Safe Urban Form

Revisiting the Relationship Between Community Design and Traffic Safety

Eric Dumbaugh
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## Focused Parking Requirements

<table>
<thead>
<tr>
<th>Classification</th>
<th>Minimum Parking (s.f.)</th>
<th>RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office Building</td>
<td>250 s.f.</td>
<td>1.0</td>
</tr>
<tr>
<td>Personal Service Shop</td>
<td>250 s.f.</td>
<td>1.0</td>
</tr>
<tr>
<td>Private School or Comm. Studio</td>
<td>100 s.f.</td>
<td>1.0</td>
</tr>
<tr>
<td>Retail Sales &amp; Service:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-1</td>
<td>250 s.f.</td>
<td>1.0</td>
</tr>
<tr>
<td>C-2</td>
<td>350 s.f.</td>
<td>1.0</td>
</tr>
<tr>
<td>C-3</td>
<td>250 s.f.</td>
<td>1.0</td>
</tr>
<tr>
<td>Restaurant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(w/o drive-through)</td>
<td>65 s.f.</td>
<td>1.0</td>
</tr>
<tr>
<td>(w/ drive-through)</td>
<td>100 s.f.</td>
<td>1.0</td>
</tr>
<tr>
<td>Rooming/Boarding House</td>
<td>Person</td>
<td>1.0</td>
</tr>
<tr>
<td>Sales Display</td>
<td>250 s.f.</td>
<td>1.0</td>
</tr>
<tr>
<td>Single-family Dwelling</td>
<td>DU</td>
<td>2.0</td>
</tr>
<tr>
<td>Shopping Center***:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-1</td>
<td>250 s.f.</td>
<td>1.0</td>
</tr>
<tr>
<td>C-2</td>
<td>350 s.f.</td>
<td>1.0</td>
</tr>
<tr>
<td>C-3</td>
<td>250 s.f.</td>
<td>1.0</td>
</tr>
<tr>
<td>Townhouse</td>
<td>DU</td>
<td>2.0</td>
</tr>
</tbody>
</table>

- What are the effects on site development?
Example 1: A Small Urban Building

- 50 sf x 100 sf = 5000 sf footprint
- 5 stories = 25,000 sf
- 1 space per 250 sf = 100 parking spaces
- Stall = 9x20 = 180 sf
- Min area = 18,000 sf
- Aisles and stall reqmt’s – typically require same area as parking
- Parking area = 36,000 sf
- Area = 0.83 acres.
- Equivalency is the area of 8 of the shown buildings
Example 2: What about the Louvre?

- 3 million sf
- 12,000 parking spaces
- 4.3 million sf parking + aisles
- 100 acres of parking
What if the Louvre met conventional parking standards in the US?
The Mall of Georgia

- 2.2 million square feet of retail...
- ... on 180 acres.
Safe Urban Form

Revisiting the Relationship Between Community Design and Traffic Safety

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The Urban Grid at the Turn of the 20th Century

“I]t has been the tendency of street planners, whether acting for the city or for landowners, to give quite inadequate attention to the need of the public for main thoroughfares laid out with sole regard for the problems of transportation.”

An Alternative: Central Park
Olmstead’s Plan for Central Park
Central Park’s Transverse Roads
“[There needs to be] a pronounced differentiation between main thoroughfares intended for traffic carriers and secondary or intermediate ones intended for local development.”

- City Planning, 1916
Functional Design

- **Arterials**
  - higher mobility
  - low degree of access

- **Collectors**
  - balance between mobility and access

- **Locals**
  - lower mobility
  - high degree of access

**Mobility**

**Land Access**
The most important reason for wide highways as boundaries arises from their relation to street safety.

With adequate express channels in the circumference of the unit, through traffic will have no excuse for invading its territory, and its own internal streets can fairly and deliberately be made inconvenient and forbidding for vehicles having no destination within the neighborhood confines.

- Clarence Perry, 1939
Perry’s Proposal for Retail Uses

It is the one of the advantages of the [neighborhood] unit scheme that it makes good business locations definite and easily found... at the traffic junctions, on the main highways which bound the unit.

- Clarence Perry, 1939
The gridiron street pattern is as obsolete as a fortified town wall. Every year, there were more Americans killed and injured in automobile accidents than the total American war causalities in any year... it was in answer to these conditions that the Radburn plan was formed.

- Clarence Stein
“Our new subdivisions have built-in traffic safety.”

- Harold Marks, 1957

Problems:

- Did not account for VMT
- Did not consider the effects of shifting retail and traffic onto arterials.
Guiding Safety Ideas

Guiding Design Ideas:

1. Design roadways for specific traffic functions.
2. Redesign street network to reduce cut-through traffic.
3. Relocate traffic-generating land uses (i.e., commercial and retail) onto arterial roadways.
Separating Arterial Design from Land Use and Community Design

• 1916: First Federal Highway Act
  – Created state bureaus of public roads (later DOTs).
  – Responsible for the development of state (and national) highway systems.
  – Major trade routes typically included in state highway systems.

• 1932: Federal gas tax adopted to support state highway systems.

“Get the farmer out of the mud!”
Revisiting Traffic Safety and Urban Form
Revisiting Crash Incidence and Urban Form
Conventional Suburban Form in San Antonio
Conventional Suburban Form in San Antonio
Operationalizing Neighborhoods: Buffered Block Groups
# Modeling Safety and Urban Form

<table>
<thead>
<tr>
<th>Control Variables</th>
<th>Urban Form Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block Group Acreage</td>
<td>Population Density</td>
</tr>
<tr>
<td>VMT</td>
<td># 3-Leg Intersections</td>
</tr>
<tr>
<td>Median Household Income</td>
<td># 4-Leg Intersections</td>
</tr>
<tr>
<td>Population Cohorts</td>
<td>Arterial Lane Miles</td>
</tr>
<tr>
<td>- 75 and Older</td>
<td>Freeway Lane Miles</td>
</tr>
<tr>
<td>- Population 18-24</td>
<td># Arterial-Commercial Uses</td>
</tr>
<tr>
<td></td>
<td># Big Box Stores</td>
</tr>
<tr>
<td></td>
<td># Neighborhood-Scaled Commercial Uses</td>
</tr>
</tbody>
</table>
Dependent Variables

- Total Crashes
- Injurious Crashes
- Fatal Crashes
Control Variables

• Block Group Acreage
• Median Household Income
• Young Drivers (Ages 18-24)
• Older Drivers (Ages 75 older)
Urban Form Variables

- Net population density (Population/Net Residential Acreage)
- Count of 3-leg intersections
- Count of 4 or more-leg intersections
- Centerline miles of freeways
- Centerline miles of arterials
• **Strip Commercial:** A retail or commercial use located adjacent to an arterial thoroughfare.

• **Big Box:** A retail or commercial use with a building area of 50,000 sf or more, but with an FAR of 0.4 or less.

• **Neighborhood Retail:** A retail or commercial use occupying 20,000 sf or less, but with an FAR of 1.0 or greater.
## Negative Binomial Models

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Injurious</th>
<th>Fatal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block group acreage</td>
<td>-0.0006***</td>
<td>-0.0004*</td>
<td>0.0005</td>
</tr>
<tr>
<td>Vehicle miles of travel (millions)</td>
<td>0.0075***</td>
<td>0.0064***</td>
<td>0.0056**</td>
</tr>
<tr>
<td>Median household income</td>
<td>0.0003</td>
<td>-0.0044**</td>
<td>-0.0083*</td>
</tr>
<tr>
<td>Population aged 18 to 24</td>
<td>0.0010**</td>
<td>0.0008***</td>
<td>0.0004</td>
</tr>
<tr>
<td>Population aged 75 and older</td>
<td>0.0006#</td>
<td>0.0003</td>
<td>-0.0002</td>
</tr>
<tr>
<td>Net population density</td>
<td>-0.0005#</td>
<td>-0.0006*</td>
<td>-0.0005</td>
</tr>
<tr>
<td>Number of three-leg intersections</td>
<td>0.0008</td>
<td>-0.0009</td>
<td>-0.0073#</td>
</tr>
<tr>
<td>Number of four-or-more-leg intersections</td>
<td>0.0050*</td>
<td>0.0068**</td>
<td>-0.0099#</td>
</tr>
<tr>
<td>Freeway miles</td>
<td>-0.0181</td>
<td>-0.0028</td>
<td>0.0488</td>
</tr>
<tr>
<td>Arterial miles</td>
<td>0.1495***</td>
<td>0.1714***</td>
<td>0.1998*</td>
</tr>
<tr>
<td>Number of arterial-oriented retail and commercial uses</td>
<td>0.013***</td>
<td>0.0111***</td>
<td>0.0053</td>
</tr>
<tr>
<td>Number of big box stores</td>
<td>0.0658***</td>
<td>0.0401*</td>
<td>-0.0367</td>
</tr>
<tr>
<td>Number of pedestrian-scaled retail and commercial uses</td>
<td>-0.0218#</td>
<td>-0.0335**</td>
<td>-0.0120</td>
</tr>
</tbody>
</table>

*p < .10   *p < .05   **p < .01   ***p < .001
Control Variables
Control Variable: Million Vehicle Miles Traveled

As MVMT increases, so does:

- Total Crashes (0.0075)
- Injurious Crashes (0.0064)
- Fatal Crashes (0.0056)
Control Variables: Median Income

Median income has no effect on total crashes, but is associated with significantly fewer fatal and injurious crashes.

This is likely attributable to the ability to purchase newer (and more crashworthy) automobiles.
Control Variable: Older Adults

The presence of adults aged 75 or older is associated with more total crashes, but has no effect on injurious or fatal crashes.
Control Variable: Young Adults

The presence of persons aged 18-24 is associated with significantly more total and injurious crashes, and more fatal crashes too (although not quite at statistically-significant levels).
Safety and Urban Form
Wider lanes and longer sight distances lead to higher vehicle speeds...

Source: Fitzpatrick et. al. (2001)
...which leads to longer stopping sight distances...
...meaning drivers are unprepared to quickly respond to common urban “hazards.”
**Systematic Design Error:** A mismatch between the way a designer *intends* a designed environment to be used, and the way it is *actually* used.

- Arterials are designed and intended for higher-speed, mobility functions
- Roadside development forces them to serve access functions.
- This combining of functions creates the majority of urban traffic safety problems:
  - Rear-end, angle, pedestrian and roadside crashes
Arterials

Each additional mile of arterial thoroughfare within a community is associated with:

- 15% increase in total crashes.
- 17% increase in injurious crashes.
- 20% increase in fatal crashes.
Arterial-Oriented Commercial Uses

Each additional arterial-oriented commercial use is associated with:

- 1.3% increase in total crashes.
- 1.1% increase in injurious crashes.
- Note: These effects are agglomerative.
Big Box Stores

Each additional big box store is associated with:

- 6.6% increase in total crashes.
- 4% increase in injurious crashes.

Table 2. Number and percentages of crashes in the City of San Antonio, by crash type and location, 2004–2006.

<table>
<thead>
<tr>
<th>Type</th>
<th>Fatal</th>
<th>%</th>
<th>Injurious</th>
<th>%</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeway</td>
<td>104</td>
<td>24.0</td>
<td>5,349</td>
<td>20.4</td>
<td>29,843</td>
<td>19.8</td>
</tr>
<tr>
<td>Arterial</td>
<td>128</td>
<td>29.6</td>
<td>9,799</td>
<td>37.4</td>
<td>51,523</td>
<td>34.2</td>
</tr>
<tr>
<td>Collector</td>
<td>27</td>
<td>6.2</td>
<td>1,916</td>
<td>7.3</td>
<td>10,001</td>
<td>6.6</td>
</tr>
<tr>
<td>Local</td>
<td>103</td>
<td>23.8</td>
<td>6,613</td>
<td>25.2</td>
<td>39,619</td>
<td>26.3</td>
</tr>
<tr>
<td>Private/off-network</td>
<td>71</td>
<td>16.4</td>
<td>2,555</td>
<td>9.7</td>
<td>19,640</td>
<td>13.0</td>
</tr>
<tr>
<td>Total</td>
<td>433</td>
<td>100.0</td>
<td>26,254</td>
<td>100.0</td>
<td>150,526</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Note: Percentages may not add to 100 due to rounding.
The Point: Land Use Decisions are Creating Traffic Safety Problems
2006 Crashes in Bryan/College Station
The conventional response is to address safety through by posting signs to change behavior

• Drivers read the road – not signs.

75% of drivers in urban areas ignore posted speed limits

Drivers fail to interpret roughly half of all road signs

Sources: Al-Madani and Al-Jahani, 2002; Chowdhury et. al., 1998; Fitzpatrick et. al., 2003; Fitzpatrick et. al., 1996; Kubilins, 2000; Tarris et al., 2000
Drivers read the road

- Drivers are *naturally inclined* to read the road – not signs

Source: Recarte and Nunes, 2002

Minor arterial designed to freeway standards
Neighborhood-Scaled Commercial Uses

Each additional neighborhood-scaled retail use is associated with

- 2.2% decrease in total crashes.
- 3.3% decrease in injurious crashes.
Considering Livable Streets

- Per vehicle mile traveled, livable streets report:
  - 40% fewer midblock crashes than roadway averages.
  - 100% fewer fatalities.

Source: Dumbaugh, 2006
The Livable Street Approach

Case Illustration:
Woodland Blvd

5-Year Totals:
• 0 Roadside Crashes
• 4 Injurious Midblock Crashes
• 0 Fatalities
Population Density

Higher concentrations of people are associated with:

- Fewer total crashes (-0.0005).
- Fewer injurious crashes (-0.0006).
Density may be more important for its moderating effects...

Higher densities:

• reduce VMT, which reduces crash incidence.

• Encourages “urban” development configurations, which reduces crash incidence.
Density and critical masses

Figure 1: Walking and bicycling in 68 California cities in 2000.

Figure 2: Walking and bicycling in 47 Danish towns in 1993–96.

Figure 3: Bicycling in 14 European countries in 1998.

Figure 4: Walking and bicycling in eight European countries in 1998.

Source: Jacobsen, 2003
What about intersections?

• Intersections reduce speeds - and thus fatal crashes – but...

• They also increase traffic conflicts.
  – 4-leg intersections are associated with INCREASED total and injurious crashes.
  – 3-Leg intersections have NO EFFECT on total or injurious crashes.
Reconsidering Street Networks

- The results do not suggest that a wholesale return to the grid is desirable.

- **Hybrid street networks**, using frequent T-intersections, are preferable to limited access or grid-iron configurations, ceteris paribus.
Intersection Alternatives

Reduces intersection conflict points from 32 to 8
Finally: What About Urban Freeways?

Freeways are not meaningfully related to total or injurious crashes.

They are associated with a positive, although statistically insignificant (0.25) increase in fatal crashes.

The principal effect of freeways is simply to enable people to drive faster.
Design Implications

1. Manage the mobility and access functions of urban arterials.

2. Orient retail and commercial uses towards lower-speed thoroughfares.

3. Plan land use, speed management, and access control at the network scale.
Solution 1: The Freeway Approach (T2)

Freeways address safety through design:

- Mobility emphasized over access.
- Grade separated – eliminating intersections.
- Wide spacing between on- and off-ramps (ideally) to permit safe merging.
- No direct land use access
- No “sensitive” road users.

Freeways are an effective design… from a safety perspective
Solution 2: Access Management (T3)

- Similar design solution appropriate on urban arterials where access-management principles are fully applied.

- Similar characteristics:
  - Higher speeds
  - Few driveways and side streets.
  - Deceleration lanes.

### Crash Rates on Urban and Suburban Roads with Different Levels of Access Control
(per Million Vehicle Miles)

<table>
<thead>
<tr>
<th>Access Points per Mile</th>
<th>Median Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Undivided</td>
</tr>
<tr>
<td>&lt;20</td>
<td>3.8</td>
</tr>
<tr>
<td>20-40</td>
<td>7.3</td>
</tr>
<tr>
<td>40-60</td>
<td>9.4</td>
</tr>
<tr>
<td>&gt;60</td>
<td>10.6</td>
</tr>
</tbody>
</table>

Source: (Committee on Access Management 2003).
A Caution about Access Management...

Space for:
- Safety
- Operations
- Flexibility
- Signal Progression
- Aesthetics

Why is ½ mile spacing so good?

45 mph
2,610 ft
Solution 3:
Livable Streets (T4-6)

- If you can’t eliminate access, then design a roadway so that speeds are matched to the roadway’s access function… which is to say, low.

- The safety performance of livable streets comes because they encourage speeds that are appropriate for access functions.
<table>
<thead>
<tr>
<th>Access Points per Mile</th>
<th>Undivided</th>
<th>Two-Way Left-Turn Lane</th>
<th>Nontraversable Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20</td>
<td>3.8</td>
<td>3.4</td>
<td>2.9</td>
</tr>
<tr>
<td>20-40</td>
<td>7.3</td>
<td>5.9</td>
<td>5.1</td>
</tr>
<tr>
<td>40-60</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>
</tbody>
</table>

Source: (Committee on Access Management 2003).
The Sprawl Transition Solution: The Hybrid “Lifestyle Center” Approach

Integrating access management and livable streets
The German Functional Classification System

**Intermediate Functions**

Urban surface highways… NEIN!

<table>
<thead>
<tr>
<th>Step 3</th>
<th>Road Surroundings</th>
</tr>
</thead>
<tbody>
<tr>
<td>without buildings concentration: low or zero</td>
<td>with buildings concentration: high</td>
</tr>
<tr>
<td>mobility (connector)</td>
<td>access (collector)</td>
</tr>
<tr>
<td>local, ped. use</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 4</th>
<th>Road Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connector</td>
<td>Statewide or Interstate Connection</td>
</tr>
<tr>
<td></td>
<td>Overregional/Regional</td>
</tr>
<tr>
<td>A</td>
<td>A1</td>
</tr>
<tr>
<td>B</td>
<td>B1</td>
</tr>
<tr>
<td>C</td>
<td>C1</td>
</tr>
<tr>
<td>D</td>
<td>D1</td>
</tr>
<tr>
<td>E</td>
<td>E1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Categories A1 to AV</th>
<th>Area Accessibility Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>A IV</td>
</tr>
<tr>
<td>A2</td>
<td>B IV</td>
</tr>
<tr>
<td>A3</td>
<td>C IV</td>
</tr>
<tr>
<td>A4</td>
<td>D IV</td>
</tr>
<tr>
<td>A5</td>
<td>E IV</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 5</th>
<th>Road Category</th>
<th>Travel Speed Range [km/h]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A I</td>
<td>70 - 100</td>
<td></td>
</tr>
<tr>
<td>A II</td>
<td>60 - 90</td>
<td></td>
</tr>
<tr>
<td>A III</td>
<td>50 - 80</td>
<td></td>
</tr>
<tr>
<td>A IV</td>
<td>40 - 60</td>
<td></td>
</tr>
<tr>
<td>A V</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>A VI</td>
<td>NO</td>
<td></td>
</tr>
</tbody>
</table>

| Primary Arterial | B II | 50 - 70 |
| Primary / Secondary Arterial | C III | 30 - 50 |
| Secondary Arterial | B III | 40 - 60 |
| Main Collector | B IV | 30 - 50 |
| Collector | C IV | 30 - 40 |
| Local | D IV | 20 - 30 |
| Local Pedestrian Use | E V | NO |
| E VI | NO |

50 km/h (30 mph) MAX in developed areas
The CNU/ITE Manual

Guidance for higher-volume thoroughfares providing access functions (i.e., 25 MPH – 35 MPH)

Commercial Street

Avenue/Boulevard
Planning and Design at the Network Level

Networks should manage speeds to be consistent with context and use.
Linking Design to Urban Form

The Transect
Concluding thoughts

• Urban traffic safety is as much a LAND USE PROBLEM as a traffic engineering problem.

• Pedestrian safety vs. motorist safety is a false choice.

• Urban designers and planners need to re-assess their role in addressing urban traffic safety.
Want more information?

- The article **Safe Urban Form** can be downloaded for free at:
  
  http://www.informaworld.com/smpp/content~db=all~content=a911996851

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