Design Considerations for "Complete Streets"

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Objective

- Provide design geometrics and features that accommodate balanced operations of bicycles, pedestrians and vehicles on a ‘complete street’

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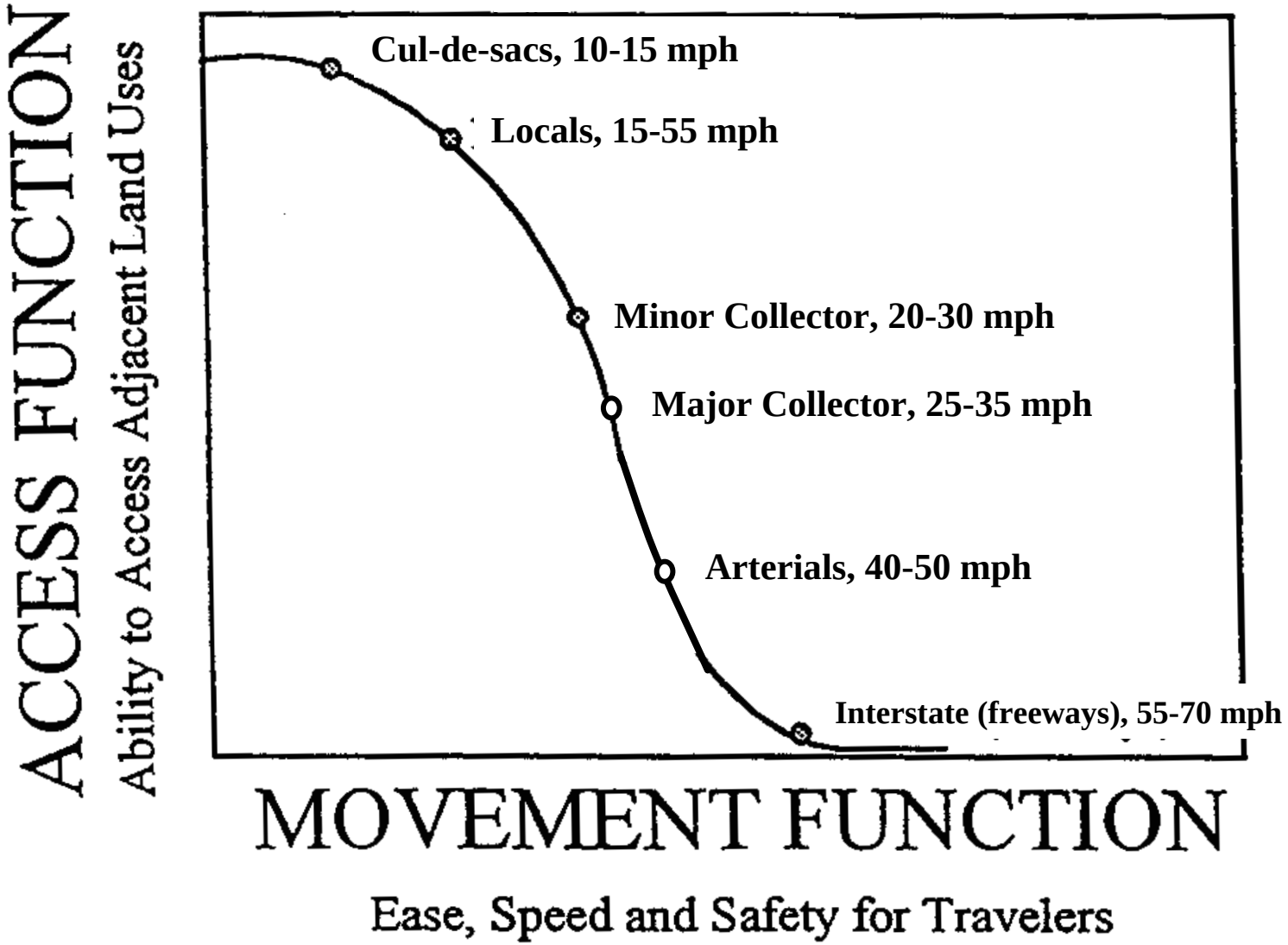
ACCESS FUNCTION
Ability to Access Adjacent Land Uses
Cul-de-sacs, 10-15 mph
Locals, 15-55 mph
Minor Collector, 20-30 mph
Major Collector, 25-35 mph
Arterials, 40-50 mph
Interstate (freeways), 55-70 mph
MOVEMENT FUNCTION
Ease, Speed and Safety for Travelers

- 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

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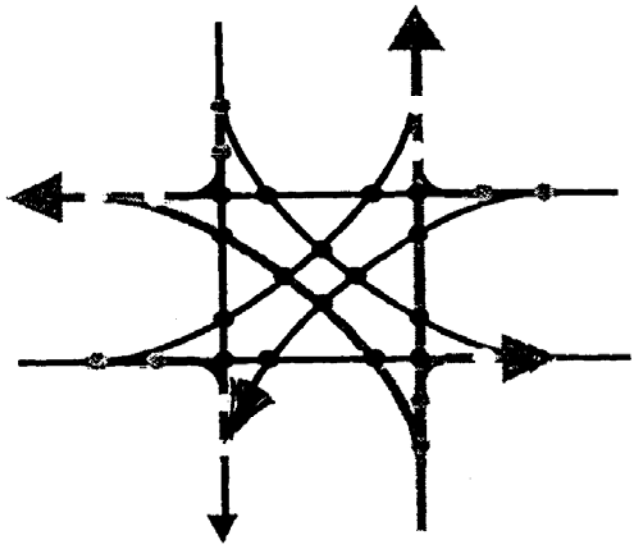
Design Considerations

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

Vehicle Conflicts

Conflict points: Conventional intersection



Conflict Types	
• Diverge:	8
Merge:	8
• Crossing:	16
Total:	32

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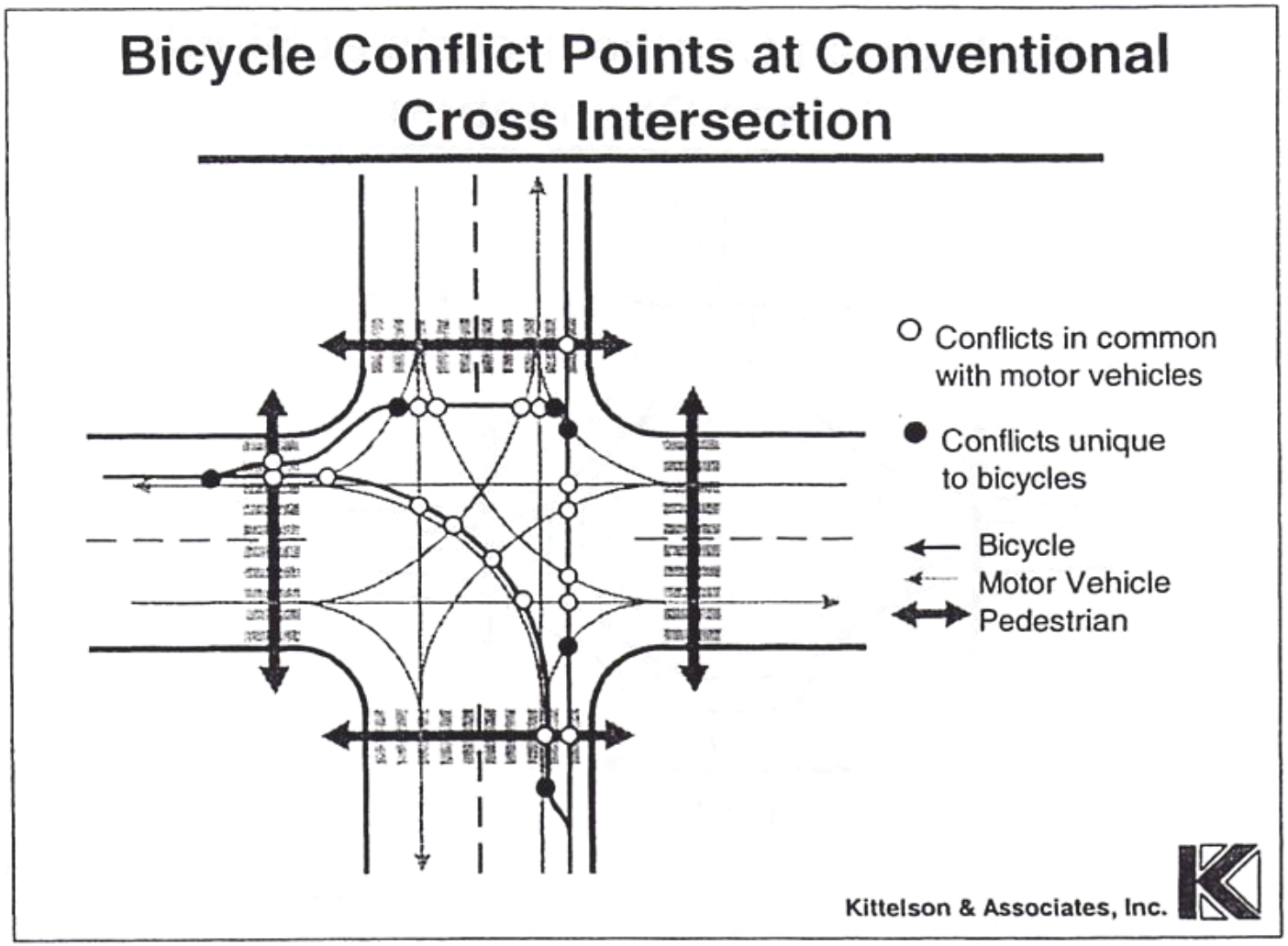
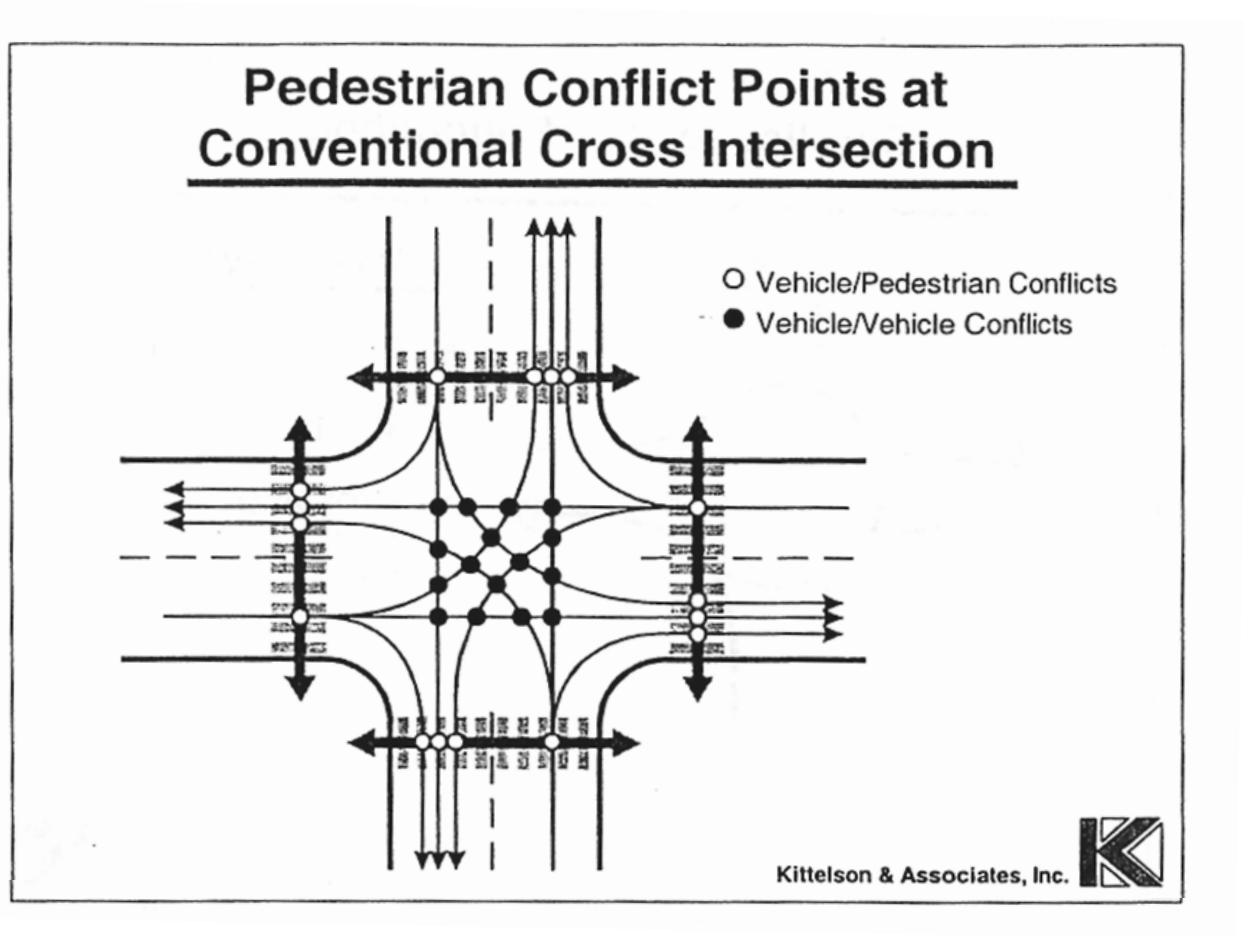
Bicycle Conflicts



Pedestrian Conflicts



Speed

Speed determines:

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

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Speed and Safety

- Accident severity is a function of speed magnitude
- Accident potential is more a function of speed differential

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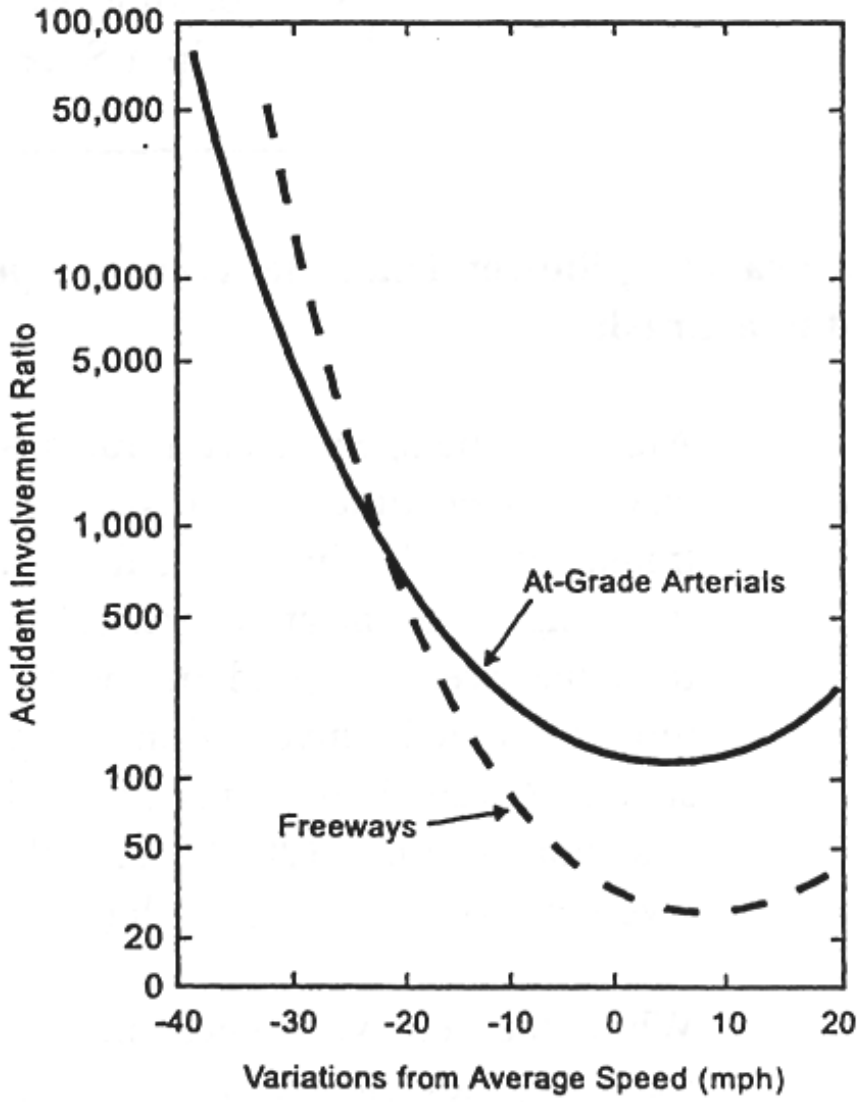

Maintain 10-15 mph, or less, speed differential

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

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Human Factors

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

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Human Factors

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

Typically 0.5 sec - 4.0 sec

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Human Factors Design Perception Reaction Time

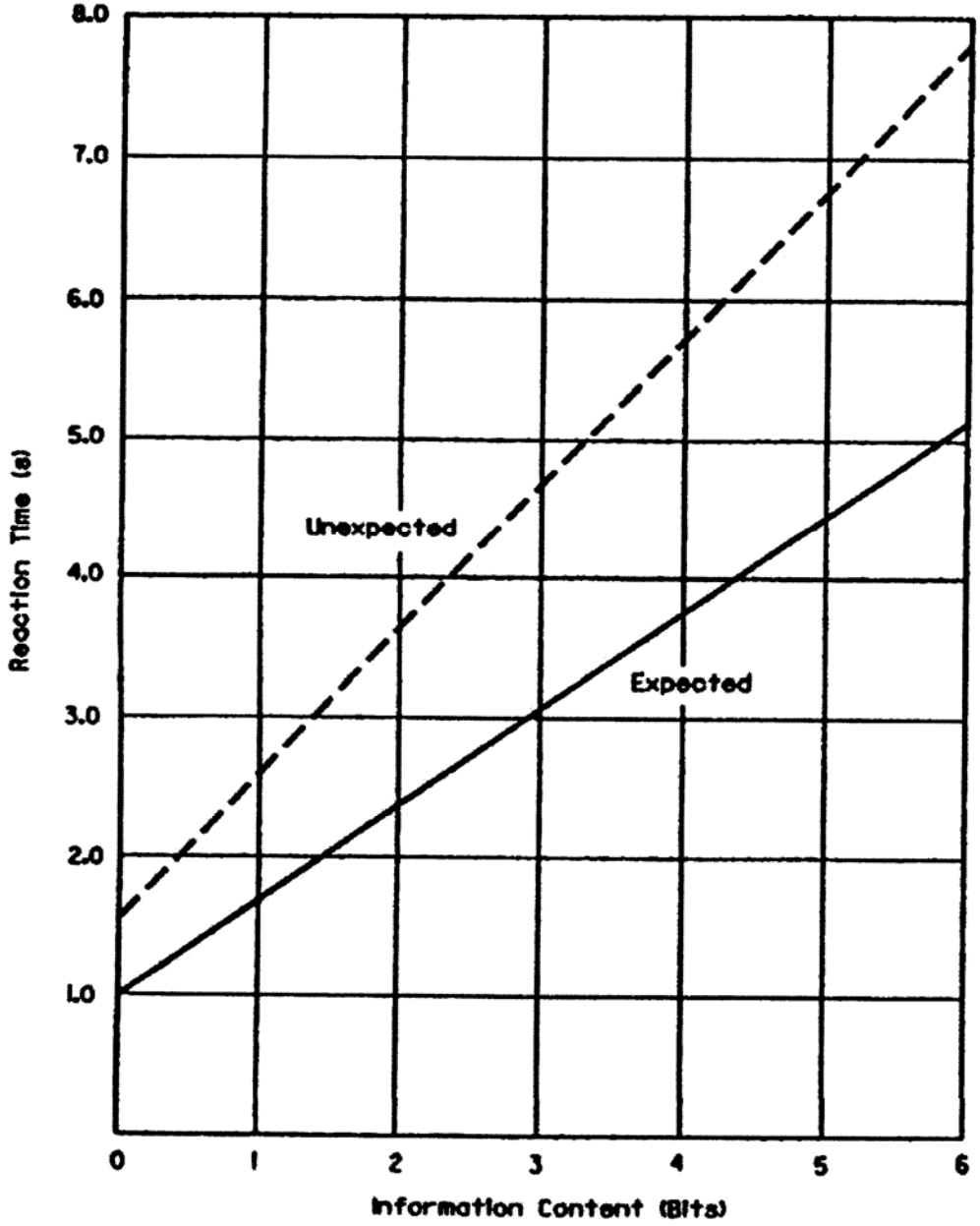

Exhibit 2-27. 85th-Percentile Driver Reaction Time to Expected and Unexpected Information

Source: *2001 AASHTO Policy on Geometric Design*

Stopping Sight Distance

Must be provided for 100% of roadway

SSD = Perception Reaction Distance + Braking Distance

Speed	SSD	Time
15 mph	80 ft	3.6 sec
20 mph	115 ft	3.9 sec
25 mph	155 ft	4.2 sec
30 mph	200 ft	4.5 sec
35 mph	250 ft	4.9 sec
40 mph	305 ft	5.2 sec

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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

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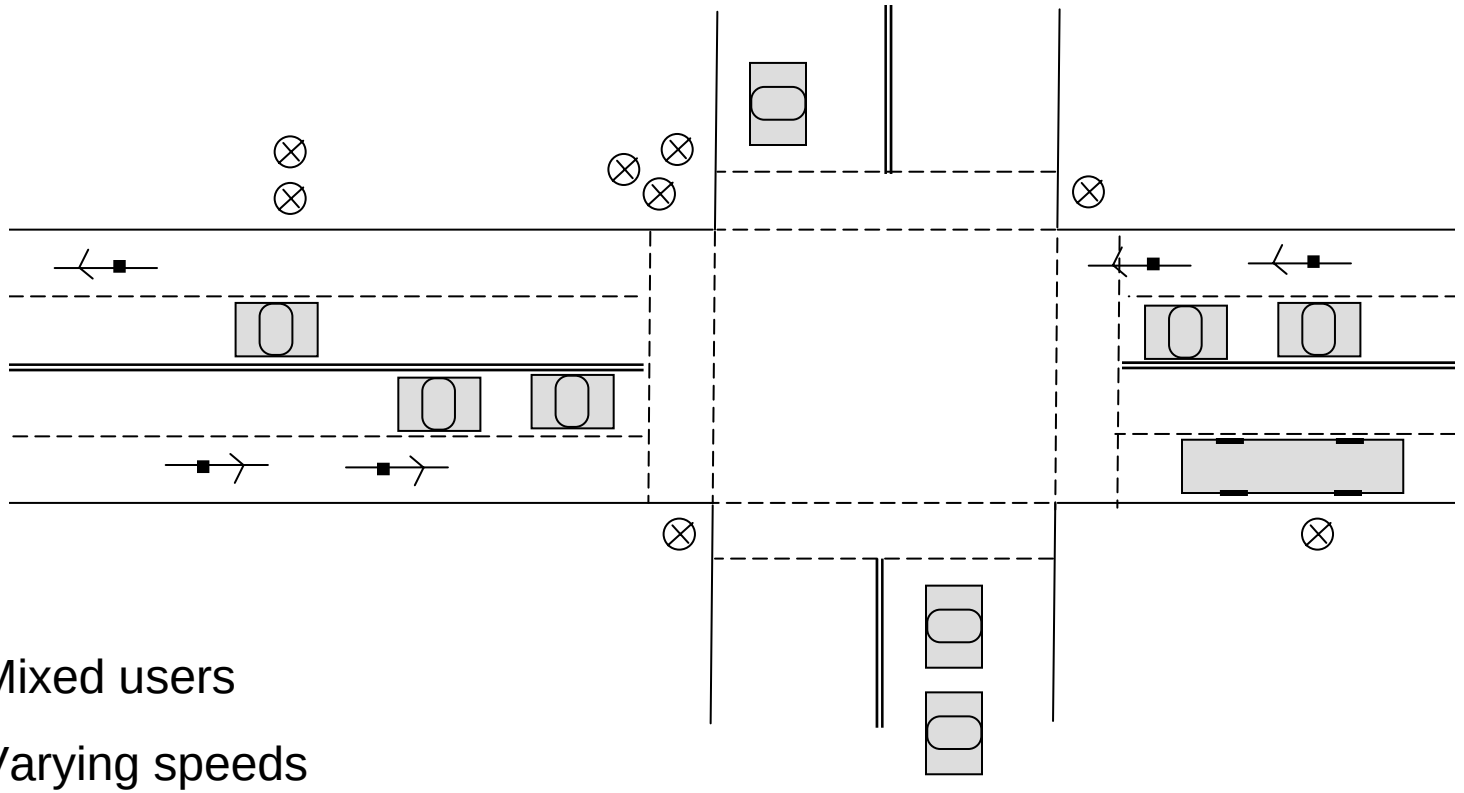
‘Complete Street’ Design Situation



- 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

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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

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Control Conflicts

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

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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)

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Reduce Parking

- Reduce lateral conflicts
- Improves sight distance
- Increases traffic flow 30%
- Reduces crashes 20-40%

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Accident Rates* by Median Type

Access Points per mile	Undivided	TWLTL	Non-Traversable
<20	3.8	3.4	2.9
20.01-40	7.3	5.9	5.1
40.01-60	9.4	7.9	6.8
>60	10.6	9.2	8.2
Total	9.0	6.9	5.6

* Crashes per million vehicle miles

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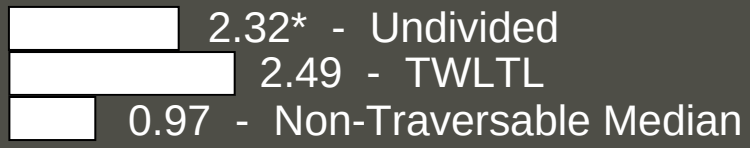
Pedestrian Crash Rates* on Suburban Arterials

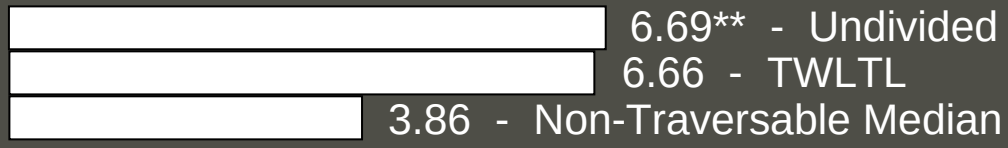
Intersection:



2.32* - Undivided
2.49 - TWLTL
0.97 - Non-Traversable Median

* Crashes per 100-million entering vehicles

Midblock:



6.69** - Undivided
6.66 - TWLTL
3.86 - Non-Traversable Median

** Crashes per 100-million vehicle miles

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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

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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

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Use One-Way Streets

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

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Use Roundabouts

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

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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

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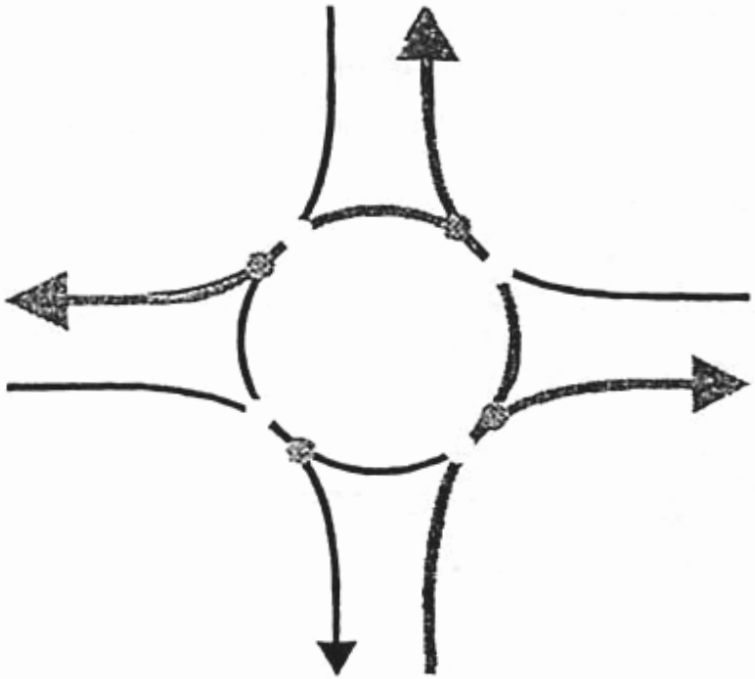
Conflict points: Roundabout



Conflict Types	
Diverge:	4
Merge:	4
Crossing:	0
Total:	8

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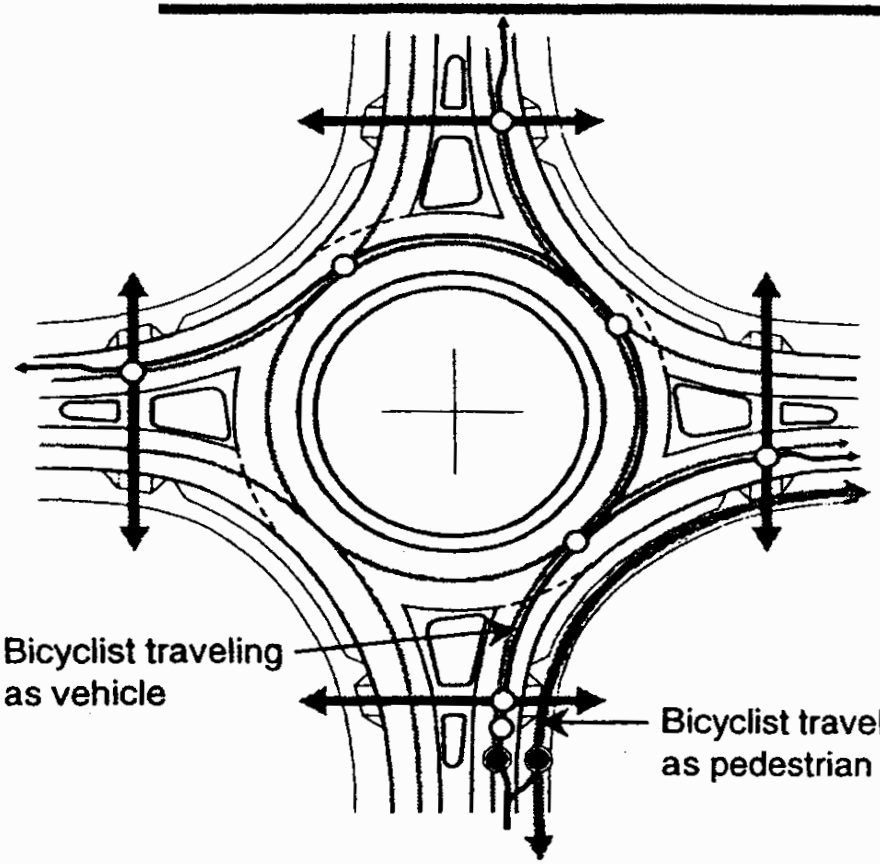
Bicycle Conflict Points at Single-lane Roundabout



○ Conflicts in common with motor vehicles

● Conflicts unique to bicycles

← Bicycle

← Motor Vehicle

↔ Pedestrian

Bicyclist traveling as vehicle

Bicyclist traveling as pedestrian

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Conclusions

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

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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

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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

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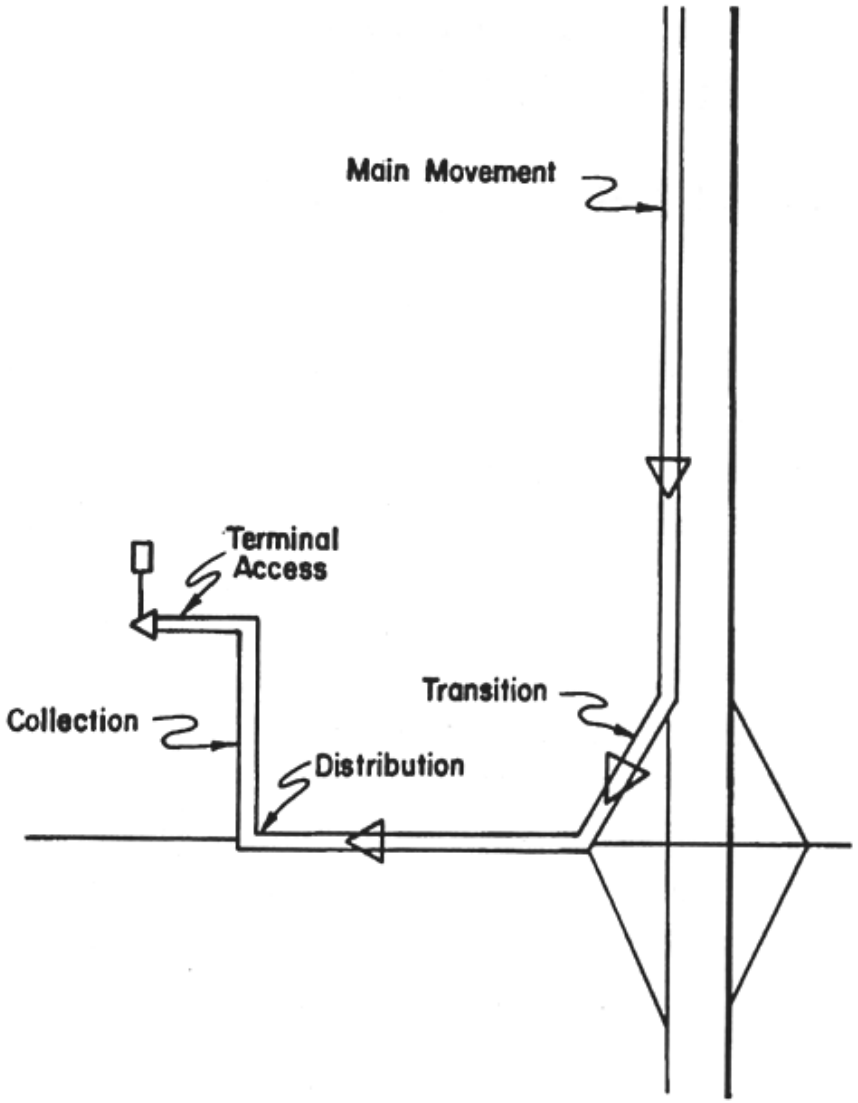

Exhibit 1-1. Hierarchy of Movement

Source: *2001 AASHTO Policy on Geometric Design*