at signalized intersections where signals are actuated





Adding Traffic Signals

Signal Timing Strategies

Pedestrian Signals

Leading Pedestrian Intervals

Bicycle Detection and Timing

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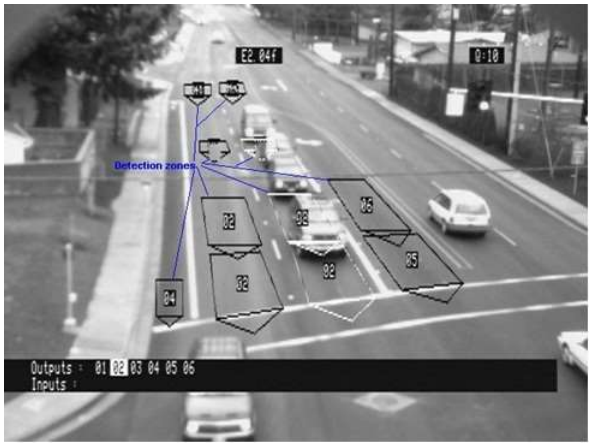
BICYCLE DETECTION AND TIMING

- Range of technologies available: buttons, loops, video, microwave, radar, infrared



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BICYCLE DETECTION AND SIGNALS

- Adjust signals to allow minimum green time for bicyclists to clear intersection

- California's formulas provide guidance:
  - Travel speed: 14.7 feet/second, plus
  - 6 second start-up time
- Davis, CA, provides minimum bicycle green time of 12 seconds

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BICYCLE DETECTION AND SIGNALS

- Bicycle signal faces can be provided and given exclusive phases to reduce conflicts

Adding Traffic Signals

Signal Timing Strategies

Pedestrian Signals

Leading Pedestrian Intervals

Bicycle Detection and Timing

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Road Diets

- Road Diets (lane reduction)
- Lane Diets (Narrowing)
- Use space for other purposes
- Minimize crossing distances and intersection size

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Road diet candidate guidelines

- ADT (Road Diet Candidate)
  - 24,000 or less
- Peak hourly volume (Road Diet Candidate)
  - Below 875 vehicles per day in one direction
- Case with higher ADT
  - Lake Washington Blvd. Kirkland, WA
    - Initial volume of 23,000 vehicles per day
    - Increased nearly 26,000 after conversion
    - During one period about 30,000 vehicles per day

Summarized from FHWA Road Diet Informational Guide

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Example: East Boulevard, Charlotte NC

San Francisco, CA

- ADT ranged from 16,000 to 24,000
- Posted Speeds: 35 mph
- After project, 85th percentile speeds reduced from 43 to 40 mph

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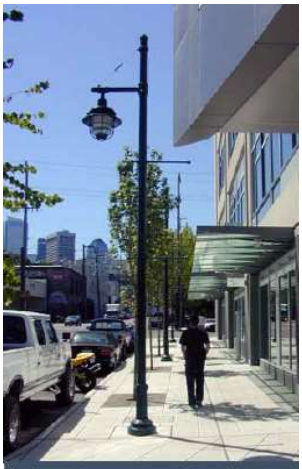
Lighting improvements

- Along Corridors
- Lighting at Signals
- Lighting at Uncontrolled Crossings
- LED lighting



Pedestrian lighting in South Lake Union

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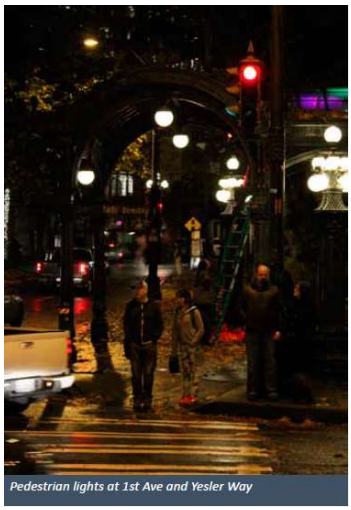
LIGHTING ALONG CORRIDORS

- Help pedestrians safely navigate sidewalks & pathways
- Provide for visibility & security at all hours
- Extend hours a business district is active
- Encourage walking as part of an active lifestyle
- Improve access to transit & other services at night/early morning



Pedestrian lights at 1st Ave and Yesler Way

Lighting Along Corridors

Lighting at Signals

Lighting at Uncontrolled Crossings

LED Lighting

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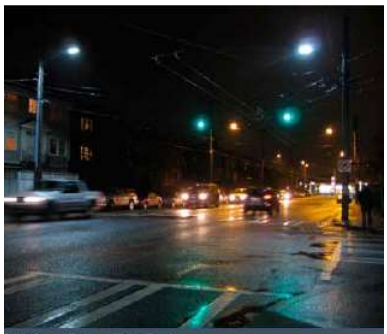
LIGHTING ALONG CORRIDORS

- Consider roadway and pedestrian-way lighting
- Roadway: 25 ft or higher
  - Works for motorists but often insufficient for pedestrians
- Pedestrian: 20 ft or less from surface



LED Streetlights on 10th Ave E

Pedestrian lighting in South Lake Union

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INTERSECTION LIGHTING

- No specific research done to address higher background luminance typically found at intersections
- 30 vertical lux considered conservative estimate

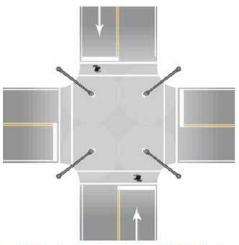

Figure 13. Drawing. Traditional intersection lighting layout.

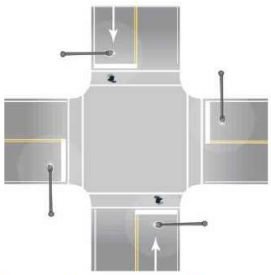

Figure 14. Drawing. New design for intersection lighting layout for crosswalks.

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MIDBLOCK LIGHTING

- Informational Report on Lighting Design for Midblock Crosswalks FHWA-HRT-08-053 April 2008

Fig 11. Traditional midblock crosswalk lighting layout

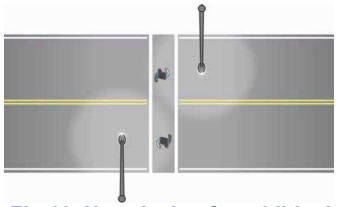

Fig 12. New design for midblock crosswalk lighting layout

Recommended lighting level: 20 lux at 5' above pavement

FHWA Report http://www.tfhrc.gov/safety/pubs/08053/08053.pdf

Lighting Along Corridors

Lighting at Signals

Lighting at Uncontrolled Crossings

LED Lighting

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LED LIGHTING

- More agencies moving toward LED lighting due to:
  - Whiter light/better color recognition
  - Lower energy costs
  - Less maintenance

Advantages

- Lower energy use
- Longer lamp life
- No warm-up time
- Good light quality
- Directional (less light pollution)
- Environmentally friendly

Disadvantages

- High initial cost
- Sensitive to heat
- Long-term performance issues

Lighting Along Corridors

Lighting at Signals

Lighting at Uncontrolled Crossings

LED Lighting

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Bicycle facilities

- Mixing Zone Treatments at Intersections
- Protected Intersections
- Separated or Buffered Bike Lanes
- Use of Parallel Routes (Bicycle Boulevards)

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OPTIONS FOR BIKE FACILITIES

Bike Facility Options

Mixing Zone Treatments

Protected Intersections

Separated or Buffered Bike Lanes

Parallel Routes

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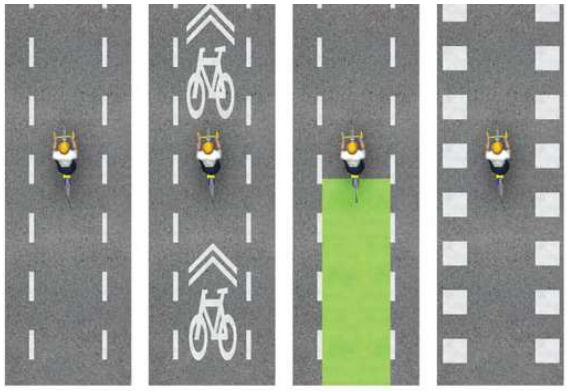
MIXING ZONES

- Mark conflict zones at and leading up to intersections to communicate desired movement



Bike Facility Options

Mixing Zone Treatments

Protected Intersections

Separated or Buffered Bike Lanes

Parallel Routes

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MIXING ZONES

- Mark conflict zones at and leading up to intersections to communicate desired movement

Bike Facility Options

Mixing Zone Treatments

Protected Intersections

Separated or Buffered Bike Lanes

Parallel Routes

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BIKE BOXES

- Allows bicyclists to queue at front of traffic when waiting for signal
- Improves visibility and reduces turning conflict

Bike Facility Options

Mixing Zone Treatments

Protected Intersections

Separated or Buffered Bike Lanes

Parallel Routes

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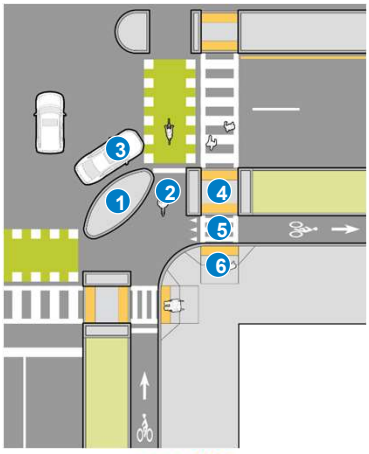
PROTECTED INTERSECTIONS

- Newer design to reduce conflict points at intersections

1. Corner refuge island
2. Forward bicycle queuing area
3. Motorist yield zone
4. Pedestrian crossing island
5. Pedestrian crossing of separated bike lane
6. Pedestrian curb ramp



massDOT

Bike Facility Options

Mixing Zone Treatments

Protected Intersections

Separated or Buffered Bike Lanes

Parallel Routes

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PROTECTED INTERSECTIONS

- Example from Chicago:

Bike Facility Options

Mixing Zone Treatments

Protected Intersections

Separated or Buffered Bike Lanes

Parallel Routes

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BUFFERED BIKE LANES

- Added buffer between bike lane and travel lane
- Shy distance allows more comfortable travel and weaving space to avoid door zones
- No physical separation means more opportunity for conflicts

Bike Facility Options

Mixing Zone Treatments

Protected Intersections

Separated or Buffered Bike Lanes

Parallel Routes

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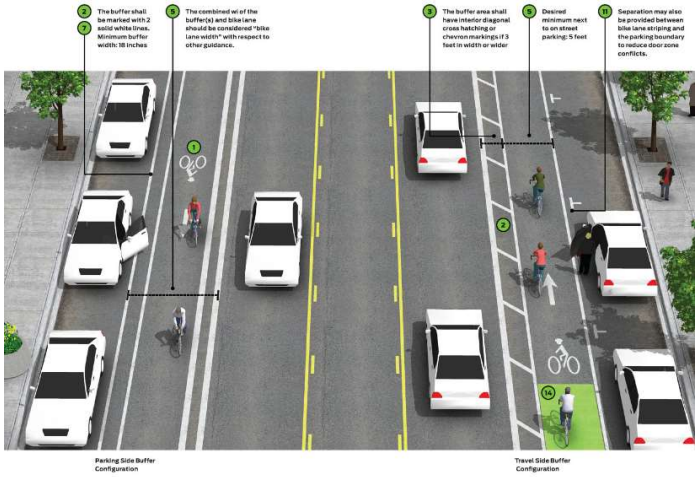
BUFFERED BIKE LANES



Bike Facility Options

Mixing Zone Treatments

Protected Intersections

Separated or Buffered Bike Lanes

Parallel Routes

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BUFFERED BIKE LANES

Bike Facility Options

Mixing Zone Treatments

Protected Intersections

Separated or Buffered Bike Lanes

Parallel Routes

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SEPARATED BIKE LANES

- Vertical barrier separating bike lane from traffic lane
- Can be one-way, two-way, or contraflow
- Raised to sidewalk level or on roadway

Bike Facility Options

Mixing Zone Treatments

Protected Intersections

Separated or Buffered Bike Lanes

Parallel Routes

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SEPARATED BIKE LANES

Advantages

- Very low stress midblock
- Encourages bike riding
- More conspicuous
- Crash rate reductions

Disadvantages

- Special intersection treatments
- Special driveway treatments
- Additional space needed
- More costly than bike lanes
- More to learn

Bike Facility Options

Mixing Zone Treatments

Protected Intersections

Separated or Buffered Bike Lanes

Parallel Routes

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SEPARATED BIKE LANES

Bike Facility Options

Mixing Zone Treatments

Protected Intersections

Separated or Buffered Bike Lanes

Parallel Routes

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SEPARATED BIKE LANES

Bike Facility Options

Mixing Zone Treatments

Protected Intersections

Separated or Buffered Bike Lanes

Parallel Routes

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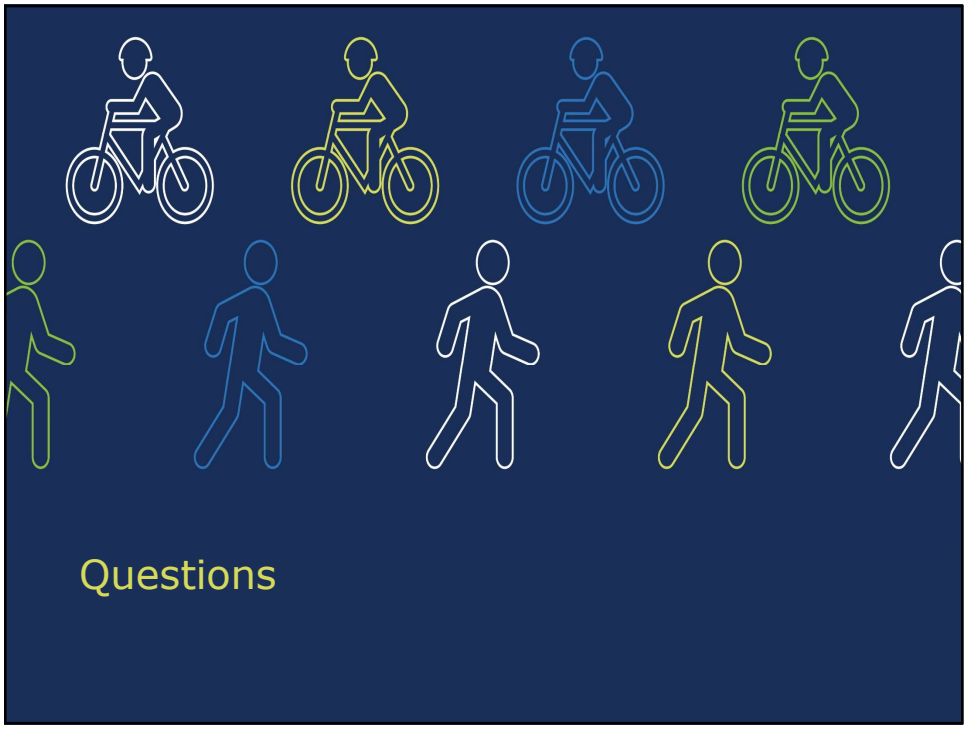

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