Vehicle Miles Traveled Trends and Implications for the US Interstate Highway System

The National Academies of Sciences, Engineering, and Medicine Transportation Research Board Future Interstate Study

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Disclaimer: “Prediction is very difficult, especially if it's about the future.”
Nils Bohr, Nobel laureate

How are we doing at forecasting:

- Stock market?
- Election results?
- Retail hot sellers?
- Movie/media hits?
Factors Influencing Travel Demand

Social and Economic Interactions Create Demand for Travel

Growth in Income, Knowledge

Specialization in Employment, Consumption, Social relationships, Time use

Growth in Person Travel, Commerce, Communication
Characteristics that Influence Travel Decisions

- Money Cost
- Time Cost
- Safety
- Convenience
- Reliability
- Comfort
- Flexibility
- Environmental Impact
- Image
- Social Impact

HOUSEHOLD TRAVEL
“...the current pace of change and uncertainty with regard to key factors that influence travel demand is unprecedented in the history of our Interstate System.”

**Historic Considerations**
- Population
- Demographic/household characteristics
- Geographic distribution
- Economic conditions
- Capital and operating/fuel costs
- Modal traits/preferences

**Emerging Considerations**
- Environmental/social values
- Communication substitution for travel
- Emerging mobility options (TNC, Bikeshare, carshare, etc.)
- Driverless/autonomous vehicles and mobility services
Predicting Future Demand

1. Determine factors that impact demand.
2. Determine the relationship between those factors and travel (and all the interrelationships).
3. Predict those factors into the future.
Therefore: Uncertainty

- Uncertainty regarding our knowledge of travel behavior in the emerging contexts.
- Uncertainty regarding future demand
  - In total
  - By mode
  - By functional class/on the Interstate
- Uncertainty regarding future facility capacity
  - Amount of transportation infrastructure that will be available
  - Throughput of a given facility
National VMT and VMT per Capita Trend, Moving 12-Month Total, 1990–2016

8 year reprieve

- **Vehicle-Distance Traveled (Billion Miles)**
- **VMT per Capita, Annual**

- **Annual Vehicle-Distance Traveled (Billion Miles)**
- **VMT per Capita**
National VMT and VMT per Capita, Percent Change from 1992

Graph showing the annual vehicle-distance traveled (Billion Miles) and VMT per capita percent change from 1992 from Jan-92 to Jan-17.
### Vehicle Miles of Travel Shares by Market Segment

<table>
<thead>
<tr>
<th></th>
<th>Light Vehicles</th>
<th>Heavy Vehicles</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Urban</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household-Based</td>
<td>64.56%</td>
<td>5.45%</td>
<td>70.0%</td>
</tr>
<tr>
<td>Public Vehicle, Utility, Service-Based</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household-Based</td>
<td>55.52%</td>
<td>9.04%</td>
<td></td>
</tr>
<tr>
<td><strong>Rural</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household-Based</td>
<td>21.90%</td>
<td>4.54%</td>
<td>30.0%</td>
</tr>
<tr>
<td>Public Vehicle, Utility, Service-Based</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household-Based</td>
<td>77.42%</td>
<td>12.60%</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>90.02%</td>
<td>9.98%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Sources: CIA 2013, Table 2-1, Commuting in Perspective; 2015 Highway Statistics, Tables VM2 and VM4
Role of Urban and Rural Interstate Highways in Accommodating VMT

Urban Interstate as a share of total VMT
Rural Interstate as a share of total VMT
### Changes in US Interstate Extent and Use, 1980–2015

<table>
<thead>
<tr>
<th></th>
<th>Centerline Miles</th>
<th>Lane Miles</th>
<th>VMT (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Urban Interstate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change</td>
<td>9,848.1</td>
<td>56,279.5</td>
<td>379,944.3</td>
</tr>
<tr>
<td>Percent</td>
<td>106.9%</td>
<td>116.1%</td>
<td>235.6%</td>
</tr>
<tr>
<td><strong>Rural Interstate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change</td>
<td>-2,914.9</td>
<td>-12,728.3</td>
<td>100,681.6</td>
</tr>
<tr>
<td>Percent</td>
<td>-9.14%</td>
<td>-9.7%</td>
<td>74.53%</td>
</tr>
</tbody>
</table>

Note: Decline in centerline miles and lane miles for rural Interstate attributable to reclassification of roadway segments to urban. As urban areas expand, more geography classified as urban.

Source: Highway Statistic Series, Tables VM-202, HM-260, HM-220
Average Daily VMT per Lane Mile, Urban and Rural

[Graph showing the increase in VMT (thousands) over time from 1980 to 2015, with two lines: one for Average Daily Rural Interstate VMT/Lane Mile and another for Average Daily Urban Interstate VMT/Lane Mile.]
Uncertainty Favors Seeking Robust Strategies and Testing against a Range of Conditions

(Merriam-Webster)

- **robust**
  
  $d$ : capable of performing without failure under a wide range of conditions
What Considerations go into Scenario Development?

• What consideration do we believe will be significant with respect to future travel demand?
Framework for Exploring Factors Influencing Travel Demand

Socio-Demographic Conditions
Household/Person Characteristics
- Income/wealth levels and distribution
- Age/activity level
- Culture/values
- Racial/ethnic composition
- Immigration status/tenure
- Gender
- Family/household composition

Land Use Context
- Regional/national distribution
- Density
- Mix of land uses
- Urban form
- Urban/network design
- Contiguity of development

Business, Governance, Institutional Context
- Scale of activity concentration
- Economic structure of service delivery (healthcare, education, government services, etc.)

Travel Demand
- Local person travel
- Tourism/long trips
- Freight
- Commercial travel

Travel Impacts:
- Change Trip Frequency
- Change Destination
- Change Mode
- Change Path

Transportation Supply/ Performance
- Modal availability and non-travel options to carry out activity
- Modal performance
  - Cost
  - Speed/congestion
  - Safety, security
  - Reliability
  - Convenience
  - Image, etc.
  - Flexibility
  - Environmental impact
  - Multi-tasking opportunity

Legal/Political Climate
Culture
Technology
Security
Economy
Population Growth Considerations

US Population Change by Census Region

<table>
<thead>
<tr>
<th>Census Region</th>
<th>Net Change 2000–2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast</td>
<td>4.88%</td>
</tr>
<tr>
<td>Midwest</td>
<td>5.51%</td>
</tr>
<tr>
<td>South</td>
<td>22.03%</td>
</tr>
<tr>
<td>West</td>
<td>21.30%</td>
</tr>
</tbody>
</table>

Source: Census Fact Finder, Table B01003

<table>
<thead>
<tr>
<th>Growth Category</th>
<th>Number of Counties</th>
<th>Sum of Change</th>
<th>Percent of Counties</th>
<th>Percent of Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counties that grew more than 25,000</td>
<td>377</td>
<td>37,783,846</td>
<td>12.00%</td>
<td>91.31%</td>
</tr>
<tr>
<td>Counties that grew more than 5,000 to 24,999</td>
<td>439</td>
<td>5,160,638</td>
<td>13.97%</td>
<td>12.47%</td>
</tr>
<tr>
<td>Counties that grew more than 1,000 to 4,999</td>
<td>574</td>
<td>1,443,389</td>
<td>18.27%</td>
<td>3.49%</td>
</tr>
<tr>
<td>Counties that grew less than 1,000</td>
<td>457</td>
<td>189,584</td>
<td>14.54%</td>
<td>0.46%</td>
</tr>
<tr>
<td>Counties that shrunk from 1 to 999</td>
<td>749</td>
<td>-325,475</td>
<td>23.84%</td>
<td>-0.79%</td>
</tr>
<tr>
<td>Counties that shrunk from 1,000 to 4,999</td>
<td>472</td>
<td>-997,254</td>
<td>15.02%</td>
<td>-2.41%</td>
</tr>
<tr>
<td>Counties that shrunk more than 5,000 to 24,999</td>
<td>59</td>
<td>-577,965</td>
<td>1.88%</td>
<td>-1.40%</td>
</tr>
<tr>
<td>Counties that shrunk more than 25,000</td>
<td>15</td>
<td>-1,299,029</td>
<td>0.48%</td>
<td>-3.14%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3,142</strong></td>
<td><strong>41,377,734</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Census Fact Finder, Table B01003
Population Growth Variation across US Counties
Implication of Population Growth and Settlement Patterns

• Base growth around 0.7% per year for next few decades
• Growth highly concentrated in modest share of geography
• Growth highly concentrated in urban areas
• Interstate capacity challenges exacerbated by the relocating population (net relocation has approximated half of net growth).
Implication of Population Growth and Settlement Patterns

Aggregate analyses at the national level are inherently different from those that consider specific facilities. In the case of the latter, more granularity is not only possible but critical. Thus, the percentage increase in additional capacity to maintain performance will be larger than the average percent increase in roadway volumes.
Economic Growth Considerations

• The GDP – VMT relationship is changing

• Income distribution impacts travel demand
National VMT & GDP Trends

- VMT Total (Billions)
- GDP in 2016 dollars ($Billions)
# Transportation Intensiveness of Economic Sectors

<table>
<thead>
<tr>
<th>Sector</th>
<th>Amount of Transportation Required to Produce $1 of Output (2014)</th>
<th>Contribution to GDP (2015, billions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Resources and Mining Sector</td>
<td>4.2¢</td>
<td>$500.9</td>
</tr>
<tr>
<td>Utilities Sector</td>
<td>4.6¢</td>
<td>$288.3</td>
</tr>
<tr>
<td>Construction</td>
<td>3.8¢</td>
<td>$716.9</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>3.7¢</td>
<td>$2,167.8</td>
</tr>
<tr>
<td>Wholesale and Retail Trade</td>
<td>9.9¢</td>
<td>$2,130.1</td>
</tr>
<tr>
<td>Service Sectors:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information</td>
<td>1.5¢</td>
<td></td>
</tr>
<tr>
<td>Financial</td>
<td>0.8¢</td>
<td></td>
</tr>
<tr>
<td>Professional/business</td>
<td>2.8¢</td>
<td></td>
</tr>
<tr>
<td>Education and Health</td>
<td>1.6¢</td>
<td></td>
</tr>
<tr>
<td>Leisure and Hospitality</td>
<td>3.2¢</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2.9¢</td>
<td></td>
</tr>
<tr>
<td>Government</td>
<td>4.7¢</td>
<td>$2,323.6</td>
</tr>
</tbody>
</table>

National VMT & Household Income in Bottom 80% of US Households

- VMT Total (Billions)
- Household Income of Bottom 80% (2015 $Millions)
Key Factors in Travel Demand

- Fuel Prices
- Congestion/Travel Time
- Induced Demand
- Transportation Land Use
- Automation – Self-Driving Vehicles
How Fuel Prices Influence VMT

A change in fuel price results in changes in the cost of driving, which, in turn, leads to changes in the amount of driving or VMT.

VMT is relatively insensitive to changes in fuel prices, (“inelastic”), especially in the short run.

A study by Small and Van Dender estimates the fuel price elasticity of VMT in the US during 1966-2001 at -0.047 in the short term (≈20% decrease in fuel price results in ≈ 1% increase in VMT).

The study estimates the long-run fuel price elasticity of VMT to be -0.22, almost five times as large as the short run value.
How Travel Time Influences VMT

- **Congestion** increases time cost of travel and discourages travel.

- With **Self-driving vehicles**, travel time will not be as important to travelers because they can be doing other things simultaneously.

### Travel Time Elasticity of VMT

**Short run:** -0.38  **Long-run:** -0.68


**Urban**  
**Short-run** -0.27  **Long-run** -0.57

**Rural**  
**Short-run** -0.67  **Long-run** -1.33

**Induced Travel**

*Induced travel* is the increase in use of a transportation facility due to a reduction in the cost of travel that results from capacity expansion to an existing highway.

Recent evidence suggests a range of 0.3–0.6 for the short-run elasticity of VMT with respect to highway lane-miles. Thus a 100 percent increase in roadway lane miles could result in a near-term 30–60 percent increase in VMT.

The long-run elasticity is estimated to range from 0.6–1.0, indicating that roadway expansion in congested environments might ultimately produce 60–100 percent more VMT as travelers took advantage of the new capacity in the short term and perhaps made residential and travel destination decisions in the long term that further increased their travel.
# Land Use Context – Per Capita VMT by Location Type

<table>
<thead>
<tr>
<th>Urban Continuum</th>
<th>Daily VMT per Capita (Ages 20–39)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>18.0</td>
</tr>
<tr>
<td>Second City</td>
<td>23.1</td>
</tr>
<tr>
<td>Suburban</td>
<td>27.1</td>
</tr>
<tr>
<td>Town and Country</td>
<td>32.7</td>
</tr>
<tr>
<td>Location in Urbanized Area</td>
<td></td>
</tr>
<tr>
<td>In an urban area</td>
<td>24.1</td>
</tr>
<tr>
<td>In an Urban cluster</td>
<td>25.7</td>
</tr>
<tr>
<td>In an area surrounded by urban areas</td>
<td>32.9</td>
</tr>
<tr>
<td>Not in urban area</td>
<td>35.2</td>
</tr>
<tr>
<td>Size of Urbanized Area</td>
<td></td>
</tr>
<tr>
<td>1 million + with subway or rail</td>
<td>20.2</td>
</tr>
<tr>
<td>1 million + w/o subway or rail</td>
<td>25.8</td>
</tr>
<tr>
<td>500,000–999,999</td>
<td>27.9</td>
</tr>
<tr>
<td>200,000–499,999</td>
<td>24.7</td>
</tr>
<tr>
<td>50,000–199,999</td>
<td>25.9</td>
</tr>
<tr>
<td>Not in urbanized area</td>
<td>32.4</td>
</tr>
<tr>
<td>Urban/Rural</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>24.3</td>
</tr>
<tr>
<td>Rural</td>
<td>35.2</td>
</tr>
</tbody>
</table>

Automation – Self-Driving Vehicles

• Technology changes are unique in that they affect both demand and supply

• Scenario research suggests VMT impacts of automation ranging from -35% to plus 130%
VMT Forecast Sources

• FHWA forecasts an annual average growth rate of 0.47 percent for light-duty vehicles, 1.50 percent for single-unit trucks, and 1.87 percent for combination trucks, and 0.61 percent for all vehicles combined during 2014-2044.

• DOE for its 2017 Annual Energy Outlook, projects an average annual growth rate of 0.70 percent for personal and light-duty fleet travel, 1.50 percent for light commercial truck travel, and 1.3 percent for freight truck travel during 2015-2050.

• 2015 AASHTO Bottom Line Report uses 1.0 and 1.4% per year VMT growth Scenarios.

• 2015 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance uses 1.04% per year growth in VMT.
Role of Forecasts

• VMT forecasts can inform discussion regarding future Interstate System capacity requirements; however, financial and policy decisions, many made locally, will inevitably govern actual capacity expansion.

• The criticality of precision in VMT forecasts is muted by the fact that the Interstate System is part of a broader network of transportation facilities and services in which the consequences of failing to expand capacity are spread over a broader network.
Average VMT Growth in Context

- <1 % increase in population
- 2 % increase in GDP
- \( \approx 2 \% \) increase in total VMT
- need for \( \approx 3 \% \) increase in Interstate System capacity,
- \( \approx 5+\% \) increment in Interstate infrastructure asset value to sustain Interstate System performance.
VMT Growth Levels

✓ For the next two decades VMT growth levels between 0.7% (population growth level) to 2% are reasonable absent extraordinary economic events.

✓ Beyond two decades, automation may impact demand and capacity in ways that will require scenario updates based on emerging evidence.
Caveats

• Urban Interstate capacity expansion is the most complex and expensive context for capacity expansion. In urban environments, policy considerations associated with the social, environmental, and financial implications of capacity expansion will create huge challenges and place a premium on capacity expansion strategies that can be deployed within existing facility footprints.

• The investment requirements will be even higher if the cost of consensus results in low-priority investments working their way into the program of improvements.
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