Community Design & How Much We Drive

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Average VMT (per capita per day)

- 1945: 5
- 1965: 13
- 1985: 20
- 2005: 27
Evolution of Street Networks in the U.S.
Watertown, Massachusetts 1630
Philadelphia, Pennsylvania 1682
Similar to Philadelphia but with significantly more open space.

Savannah, Georgia 1733

(http://www.wsu.edu/~owenms/URBAN/savannah.jpg)
Radburn, New Jersey 1929

Americanized version of the English Garden City

One of the earliest hierarchical road systems in the U.S.

(Southworth & Ben-Joseph, 1997)
Early street network and classification agents

• Charles Mulford Robinson—width and arrangement of streets 1911, Raymond Unwin, Harland Bartholomew; all sought through early City Planning Conferences (1909 on) to move from City Beautiful to City Functional

• Group think in 1915, City Club of Chicago conference to plan the suburb of the future used “formalized Neighborhood unit of William Drummond (Mumford later noted plagiarism by Clarence Perry and Radburn planners in the 1920s)

• Olmsted Jr. and Bion Arnold notable early collaboration to synthesize a scientific approach in Pittsburgh, earlier effort by Bartholemew in St. Louis

• Along with all of Burnham and Bennet’s plans used functional classification to separate allegedly faster and heavier traffic
“The flood of motors had already made the gridiron pattern, which had formed the framework for urban real estate for over a century, as obsolete as a fortified town wall.”

– Charles Stein
Radburn Designer

• Standards for functional classification, single use zoning, curvilinear unconnected streets and cul de sacs (AASHO, Bureau of Public Roads, state engineering schools, and early ITE)

• Herbert Hoover’s influence on standardized state planning statutes

• 1939, Toll Roads and Free Roads, FDR transmitted to Congress for the Bureau of Public Roads, called cities “decayed” and warned if no quick action urban mayors would come up with urban renewal plans of their own
Evolution of the Street Network
Called for the “abolition of the distinction between town and country by a more equable distribution of the population over the countryside.”

- Karl Marx

*The Communist Manifesto* (1848)
Federal Housing Administration (FHA) created publications recommending specific street patterns...

Formally endorsed hierarchical street layouts with cul-de-sacs
FHA called the grid layout: monotonous, with little character, uneconomical, and a safety issue...
1938 - FHA Technical Bulletin No. 7
Planning Profitable Neighborhoods

"short blocks not economical"

We should “discourage through traffic”

FHA was not only responsible for providing both mortgages & mortgage insurance, they also reviewed subdivision plans & made recommendations based upon these standards...

Overall, FHA played a role in over 22 million properties before 1960
• Various Defense Highway Acts passed 1939-1956
• Followed Rural Electrification, Water Pollution Control, Federal Power Acts
• Ignored any value to local capacity and networks
• Eisenhower Presidential Library has memo in which Eisenhower blames FHWA for trapping him with expressways to city centers
It was not until the 1950s when transportation engineers began recommending designs based upon a street hierarchy and cul-de-sacs...

**even though there was little research to support these changes**
How Do We Characterize Street Networks?

Connected
Dense
Gridded
Road Density
Block Size

Link to Node Ratio
Intersection Density
Hierarchical
Patterns
There are 3 fundamental items of interest in characterizing a street network...

i. Configuration
ii. Network Density
iii. Connectivity
Problems with the Traditional Indices...

1. Street Connectivity & Street Network Density are regularly treated like interchangeable entities

2. Even if used correctly, the numbers produced are difficult to convey & visualize

3. No sense of configuration!
Street Configurations
Citywide Street Network

Neighborhood Street Network

Tree

Grid

(Adapted from Stephen Marshall, Streets & Patterns)
Street Network Density & Street Connectivity
### Street Network Density

| Intersection Density | 144 | 144 | 144 |

### Street Connectivity

| Link to Node Ratio   | 1.61 | 1.13 | 1.16 |
| Connected Node Ratio | 0.99 | 0.78 | 0.73 |

**HIGH CONNECTIVITY ≠ A DENSE NETWORK**
Network Scale

Portland: 550 Intersections per Square Mile
Denver: 200 Intersections per Square Mile
Atlanta: 110 Intersections per Square Mile
Salt Lake City: 45 Intersections per Square Mile
<table>
<thead>
<tr>
<th></th>
<th>1.80</th>
<th>1.81</th>
<th>1.83</th>
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<tr>
<td><strong>Link to Node Ratio</strong></td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
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<tr>
<td><strong>Connected Node Ratio</strong></td>
<td>81</td>
<td>144</td>
<td>225</td>
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<tr>
<td><strong>Intersection Density</strong></td>
<td>660'</td>
<td>480'</td>
<td>375'</td>
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<tr>
<td><strong>Avg. Block Length</strong></td>
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**Street Connectivity**

**Street Network Density**
Traditional Street Network Measures

Street Network Density

Intersection Density

\[
\text{Intersection Density} = \frac{\text{# intersections}}{\text{unit area (typically square miles)}}
\]

Centerline Street Density

\[
\text{Centerline Street Density} = \frac{\text{centerline miles of streets}}{\text{unit area (typically square miles)}}
\]

Average Block Size
Traditional Street Network Measures

Street Connectivity

Link to Node Ratio

- \# \textbf{links} (road segments btw. intersections)
- \# \textbf{nodes} (intersections incl. dead ends)

The Connected Node Ratio (CNR)

- \# \textbf{real intersections} (does not incl. dead ends)
- total \# \textbf{of intersections} (real + dead ends)
California City Study
California City Study

24 medium-sized California cities

Geographically diverse with varying network types
Data included in the Models

Street Network Properties
- Street configuration
- Street network density
- Street connectivity

Street Design Properties
- Avg. Total # of Lanes
- Avg. Shoulder Width
- Raised Median
- Painted Median
- On-Street Parking
- Bike Lanes
- Raised Curbs

Traffic Counts
- Relative Activity Level
- Distance from City Center
- Proximity to Highway
- Income
- Mix of Land Uses
Degree of Mixed Land Use

Methodology adapted from Graham & Glaister (2003)

$$PE_i = \sum_j \frac{E_j}{d_{ij}} \quad \text{and} \quad PP_i = \sum_j \frac{P_j}{d_{ij}}, \quad \text{where} \quad i \neq j$$

Represents the **level of activity** based upon the levels of **population & employment** of each Block Group relative to all other Blocks Groups.

$$M_i = \frac{PE_i}{PP_i}$$

- $M_i = \text{Degree of Mixed Land Uses}$
- $PE_i = \text{Proxy for employment}$
  - $E_j = \text{Employment of Block Group } j$
- $PP_i = \text{Proxy for population}$
  - $P_j = \text{Population of Block Group } j$
- $d_{ij} = \text{Centroid distance from Block Group } i \text{ to Block Group } j$
Results
VMT: Effect of Proximity to the City Center

The graph illustrates the relationship between proximity to the city center and VMT (Vehicle Miles Traveled). The x-axis represents different distances from the city center: 1/2 mile, 2 miles, 3.5 miles, and 5 miles. The y-axis measures VMT values. The data shows an increasing trend, indicating that as the distance from the city center increases, VMT also increases.
VMT: Degree of Mixed Land Use

- Low
- Medium
- High

The graph shows the trend of VMT across different degrees of mixed land use, with High showing an increase and Low showing a decrease.
VMT: Effect of On-Street Parking
VMT: Effect of More Lanes on Major Roads

The graph shows the effect of more lanes on major roads. The y-axis represents VMT (Vehicle Miles Traveled), and the x-axis represents the number of lanes.

- **2 Lanes**: Represented by the blue line, with VMT values decreasing as the number of lanes increases.
- **6 Lanes**: Represented by the orange line, with VMT values increasing as the number of lanes increases.

The data indicates that increasing the number of lanes generally leads to higher VMT, while decreasing the number of lanes leads to lower VMT.
<table>
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<tr>
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<th>TT</th>
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<tr>
<td>Intersection Density</td>
<td>140</td>
<td>130</td>
<td>160</td>
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<tr>
<td>Link to Node Ratio</td>
<td>1.15</td>
<td>1.18</td>
<td>1.24</td>
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<td>Avg. # of Lanes</td>
<td>2.9</td>
<td>3.4</td>
<td>3.2</td>
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<tr>
<td>VMT (per person)</td>
<td>22.7</td>
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<tr>
<td>Intersection Density</td>
<td>225</td>
<td>289</td>
<td>265</td>
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<tr>
<td>Link to Node Ratio</td>
<td>1.34</td>
<td>1.37</td>
<td>1.40</td>
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<tr>
<td>Avg. # of Lanes</td>
<td>2.9</td>
<td>2.5</td>
<td>2.8</td>
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<tr>
<td>VMT (per person)</td>
<td>20.6</td>
<td>19.6</td>
<td>19.2</td>
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VMT: Effect of Link to Node Ratio
VMT: Effect of Intersection Density
VMT: Effect of Intersection Density

Graph showing the effect of intersection density on VMT with different density ranges marked on the x-axis. The y-axis represents the VMT values with various density bands.
VMT: Effect of a Curvilinear Network
VMT: Effect of a Citywide Street Int. Density

- 20 / sq. mi.
- 80 / sq. mi.
- 140 / sq. mi.

26
16
18
20
22
24
26
28

20 / sq. mi.
80 / sq. mi.
140 / sq. mi.
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<th>MODE CHOICE</th>
<th>LT</th>
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<tr>
<td>% Transit</td>
<td>3.3%</td>
<td>4.3%</td>
<td>2.1%</td>
<td>2.9%</td>
</tr>
<tr>
<td>% Walking</td>
<td>2.9%</td>
<td>3.5%</td>
<td>1.9%</td>
<td>2.9%</td>
</tr>
<tr>
<td>% Biking</td>
<td>1.6%</td>
<td>2.5%</td>
<td>0.9%</td>
<td>1.7%</td>
</tr>
<tr>
<td>% Driving</td>
<td>92.2%</td>
<td>89.7%</td>
<td>95.1%</td>
<td>92.5%</td>
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<tr>
<td>% Transit</td>
<td>N/A</td>
<td>4.3%</td>
<td>10.2%</td>
<td>10.9%</td>
</tr>
<tr>
<td>% Walking</td>
<td>N/A</td>
<td>4.8%</td>
<td>4.0%</td>
<td>9.5%</td>
</tr>
<tr>
<td>% Biking</td>
<td>N/A</td>
<td>3.3%</td>
<td>4.2%</td>
<td>4.6%</td>
</tr>
<tr>
<td>% Driving</td>
<td>N/A</td>
<td>87.6%</td>
<td>81.6%</td>
<td>75.0%</td>
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Percentage of People Walking or Biking
Effect of Intersection Density for Cul-de-sac Network

0%

5%

10%

< 81  81-144  144-225  225+
Percentage of People Walking or Biking
Effect of Intersection Density for Gridded Network

- 0%
- 5%
- 10%

Intersection Density:
- < 81
- 81-144
- 144-225
- 225+
For all types of street patterns, both street network & street design characteristics play major roles in how people use the transportation system. Across the board, denser street networks with more urban street features are associated with less driving.
Effect of Community Design on VMT?
Community Design & How Much We Drive

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