Fuel Economy Testing and Connected Automated Vehicles

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Costa Samaras
Carnegie Mellon University
csamaras@cmu.edu
@CostaSamaras
Automation Has Interdependent Effects on Energy

- National Energy Use
- Regional: Land Use, Density, Travel Patterns
- City: Infrastructure Design, Services, and Management
- Vehicle: Design and Optimization
How Will Fuel Economy Be Affected?

- Vehicle models such as Autonomie, PSAT, VTCFCM
There Are Six Levels of Automation

<table>
<thead>
<tr>
<th>Level</th>
<th>Name</th>
<th>Who is Driving?</th>
<th>Who is Monitoring?</th>
<th>Who Intervenes?</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Automation</td>
<td>✖</td>
<td>✖</td>
<td>✖</td>
</tr>
<tr>
<td>1</td>
<td>Driver Assist</td>
<td>✖</td>
<td>✖</td>
<td>✖</td>
</tr>
<tr>
<td>2</td>
<td>Partial Automation</td>
<td>✖</td>
<td>✖</td>
<td>✖</td>
</tr>
<tr>
<td>3</td>
<td>Conditional Automation</td>
<td>✖</td>
<td>✖</td>
<td>✖</td>
</tr>
<tr>
<td>4</td>
<td>High Automation</td>
<td>✖</td>
<td>✖</td>
<td>✖</td>
</tr>
<tr>
<td>5</td>
<td>Full Automation</td>
<td>✖</td>
<td>✖</td>
<td>✖</td>
</tr>
</tbody>
</table>

Source: Adapted from NHTSA and SAE J3016

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Civil and Environmental Engineering
Automation Can Make Cars More Efficient
Simulated Fuel Economy Across Level 2 and Connected Features

• Simulate individual AVs following vehicle obeying the current EPA urban and freeway test cycles

• Use the drive schedules derived from these simulations to run additional cycles to weight in the official fuel economy, for any vehicle with Level 2 features or above

• Two Level 2 Automation rulesets
  – One with a target headway
  – One with a target velocity

• Connected-Autonomous Vehicle Proxy
  – The AV attempts to keep constant acceleration for a period of time based upon foresight of the lead vehicles actions
No Incentives to Prioritize Fuel Economy When Designing CAVs

- Our results showed that AV technology can increase mpg up to +10%, or decrease down to -3% depending on how it is implemented.
- Control strategies that are most similar to those currently on the market were more likely to have a decrease in fuel economy.
- Currently manufacturers who add these features can advertise them only as a convenience improvement, without any fuel economy benefit.
Challenges With Off-Cycle Credits

• Off-cycle technology credits only apply to new and nonstandard technologies.

• The process is non-standardized, and a manufacturer must submit a testing and validation method, which has to be granted preliminary approval, and go through a public review process. In addition, the EPA will not certify the method or results meaning that these technologies may not be tested equivalently.

• The final challenge is that this will only apply for CAFE standards and not fuel economy ratings that inform the consumer.
Fuel economy testing of autonomous vehicles
Avi Chaim Mersky⁎, Constantine Samaras
Carnegie Mellon University, Swartz Hall 115, 5000 Forbes Avenue, Pittsburgh, PA 15213-3890, USA

Abstract
Environmental pollution and energy use in the light-duty transportation sector is currently regulated through fuel economy and emissions standards, which typically account for quantity of pollutants emitted and volume of fuel used per distance driven. In the United States, fuel economy testing consists of a vehicle on a treadmill, while a trained driver follows a fixed drive cycle. By design, the current standardized fuel economy test system neglects differences in how individuals drive their vehicles on the road. Autonomous vehicle (AV) technology is introduced, more aspects of driving are shifted to functions of decisions made by the vehicle, rather than the human driver. Yet the current fuel economy testing procedure does not have a mechanism to evaluate the impact of AV technology on fuel economy ratings, and subsequent regulations such as Corporate Average Fuel Economy (CAFE). This paper develops a method to incorporate the impact of AV technology within the bounds of current fuel economy test, and simulates a range of automated following drive cycles to estimate changes in fuel economy. The results show that AV following algorithm design without considering efficiency can degrade fuel economy by up to 21%, while efficiency-focused control strategies may equal or slightly exceed the existing EPA fuel economy test results, by up to 10%. This suggests the need for a new near-term approach in fuel economy testing to account for connected and autonomous vehicles. As AV technology improves and adoption increases in the future, a further reimagining of drive cycles and testing is required.

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What pathways affect MPG benefits?

- Efficient driving
- Efficient routing
- Platooning
- Congestion
- Less congestion due to crashes
Level 2 technologies can save energy but what about rebound?

Autonomous Vehicles Will Be Introduced Because of Safety Benefits

Policy Can Probably Guide the Sign for Energy

- New sources of demand could be balanced with increased efficiency standards and/or lower GHG fuel standards
- Local land use and State infrastructure investments will affect the energy use of autonomous vehicles
- Shared autonomous electric vehicles shift the way we think about infrastructure and mobility
- Freight and logistics networks will be early adopters
Questions?

Thank you!

[Email: csamaras@cmu.edu]

[Handle: @CostaSamaras]
Reducing Electricity Emissions Looks Easy Compared to Transportation

- Fuel Oil: Marine
- Natural Gas: Pipelines
- Electricity: Transit
- Diesel: Primarily from Trucks
- Jet Fuel & Aviation Gas
- Gasoline: Primarily from Light-Duty Vehicles

U.S. Transportation Sector GHGs (Million Metric Tons CO2-eq)

- 80% Below 2005 Transportation Emissions

Data from Oak Ridge National Laboratory. Small amount from LPG is included and not labeled.

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Automation Could Increase Travel Access

• Analyzed NHTS data to understand travel demand by age and gender
• If underserved groups each traveled as much as the general population, VMT would increase by 14%, or about 300 billion miles
• Increases access, but brings additional challenges: need objective assessments and policy analyses with multi-criteria

Summary

• AV features could increase or decrease vehicle fuel economy
• If everyone drove like typical adults VMT would go up ~14%
• Early automation features pass a cost benefit test right now
• A clean grid needed for life cycle environmental benefits of AEVs