Roadway Capacity Implications of Connected and Autonomous Vehicles

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Outline

- Background
- Operational Analysis
- Planning Analysis
- Future Research
- Conclusion
Public Perception of Capacity Implications

- San Diego Union Tribune. October 11, 2016

  - “say no to SANDAG: reject backward looking Measure A”

  - “… projects that may not be necessary in a future in which networks of autonomous vehicles reduce congestion”

  - “… no one has a firm grasp on what those needs will be in five or ten years time”
Safety Implications of Automated Vehicles

Accident Rate

Traditional Vehicles

Automated Vehicles

Capacity Implications Of Connected and Autonomous Vehicles
## SAE Levels of Automation

<table>
<thead>
<tr>
<th>Level 0</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="blue.png" alt="Car" /></td>
<td><img src="purple.png" alt="Car" /></td>
<td><img src="purple.png" alt="Car" /></td>
<td><img src="purple.png" alt="Car" /></td>
<td><img src="red.png" alt="Car" /></td>
<td><img src="red.png" alt="Car" /></td>
</tr>
<tr>
<td>No automation</td>
<td>Some assistance to driver</td>
<td>Driver operation with some automated functions</td>
<td>Vehicle operation with driver ready to take control</td>
<td>Vehicle capable of all functions under certain conditions</td>
<td>Full automation</td>
</tr>
</tbody>
</table>

**Capacity Implications Of Connected and Autonomous Vehicles**
The Challenge of Full Automation

Capacity Implications Of Connected and Autonomous Vehicles
ITE Statement on Connected and Automated Vehicles

- We will only get to zero fatalities and serious injuries through CV/AV technology.
- We support the rapid adoption of safety assist (SAE Levels 0 and 1) technologies.
- SAE Level 2 systems have not been proven safe for use on the open road, in all intended environments.
- Currently, there is insufficient evidence that SAE Level 3 systems with partial automation can be safely implemented.
- SAE Level 4 systems are the most appropriate as an objective for “driverless vehicles”
Steps in Typical Highway Capacity Manual Process

- Observe Operations to Determine Appropriate Parameters
- Data Collection
- Data Analysis to Determine Sensitivity of Input Parameters
- Develop Model
  *Analysis Supplemented by Simulation*
- Calibrate Model Based on Observed Data
- Validate Model

HCM Procedures
- Planning *(Simple)* and Operations *(Complicated)*
Freeways

Capacity Implications Of Connected and Autonomous Vehicles

Traditional Vehicle

Automated Vehicle
Merge Areas

Traditional Vehicle

Automated Vehicle

Capacity Implications Of Connected and Autonomous Vehicles
Capacity Implications Of Connected and Autonomous Vehicles

Rural Two-Lane Highways
Unsignalized Intersections

Capacity Implications Of Connected and Autonomous Vehicles
Signalized Intersections

Phase Time = 3.8 + (2.1 x n)

n = Number of Vehicles

Phase Time = ?

Phase Time = ?
Sample Analysis of Headway Versus Penetration Rate of Automated Vehicles

CAVS & Traffic Signals: Saturation Headway

Average headway of mixed traffic VS penetration rate of AV
Planning Analysis

- Typically Analysis of Future Conditions
- Default Values
- Reduced Accuracy of Input Values and Final Results
Future Research

Pooled-Fund Study: CAV Capacity Modification Factors

Effects of Automated/Connected Vehicles on Freeway Capacity and Operations
Conclusion

High Expectations

Many Unknowns
- Is SAE Level 5/Full Automation possible in the foreseeable future?
- When will it occur?
- What level of safety will be demanded by the public?
- What will the capacity effects be with a mixture of automated and traditional vehicles?
- What are the effects of CAV’s on travel demand?
- What are the effects of other innovative technologies such as Mobility as a service

Current research may provide some answers

More research needed