Design Considerations for “Complete Streets”
Objective

- Provide design geometrics and features that accommodate balanced operations of bicycles, pedestrians and vehicles on a ‘complete street’
Minor Collector, 20-30 mph
Major Collector, 25-35 mph
Cul-de-sacs, 10-15 mph
Locals, 15-55 mph
Arterials, 40-50 mph
Interstate (freeways), 55-70 mph

ACCESS FUNCTION
Ability to Access Adjacent Land Uses

MOVEMENT FUNCTION
Ease, Speed and Safety for Travelers
• Arterials are high volume, high speed streets
  – Make up 10% of street system
  – Carry 48% of vehicle miles of travel
  – Provide separate bike lane / path
  – Cross pedestrians at intersections or mid-block with high type design and control
Design Considerations

- Speed
- Volume / conflicts
- User / vehicle characteristics
- Human factors
Vehicle Conflicts

Conflict points: Conventional intersection

<table>
<thead>
<tr>
<th>Conflict Types</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Diverge</td>
<td>8</td>
</tr>
<tr>
<td>Merge</td>
<td>8</td>
</tr>
<tr>
<td>Crossing</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>32</strong></td>
</tr>
</tbody>
</table>

Kittelton & Associates, Inc.
Bicycle Conflicts

Bicycle Conflict Points at Conventional Cross Intersection

- Conflicts in common with motor vehicles
- Conflicts unique to bicycles

- Bicycle
- Motor Vehicle
- Pedestrian

Kittelson & Associates, Inc.
Pedestrian Conflicts

Pedestrian Conflict Points at Conventional Cross Intersection

- Vehicle/Pedestrian Conflicts
- Vehicle/Vehicle Conflicts

Kittelton & Associates, Inc.
Speed

Speed determines:

- Horizontal curvature
- Sight distance
- Intersection layout and elements
- Roundabout design
Speed and Safety

• Accident severity is a function of speed magnitude
• Accident potential is more a function of speed differential
Maintain 10-15 mph, or less, speed differential
Human Factors

- 90-95% of operating information is visual
- Ability to see
  - 3-5° cone of vision - excellent vision
  - 10° cone - good vision
  - 20° cone - satisfactory vision
  - 70-90° cone - peripheral vision
Human Factors

• How drivers / humans see
  – ~0.25 sec – eye shift
  – ~0.25 sec – eye focus
  – 0.5-1.0 sec – head/body movement
Human Factors

- Perception – Reaction Time
  - Perception
  - Intellection
  - Emotion
  - Volition

Typically 0.5 sec - 4.0 sec
Human Factors Design Perception Reaction Time

Source: 2001 AASHTO Policy on Geometric Design

Exhibit 2-27. 85th-Percentile Driver Reaction Time to Expected and Unexpected Information
Stopping Sight Distance

Must be provided for 100% of roadway

SSD = Perception Reaction Distance + Braking Distance

<table>
<thead>
<tr>
<th>Speed</th>
<th>SSD</th>
<th>Time</th>
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</thead>
<tbody>
<tr>
<td>15 mph</td>
<td>80 ft</td>
<td>3.6 sec</td>
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<tr>
<td>20 mph</td>
<td>115 ft</td>
<td>3.9 sec</td>
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<tr>
<td>25 mph</td>
<td>155 ft</td>
<td>4.2 sec</td>
</tr>
<tr>
<td>30 mph</td>
<td>200 ft</td>
<td>4.5 sec</td>
</tr>
<tr>
<td>35 mph</td>
<td>250 ft</td>
<td>4.9 sec</td>
</tr>
<tr>
<td>40 mph</td>
<td>305 ft</td>
<td>5.2 sec</td>
</tr>
</tbody>
</table>
Driver Expectancy

• The psychological impact on driver expectations and behavior from the combined formal and informal information based on previous knowledge and experiences:
  – Formal info – signs, markings, signals
  – Informal info – curbs, parked vehicles, street furniture
‘Complete Street’ Design Situation

- Mixed users
- Varying speeds
- Numerous conflicts
- High degree of complexity
- User workload is high
‘Complete Street’ Design Objectives

- Control speeds
- Achieve uniformity in speeds
- Reduce volumes / conflicts
- Provide adequate sight distance
- Demonstrate a pedestrian/bicycle environment
Control Speeds

- Control speeding
- Maintain uniform speeds
  - Conflicts become more problematic
  - Crashes become more severe
- Keep speeds within 10-15 mph of bicycle, or provide safe separation
Control Conflicts

- Eliminate most severe conflicts
- Prohibit crossing conflicts
- Eliminate left turns
  - 75% of accidents are left-turn related
Provide Adequate Sight Distance

- Stopping sight distance provides adequate sight distance to clearly discernible conflict.
- As conflicts increase, perception reaction time must increase by about 0.5 sec – 1.5 sec for each major conflict.
- Must increase sight distance for large perception reaction time.
- Eliminate sight obstructions, such as parked vehicles.
- Eliminate trees or their low limbs (up to 6.0 ft).
Reduce Parking

- Reduce lateral conflicts
- Improves sight distance
- Increases traffic flow 30%
- Reduces crashes 20-40%
## Accident Rates* by Median Type

<table>
<thead>
<tr>
<th>Access Points per mile</th>
<th>Undivided</th>
<th>TWLTL</th>
<th>Non-Traversable</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20</td>
<td>3.8</td>
<td>3.4</td>
<td>2.9</td>
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<tr>
<td>20.01-40</td>
<td>7.3</td>
<td>5.9</td>
<td>5.1</td>
</tr>
<tr>
<td>40.01-60</td>
<td>9.4</td>
<td>7.9</td>
<td>6.8</td>
</tr>
<tr>
<td>&gt;60</td>
<td>10.6</td>
<td>9.2</td>
<td>8.2</td>
</tr>
<tr>
<td>Total</td>
<td>9.0</td>
<td>6.9</td>
<td>5.6</td>
</tr>
</tbody>
</table>

* Crashes per million vehicle miles
<table>
<thead>
<tr>
<th>Type</th>
<th>Crashes per 100-million entering vehicles</th>
<th>Crashes per 100-million vehicle miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intersection</td>
<td><strong>2.32</strong> - Undivided</td>
<td><strong>6.69</strong> - Undivided</td>
</tr>
<tr>
<td>Midblock</td>
<td><strong>2.49</strong> - TWLTL</td>
<td><strong>6.66</strong> - TWLTL</td>
</tr>
<tr>
<td></td>
<td><strong>0.97</strong> - Non-Traversable Median</td>
<td><strong>3.86</strong> - Non-Traversable Median</td>
</tr>
</tbody>
</table>

*Crashes per 100-million entering vehicles

**Crashes per 100-million vehicle miles
Bulb-Outs at Intersections or Mid-Block

- Use bulb-outs at pedestrian crossings
- Provides very visible evidence of pedestrian environment
- Shortens pedestrian crossing time
- Provides visual restrictions of street geometrics
- Changes driver expectancy
Demonstrate Pedestrian / Bicycle Environment

- Drivers not intimidated by pedestrians / bicyclists since not a threat
- Show drivers through traffic control devices, geometrics and surfacing they are in pedestrian / bicycle environment
Use One-Way Streets

• Conflicts are dramatically reduced
• Severity of conflicts that occur are not as great
• Signalization and progression are more efficient
Use Roundabouts

- Reduce conflicts
- Control speeds
- Limit severity
- Dictate who has right-of-way
Roundabout Design Features

- Provide uniform speeds throughout the roundabout
- Accommodate bicycles in roundabout
- Accommodate pedestrians close to roundabout
- Use vertical features, but do not restrict sight distance
Conflict points: Roundabout

Conflict Types

- Diverge: 4
- Merge: 4
- Crossing: 0

Total: 8
Bicycle Conflict Points at Single-lane Roundabout

- Conflicts in common with motor vehicles
- Conflicts unique to bicycles

- Bicycle
- Motor Vehicle
- Pedestrian

Bicyclist traveling as vehicle
Bicyclist traveling as pedestrian
Conclusions

- Use decision sight distance to accommodate increased conflicts
- Control facility speed
- Use bulb-outs at pedestrian crossings
- Control parking
- Use roundabouts at intersections
Problems with Elderly Drivers

- Progressive loss of focusing ability
- Greater sensitivity to glare
- Eye diseases reduce acuity: cataracts, macular degeneration, glaucoma
- Dynamic visual acuity to see moving targets decreases
- Twice as much brightness needed to see per decade over 25
  - By 75, 32x the brightness of 25
Night Time Problems

• These facilities must function at night
  – People see more from silhouette than from reflected light at night
  – Non-reflectorized material can be seen from:
    • 55 ft – blue
    • 80 ft – red
    • 120 ft – yellow
    • 500 ft – retro-reflective material
  – Glare recovery
    • 2 sec – 15 yrs
    • 9 sec – 65 yrs
Exhibit 1-1. Hierarchy of Movement

Source: 2001 AASHTO Policy on Geometric Design