Retrofitting Urban Arterials Into Complete Streets

PSU Friday Transportation Seminars
PSU Center for Transportation Studies

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What is a Complete Street?

A Complete Street is comfortable, convenient & safe for travel via auto, foot, bicycle, & transit.
We know how to build good streets
Yet many roads are still built like this.

Recently completed roadway expansion with destinations on both sides of the road.

Can you spot the pedestrian?
What is a Complete Streets policy?

A complete streets policy ensures that the entire right-of-way is planned, designed & operated to provide safe access for all users.
Complete Streets is NOT:

- A design prescription
- A mandate for immediate retrofit
- A silver bullet. Other initiatives, such as context sensitivity, are still needed!
CS changes intersection design
CS changes bicycling
CS changes bicycling
CS changes transit
Who benefits from Complete Streets?

Everybody
Who wants Complete Streets?

- About **one-third** of Americans don’t drive:
  - 21% of Americans over 65.
  - All children under 16.
  - Many low income Americans cannot afford automobiles.

- 55% of Americans would rather drive less & walk more

- Transit is growing faster than population or driving
Benefits: Safety

- Sidewalks reduce pedestrian crashes 88%
- Medians reduce crashes 40%
- Road diets reduce crashes 29%
- Countdown signals reduce crashes 25%
Benefits: Better use of transit funds

➢ One year of paratransit service for a daily commuter:
  ▪ $38,500

➢ Permanent improvements to make a transit stop accessible:
  ▪ $7,000 - $58,000

Source: Maryland Transit Administration
Benefits: Health

- Americans move... without moving
- 60% of adults are at risk for diseases associated with inactivity:
  - Obesity
  - Diabetes
  - High blood pressure
  - Other chronic diseases
Benefits: Physical activity

- Residents are more likely to walk in a neighborhood with sidewalks.

- Cities with more bike lanes have higher levels of bicycle commuting.
Benefits: Reducing traffic

Trips in metro areas:

- 50% under 3 miles
- 28% under 1 mile
  - 65% of trips under 1 mile are taken by automobile
We know how to build right
Perceived Barriers to Achieving Complete Streets

- Conflicts with Federal highway standards and guidelines
- Slower speeds reduce mobility and increase costs for all vehicles
- Required to design to Level of Service C for the peak half hour 20 years hence
- Spending for peds and bikes is a luxury we cannot afford
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Nothing in Complete Streets Conflicts with National Guidelines

AASHTO: American Association of State Highway and Transportation Officials

ITE: Institute of Transportation Engineers

Guide for the Planning, Design, and Operation of Pedestrian Facilities

Designing Walkable Urban Thoroughfares: A Context Sensitive Approach
Designing Walkable Urban Thoroughfares: A Context Sensitive Approach

ITE New Recommended Practice

Sets target speed (desirable operating speed) as the most important design element
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Why Speed Matters

High speeds lead to greater chance of serious injury & death

Pedestrians’ chances of death if hit by a motor vehicle
SOURCE: Killing Speed and Saving Lives, UK Department of Transportation
Child dart-out: speed is a factor!

150’
First scenario: Speed 25 MPH

100’ = distance covered in 2.5 sec. perception/reaction time

Driver applies brakes

150’
First scenario: Speed 25 MPH

Driver applies brakes

50’ stopping distance (wet pavement)

100’

50’

150’
First scenario: Speed 25 MPH

Result: Nothing happens beyond one scared child, driver & parent!
Second scenario: Speed 38MPH

140’ = distance covered in 2.5 sec. perception/reaction time

Driver applies brakes
Second scenario: Speed 38MPH

Driver applies brakes

140’

150’
Second scenario: Speed 38MPH

In the last 10’ car slows to 36 MPH
Second scenario: Speed 38MPH

Result: a high speed crash

150'
Where do these two scenarios lie on the pedestrian fatality risk scale?

Second scenario:
Crash speed 36 MPH

First scenario:
no crash
Defining Mobility

- Typical experience:
  - 45 mph speed
  - 2 min wait at signal
Defining Mobility

- Viable alternative:
  - 2-way progression set for 30 mph
Benefit/Cost Analysis

- Reducing speed from 45 mph to 30 mph
  - For a 5-mile trip, a 3.33-minute delay
  - Assume 30,000 ADT and $20/hr driver cost
  - $12.154 million in loss to economy, right?

- Wrong!
  - Delay for each person is still 3.33 minutes
  - Less time than their daily stop for Starbucks

- Community benefit
  - Slower operating speeds
  - Safer and more comfortable ped crossings
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Roadway Capacity Analysis

- Designing to LOS C for peak hour means:
  - Unnecessary pavement, *waste of tax dollars*
  - Increased ped crossing times, thus reducing vehicular movement times
  - Increased operating speeds for other 22 hours

- **ALWAYS** design urban roadways to LOS D
Will traffic volumes always increase? Maybe not

Since 2005 US VMT has been flat
Perceived Barriers to Achieving Complete Streets

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Retrofitting Urban Arterials to Complete Streets

➢ Requires arterial traffic calming/taming:
  
  1. Controlling operating speeds
  2. Ped-friendly street crossings
     ✓ Geometric issues
     ✓ Signal considerations

➢ Requires facilities for nonmotorized users:
  
  1. Pedestrians
  2. Bicycles
  3. Transit
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Costs to Control Operating Speeds

- Design to D LOS
- Signal progression
- Narrower travel lanes
- Road diets
- Raised medians and landscaping
- Retain curb parking
Costs to Control Operating Speeds

- Design to D LOS – Less pavement = less cost
Costs to Control Operating Speeds

- Design to D LOS – Less pavement = less cost
- Signal progression – Cost to interconnect
Narrower Travel Lanes

- 70 mph lane widths not needed to handle 30 mph traffic
Narrower Travel Lanes

News Flash! 10 and 11-foot lanes are just as safe as 12-foot lanes on urban arterials with posted speeds less than 45 mph.
Costs to Control Operating Speeds

- Design to D LOS – Less pavement = less cost
- Signal progression – Cost to interconnect
- Narrower travel lanes – Less pavement = less cost
Effect of Converting 4-Lane Roads to 3-Lane and TWLTL

“Classic Road Diet”
29% reduction in total crashes/mile
Three crash types can be reduced by going from 4 to 3 lanes

1. Rear enders
Three crash types can be reduced by going from 4 to 3 lanes

2. Side swipes
Three crash types can be reduced by going from 4 to 3 lanes.
Mission District, San Francisco
North-South ADT

Handles 20,000 ADT

1998 – before Valencia Road Diet
2000 - after Valencia Road Diet
Valencia Street Bicycle Volumes
PM peak hour counts

![Bar graph showing bicycle volumes before and after bike lanes. Before bike lanes: 88 bikes/hr; after bike lanes: 215 bikes/hr.](image-url)
Costs to Control Operating Speeds

- Design to D LOS – Less pavement = less cost
- Signal progression – Cost to interconnect
- Narrower travel lanes – Less pavement = less cost
- Road diets – Install with resurfacing, no additional cost
Raised Medians

Continuous raised median
40% reduction in pedestrian crashes
Median/Parkway Landscaping
Costs to Control Operating Speeds

- Design to D LOS – Less pavement = less cost
- Signal progression – Cost to interconnect
- Narrower travel lanes – Less pavement = less cost
- Road diets – Install with resurfacing, no additional cost
- Raised medians and landscaping – With roadway reconstruction
Retain Curb Parking

Eliminating on-street parking encourages cars to go faster and discourages neighborhood business.
Costs to Control Operating Speeds

- Design to D LOS – Less pavement = less cost
- Signal progression – Cost to interconnect
- Narrower travel lanes – Less pavement = less cost
- Road diets – Install with resurfacing, no additional cost
- Raised medians and landscaping – With roadway reconstruction
- Retain curb parking – No cost, parking meter revenue
Retrofitting Urban Arterials to Complete Streets

- Requires arterial traffic calming/taming:
  1. Controlling operating speeds
  2. Ped-friendly street crossings
     ✓ Geometric issues
     ✓ Signal considerations

- Requires facilities for nonmotorized users:
  1. Pedestrians
  2. Bicycles
  3. Transit
Costs for Ped-Friendly Geometrics

- Tighten corner curb radii
- Corner “pork chop”
- Eliminate free flow right turn lanes
- Curb bulb-outs
Effect of large radius on drivers

They drive fast, ignoring pedestrians
Tighten Corner Curb Radii

Large corner radii:

- Increase crossing distance
- Longer signal time
Costs for Ped-Friendly Geometrics

- Tighten corner curb radii – With roadway reconstruction
Corner “Pork Chop” Islands

Benefits:

- Separate conflicts & decision points
- Reduce crossing distance
- Improve signal timing
- Reduce ped crashes (29%)
Costs for Ped-Friendly Geometrics

- Tighten corner curb radii – With roadway reconstruction
- Corner “pork chop” islands – With roadway reconstruction
Free Flow Right Turn Lanes

Eliminate free flow turns across crosswalks/bikeways
Free Flow Right Turn Lanes

Eliminate free flow turns across crosswalks/bikeways
Costs for Ped-Friendly Geometrics

- Tighten corner curb radii – With roadway reconstruction
- Corner “pork chop” islands – With roadway reconstruction
- Eliminate free flow right turn lanes – With ramp reconstruction
Curb Bulb-outs

- Reduce crossing distance
- Improve sight distance and sight lines
- Prevent encroachment by parked cars
- Create space for curb ramps and landings
Costs for Ped-Friendly Geometrics

- Tighten corner curb radii – With roadway reconstruction
- Corner “pork chop” islands – With roadway reconstruction
- Eliminate free flow right turn lanes – With ramp reconstruction
- Curb bulb-outs – With roadway reconstruction and on-street parking
Retrofitting Urban Arterials to Complete Streets

- Requires arterial traffic calming/taming:
  1. Controlling operating speeds
  2. Ped-friendly street crossings
    - Geometric issues
    - Signal considerations

- Requires facilities for nonmotorized users:
  1. Pedestrians
  2. Bicycles
  3. Transit
Pedestrian Signal Costs

- Time signals for 3.5 ft/sec walking speed
- Countdown
- Ped actuated HAWK signals
- Rectangular Rapid Flash Beacon
Recent studies found that previous 4.0 fps walking speed based on average walking speeds (not 15th percentile)

2009 MUTCD now recommends using a pedestrian walking speed of 3.5 fps for FDW and 3.0 fps for overall WALK phase
Pedestrian Signal Costs

- Time signals for 3.5 ft/sec walking speed
  - Signal maintenance
50% of pedestrians in the U.S. do not understand that “Flashing Don’t Walk” really means it is OK to continue walking.

So we put signs like this to “correct” the problem.
Countdown Clocks

Pedestrian count-down signal tells pedestrians how much crossing time is left
Countdown Clocks

Results from San Francisco:
25% Crash Reduction Factor after countdown signals installed
Pedestrian Signal Costs

- Time signals for 3.5 ft/sec walking speed – Signal maintenance
- Countdown clocks – Can be added for roughly $2,000/intersection
HAWK Pedestrian Hybrid Signal

HAWK (High Intensity Activated Crosswalk)
Also in 2009 MUTCD
Drivers see Beacon

Peds see Pedhead
Hybrid Beacon Sequence

1. Blank for drivers
   - Flashing yellow
   - Steady yellow

2. Steady red

3. Wig-Wag

4. Return to 1

5. 2009 MUTCD Section 4F.3
How to Develop a Pedestrian Safety Action Plan
Excerpts from Proposed MUTCD Chapter 4F
For Pedestrian Hybrid Beacons

- The CROSSWALK STOP ON RED sign shall be used
- There are Guidelines (similar to signal warrants) for Pedestrian Hybrid Beacons
  - variables include:
    - Pedestrian volume
    - Traffic speeds
    - Traffic volumes
    - Crosswalk length

![Diagram showing curves based on length and signal warrant](image-url)
## Table 21. Summary of motorist yielding compliance from three sources for red signal or beacon and active when present.

<table>
<thead>
<tr>
<th>Crossing Treatment</th>
<th>TCRP D-08/NCHRP 3-71 Study</th>
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<td># of Sites</td>
<td>Range (%)</td>
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<td>NA</td>
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<tr>
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<td>6</td>
<td>46 to 79</td>
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</table>
Pedestrian Signal Costs

- Time signals for 3.5 ft/sec walking speed – Signal maintenance
- Countdown clocks – Can be added for roughly $2,000/intersection
- Ped actuated HAWK signals – Half the cost of standard ped signal; lower warrant
Rectangular Rapid Flash LED Beacon

► Beacon is yellow, rectangular, and has a rapid “stutter” flash
► Beacon located between the warning sign and the arrow plaque
► Must be pedestrian activated (pushbutton or passive)
► Studies indicate motorist yielding rates increased from 18.2% to 81.2% for 2 beacons and to 87.8% for 4 beacons
► Interim approval from FHWA in July 2008
Pedestrian Signal Costs

- **Time signals for 3.5 ft/sec walking speed**
  - Signal maintenance

- **Countdown clocks** – Can be added for roughly $2,000/intersection

- **Ped actuated HAWK signals** – Half the cost of standard ped signal; lower warrant

- **Rectangular Rapid Flash Beacon** - $20K and no specific warrant
Costs for Facilities for Nonmotorized Users

1. Pedestrians
2. Bicycles
3. Transit
Pedestrians can get by without sidewalks on quiet streets
Shoulders serve pedestrians in rural areas
Rural Environments: Paved Shoulders

Crash Modification Factor (CMF) = 0.70
Crash Reduction of 30%
Urban/suburban Environments: Sidewalks

Crash Modification Factor (CMF) = 0.12
Crash Reduction of 88%
Buffer sidewalks with planter strip/furniture zone:

- Space for trees and street furniture
- Easy to meet ADA at driveways and curb ramps
- More pleasant to walk on
5 feet needed for two people to walk comfortably side-by-side (or to pass each other)
Sidewalk Design

Set triggers for future sidewalks

- Development densities
- Developer requirements
- Going from open to closed drainage
Costs for Facilities for Nonmotorized Users

1. Pedestrians – Create gap infill program funded by developers, new roadway construction, program small amount each year
2. Bicycles
3. Transit
Costs for Facilities for Nonmotorized Users

1. Pedestrians – Create gap infill program funded by developers, new roadway construction, program small amount each year

2. Bicycles

3. Transit
Bikes Belong

“All highways, except those where bicyclists are legally prohibited, should be designed and constructed under the assumption that they will be used by cyclists.”

AASHTO
Bikes Belong

“Therefore, bicycles should be considered in all phases of transportation planning, new roadway design, roadway construction and capacity improvement projects, and transit projects.” AASHTO
Typical Bicyclists
Typical Bicyclists
Bicyclist Characteristics

Four Bicyclist Types*

- Strong & Fearless <1%
- Enthused & Confident 7%
- Interested but Concerned 60% (Includes children)
- No Way, No How 33%

* Roger Geller, Portland, OR
Sidewalks are Low Stress

It’s okay for young kids to ride on sidewalks
An adult bicyclist on a sidewalk is not a good sign
A cyclist on a sidewalk interferes with pedestrians
A cyclist on a sidewalk places himself at risk
Especially when riding against traffic!
RELATIVE DANGER INDEX
Of various types of facilities

- Major Streets w/o bike lanes 1.28
- Minor Streets w/o bike lanes 1.04*
- Streets with bike lanes 0.5
- Mixed-use paths 0.67
- Sidewalks 5.32

(* = shared roadway)

1.00 = median

Source: William Moritz, U.W. - “Accident Rates for Various Bicycle Facilities” - based on 2374 riders, 4.4 million miles
Provide space on streets ...
- Bike lanes most appropriate on urban thoroughfares
- They get you from one part of town to another efficiently
- Intersections stop or signal controlled
- No point in striping local streets with bike lanes
Facility Selection

- Bicycle Lanes
  - OK to reduce travel lane

10 and 11-foot lanes are just as safe as 12-foot lanes on urban arterials with posted speeds less than 45 mph.
10-5-7 Retrofit

Option when:
- Current lane 22 ft (6.7 m) with parking
- Vehicle speeds 30 mph

How to implement:
- Reduce width of travel and parking lanes

Accepted by AASHTO

Implemented in Chicago
Retrofitting for Bike Lanes

- Reduce travel lane widths
- Reduce number of travel lanes
- Remove, narrow, or reconfigure parking
- Other design options

Typical “Road Diet”

![Diagram showing typical road diet with reduced lane widths and additional bike lanes](image-url)
Shared Lane Markings
Shared Lane Markings

- **“Sharrow”**
  - Reinforces shared lane concept
  - Keeps bikes away from door zone

- **Where to use:**
  - Narrow shared use road where bicyclists tend to ride too close to parked cars or curb
  - Low roadway speeds with high parking turnover
Signing of Shared Roadways

- Generic “Bike Route” signs not recommended
- Routes should be designated with a name or number.
Signing of Shared Roadways

Route Signage

- Distance
- Direction
- Destination

Directional and destination signs are now in the 2009 MUTCD (Section 2B-20)
Shared Use Paths

- Bike facilities that are separated from the roadway
- Typically located on exclusive ROW
  - No fixed objects
  - Minimal cross-flow by motor vehicles
Shared Use Paths

- Users include:
  - Bicyclists
  - Skaters
  - Wheelchairs
  - Pedestrians
  - Joggers/runners,
  - People with baby strollers
  - Dogs with people
Paths Next to Roads

- Recommended minimum separation – 5 ft
Adjacent Path Intersection
Side Path vs. Bike Lanes
Side Path vs. Bike Lanes
Side Path vs. Bike Lanes
Side Path vs. Bike Lanes
Side Path vs. Bike Lanes
Side Path vs. Bike Lanes
Traffic Restrictions

• Use bollards only when absolutely necessary
Traffic Restrictions

• Use bollards only when absolutely necessary
Traffic Restrictions

- Use bollards only when absolutely necessary

HELP!!!!
Costs for Facilities for Nonmotorized Users

1. Pedestrians – Create gap infill program funded by developers, new roadway construction, program small amount each year

2. Bicycles – Low hanging fruit first: signing and restriping with street resurfacing

3. Transit
Costs for Facilities for Nonmotorized Users

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3. Transit
Transit: Bus is most common mode
Transit: Only choice for many people
Shelters must be accessible (grass makes it inaccessible)
Good news: they fixed it!
(after attending this course)
Separated sidewalk: Shelter placed in planter strip
Every bus stop is a pedestrian crossing and all known crossing techniques apply to every bus stop.
Costs for Facilities for Nonmotorized Users

1. Pedestrians – Create gap infill program funded by developers, new roadway construction, program small amount each year

2. Bicycles – Low hanging fruit first: signing and restriping with street resurfacing

3. Transit – See ped friendly crossings previously described
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- Slower speeds reduce mobility and increase costs for all vehicles
- Required to design to Level of Service C for the peak half hour 20 years hence
- Spending for peds and bikes is a luxury we cannot afford

ALL MYTHS!
What does a Complete Street look like?

There is no magic formula
The many types of Complete Streets

Safe Routes to School
The many types of Complete Streets

Bikeways on rural roads
The many types of Complete Streets

A commercial arterial w/ bike lanes & sidewalks
The many types of Complete Streets

Residential skinny streets
The many types of Complete Streets

Historic Main Street
Complete Streets

- Are sensitive to the community
- Serve all who potentially will use the street
- Will **save money** if fully implemented
Designating peds and bikes as “alternative transportation” is like calling women alternative men

Mark Fenton
Thank you!