The Challenges

- Working in built urban context
- Building around environmental resources
- Accommodating multiple modes
- Avoiding right-of-way acquisition
- Designing a retrofit solution
Urban Areas Especially Challenging

- Much competition for space, particularly in urban areas
- Significant growth in walking, biking and transit ridership

Did you know that:

- Many downtown streets have 10’ lanes
- 9’ parking lanes are often used as traffic lanes during peak periods
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Designing the “Footprint”

- How do we size the facility?
- How do we allocate the space?
- What performance requirements apply?

Putting the Pieces Together

There are many ways to “assemble” the elements of a Cross-Section
Elements are Interdependent

Finding the Flexibility

- Number of Lanes
- Space Allocation
- Lane Widths
- Shoulder Widths
- Clear Zones and Reaction Distance
- Hazard Mitigation
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**Allocating Space in Constrained Rights-of-Way**

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**Options for Allocating Space**

- Widen about the centerline using our standard typical section
- Widen asymmetrically
- Develop new, independent centerline
- Vary alignment and width to fit
- “Outside in!” (German model)

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**Function & Influence of Lane Design**

- Accommodates variation in lateral placement of vehicles in lane (and between lanes)
- Accommodates variation in widths of vehicles
- Influences traffic safety (“forgiving”)
- Influences traffic operations (capacity)
Know the Vehicle Mix

- Large trucks and buses: 8.5 ft maximum
- SUV/Small Truck: <7.5 ft
- Passenger vehicle: <6.5 ft
- Mirrors: 0.5-1.0 ft (but various heights)

Lane Width Design Values

<table>
<thead>
<tr>
<th>Type of Roadway</th>
<th>Rural</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>US (ft)</td>
<td>Metric (meters)</td>
</tr>
<tr>
<td>Freeway</td>
<td>12</td>
<td>3.6</td>
</tr>
<tr>
<td>Ramps (1 lane)</td>
<td>12-18</td>
<td>3.6-5.7</td>
</tr>
<tr>
<td>Arterial</td>
<td>11-12</td>
<td>3.3-3.6</td>
</tr>
<tr>
<td>Collector</td>
<td>10-12</td>
<td>3.0-3.6</td>
</tr>
<tr>
<td>Local</td>
<td>9-12</td>
<td>2.7-3.0</td>
</tr>
</tbody>
</table>

Source: A Policy on Geometric Design of Highway and Streets, AASHTO

Width of Traffic Lanes

All traffic lanes shall be at least 3.6 m (12 ft) wide.
Lane Width and Risk

- Rural lane width design values based on risk-based approach (NCHRP 362)
- Less direct evidence of a safety benefit of wider lanes in urban areas
- Provide for a total cross section that considers left turning vehicles, medians, and the needs of pedestrians & bicyclists

Effects of Reduced Rural Lane Width
**Effects of Reduced Urban Lane Width**

- “The lane width effects in the analyses were generally either not statistically significant or indicated that narrower lanes were associated with lower rather than higher crash frequencies. There were limited exceptions to this general finding.”

Source: Potts et al., Relationship of Lane Width to Safety for Urban and Suburban Arterials, TRB 2007 Annual Meeting.

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**Lane Width Reductions on Freeways**

![Graph](figure23.png)

*Figure 2-3. Lane Width AMF.*
Effects of Reduced Freeway Lane Width

<table>
<thead>
<tr>
<th>Lane width (ft)</th>
<th>Reduction in Free-Flow Speed (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>0.0</td>
</tr>
<tr>
<td>11</td>
<td>1.9</td>
</tr>
<tr>
<td>10</td>
<td>6.6</td>
</tr>
</tbody>
</table>

Lane Width Considerations

- Adjoining land uses (urban or rural)
- Other modes
- Operating speed
- Vehicle mix
- Specific crash history
- Cost
### Cost of Excessive Street Width

<table>
<thead>
<tr>
<th></th>
<th>Cost per 100 Ft. of Street</th>
<th>24’ Wide</th>
<th>36’ Wide</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-inch Asphalt Paving/6-inch base</td>
<td>$6,800</td>
<td>$10,880</td>
<td></td>
</tr>
<tr>
<td>6-inch Curb and Gutter</td>
<td>1,265</td>
<td>1,265</td>
<td></td>
</tr>
<tr>
<td>4-inch Sidewalk</td>
<td>1,400</td>
<td>1,400</td>
<td></td>
</tr>
<tr>
<td>CONSTRUCTION</td>
<td>$9,465</td>
<td>$13,545</td>
<td></td>
</tr>
<tr>
<td>Land (at $100,00/acre)</td>
<td>5,600</td>
<td>8,400</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL COST</strong></td>
<td><strong>$15,065</strong></td>
<td><strong>$21,945</strong></td>
<td></td>
</tr>
</tbody>
</table>
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City of Minneapolis

Design Guidelines for Streets and Sidewalks

ACCESS MINNEAPOLIS
Ten-Year Transportation Action Plan
February 22, 2008

LAKE STREET

Mn/DOT
UM Center for Transportation Studies
Advanced Design Flexibility Workshop
May 2010
SUPPERIOR ST. - DULUTH

Problems
• Minimal through traffic
• Shortage of parking
• Speeds too high
• Four driving lanes (capacity not needed)
• Not pedestrian friendly
• Context had changed

Solution
• One through lane/direction
• Angle parking
• Intersection capacity
• Good parallel routes for possible diversions

Functions of a Shoulder
• Structural support for pavement
• Emergency refuge area
• Lateral clearance to hazards
• Recovery area for lane departures
• Maintenance or Enforcement use
• Room for pedestrians and bicyclists
Shoulder Width Design Values

Ranges for Minimum Shoulder Width

<table>
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<tr>
<th>Type of Roadway</th>
<th>Rural</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Freeway</td>
<td>4–12</td>
<td>1.2–3.6</td>
</tr>
<tr>
<td>Ramps (1-lane)</td>
<td>1–10</td>
<td>0.3–3.0</td>
</tr>
<tr>
<td>Arterial</td>
<td>2–4</td>
<td>0.6–2.4</td>
</tr>
<tr>
<td>Collector</td>
<td>2–4</td>
<td>0.6–2.4</td>
</tr>
<tr>
<td>Local</td>
<td>2–4</td>
<td>0.6–2.4</td>
</tr>
</tbody>
</table>

* FHWA interpretation: “should be considered” really means “shall” (mandatory)

Shoulder Widths on Interstates

Where truck traffic exceeds 250 DDHV, a paved width of 3.6 m (12 ft) should be considered.

* FHWA interpretation: “should be considered” really means “shall” (mandatory)
Shoulder Design Principles

- Vehicle should clear traveled way by 2 feet
- Narrower shoulders are better than none at all
- Should be continuous place of refuge
- Rare exceptions for long structures
- Consider turnouts in severe topography

Shoulder Design Principles

- Can be paved, unpaved, or simply grass
- What’s important is that they’re usable
Shoulders for Shared Capacity

- Not normally considered an option to traditional widening for corridor capacity expansion
- Considered for achieving smoother flow, for sections of one mile or less
- Not recommended where large truck traffic is a significant proportion (5% to 10%) of peak period

NCHRP Report 369
Dynamic Priced Shoulder Lanes

I-35W – UPA Project
Implemented in Fall 2009

The Clear Zone Concept

• “For adequate safety it is desirable to provide an unencumbered recovery area up to 30 feet from the edge of the travelled way”
Scope of the Roadside Problem

About one in three of all highway fatalities is the result of a single vehicle run-off-the-road crash.

The Forgiving Roadside Approach

- Reduce the frequency of roadway departures
- Reduce the probability that encroachment will result in a crash
- Reduce the severity of a crash, if one does occur
Clear Zone Design Basis (from 1960s)

Almost 60% encroached at least 10 feet

80% traveled no further than 30 feet

Only 10% went as far as 50 feet

Consider Cost Implications

Budget gains $80 million

Source: Stamatiadis, University of Kentucky, Minnesota Design Forum, February 2009
Managing Risk Through Mitigation

Mitigation Strategies for Design Exceptions

Mitigating Narrow Roads

- The operational and safety effects of lane width are combined with those of other cross-sectional elements.
- Knowledge of the total effects of lane width, shoulder width, and the roadside offers insights to mitigation when less than desirable lane widths may be necessary.
Mitigating Narrow Roads

Consider Pavement Widening at Horizontal Curves
Assess the Risk

Recognize the Hazard
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**Remove the Hazard**

**Before**

**After**

**Relocate the Hazard**

**Before**

**After**
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Reduce Impact Severity

Shield the Hazard
Delineate the Hazard

Example: CSAH 20
Addressing Transitions

Speed Changes Are Critical

Source: PennDOT, Smart Transportation Guidebook, March 2008
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Visual Cues by Land Use/Activity

Visual Cues through Design
Design Exceptions

If the decision is made to go forward with a design exception, it is especially important that measures to reduce or eliminate the potential impacts be evaluated and, where appropriate, implemented.

Tort Liability

- Document ALL critical design decision.
  - Why standard design what selected
  - How flexibility was used in a holistic context
  - Why Design Exception was justified
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Exercise