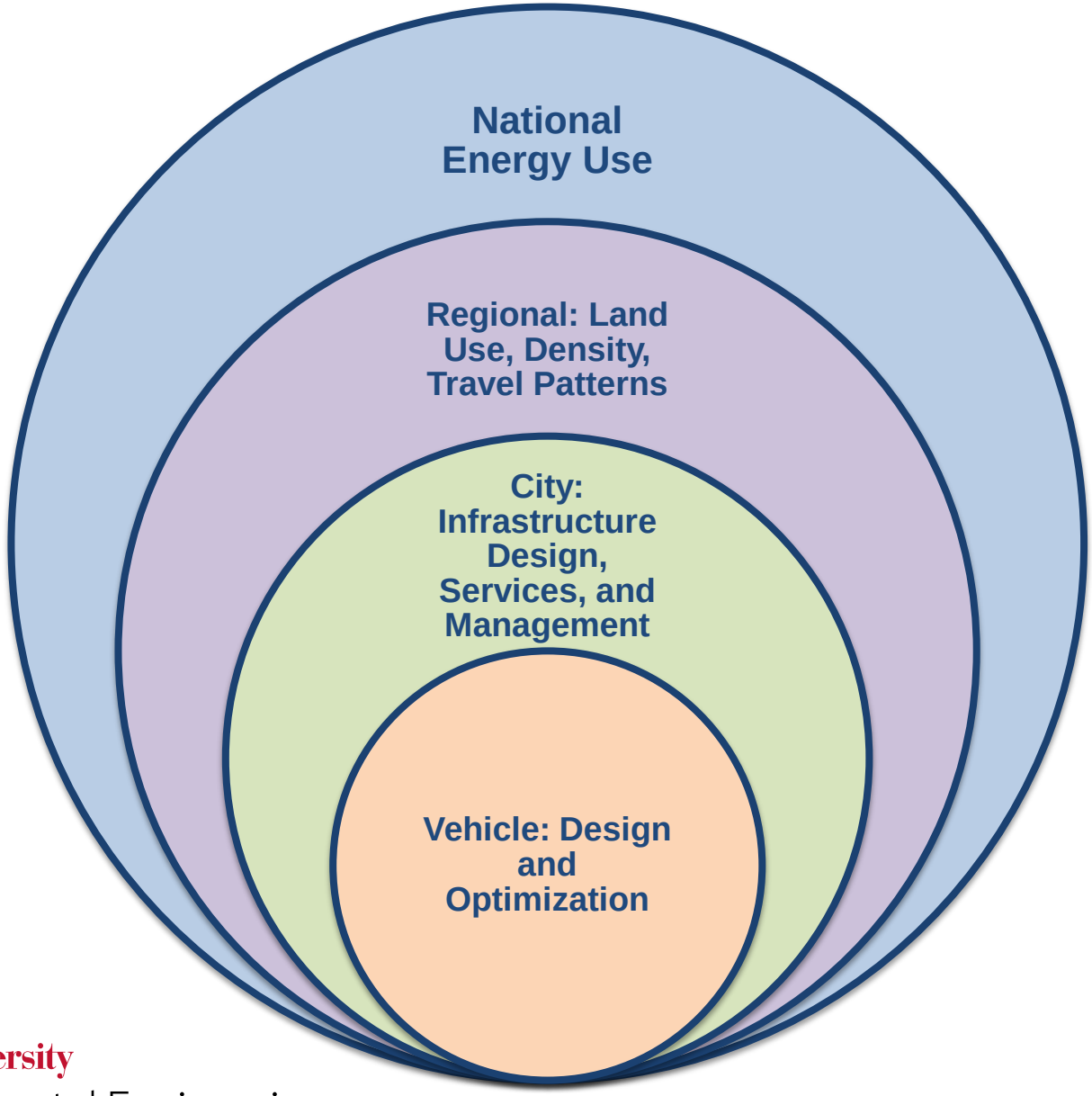
Fuel Economy Testing and Connected Automated Vehicles

April 7, 2017

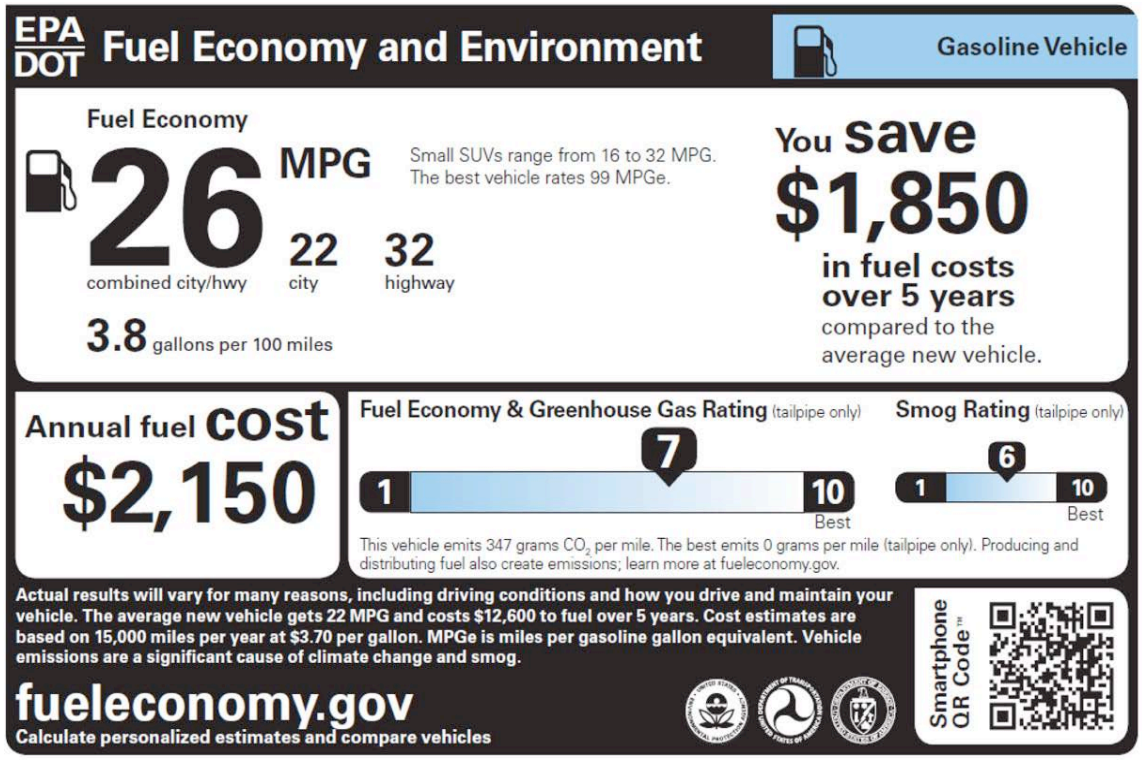
Costa Samaras
Carnegie Mellon University
csamaras@cmu.edu
@CostaSamaras

Technologies for Safe and Efficient Transportation
A U.S. DOT UNIVERSITY TRANSPORTATION CENTER
traffic21
a transportation research institute of Carnegie Mellon University

Automation Has Interdependent Effects on Energy



How Will Fuel Economy Be Affected?



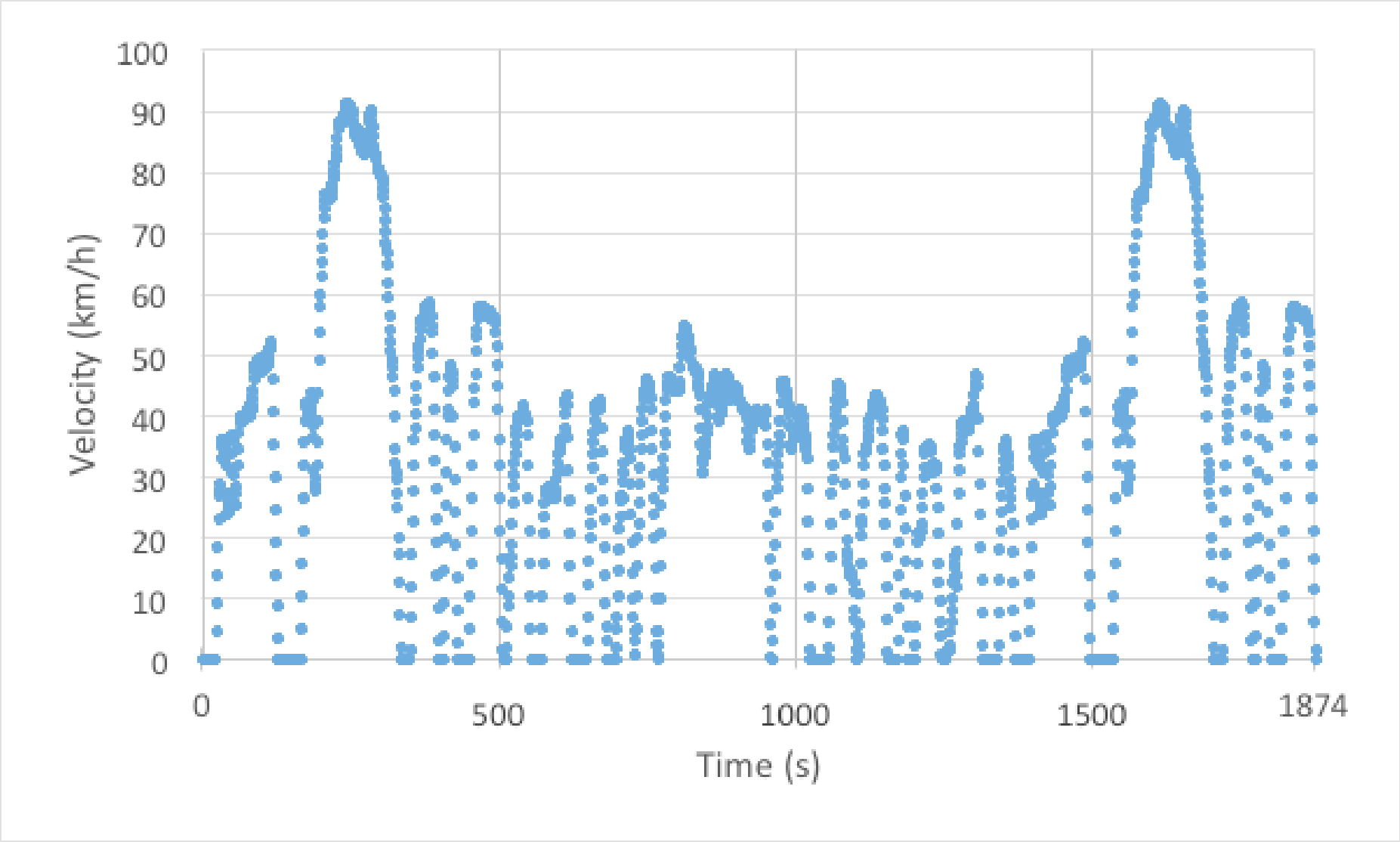
- Vehicle models such as Autonomie, PSAT, VTCFCM

There Are Six Levels of Automation

Level	Name	Who is Driving?	Who is Monitoring?	Who Intervenes?
0	No Automation	☐	☐	☐
1	Driver Assist	☐ ☐	☐	☐
2	Partial Automation	☐ ☐	☐	☐
3	Conditional Automation	☐	☐	☐
4	High Automation	☐	☐	☐ ☐
5	Full Automation	☐	☐	☐

Source: Adapted from NHTSA and SAE J3016

Automation Can Make Cars More Efficient



Source: Mersky and Samaras, 2016

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

EPA Should Incorporate AVs Into mpg Testing

Transportation Research Part C 65 (2016) 31–48

Contents lists available at ScienceDirect

Transportation Research Part C

journal homepage: www.elsevier.com/locate/trc

Fuel economy testing of autonomous vehicles

Avi Chaim Mersky*, Constantine Samaras

Carnegie Mellon University, Porter Hall 119, 5000 Forbes Avenue, Pittsburgh, PA 15213-3890, USA

ARTICLE INFO

Article history:
Received 5 September 2015
Received in revised form 31 December 2015
Accepted 2 January 2016

Keywords:
Autonomous vehicles
Fuel economy
Adaptive cruise control
AV
ACC
Vehicle testing

ABSTRACT

Environmental pollution and energy use in the light-duty transportation sector a currently regulated through fuel economy and emissions standards, which typically asse quantity of pollutants emitted and volume of fuel used per distance driven. In the Unit States, fuel economy testing consists of a vehicle on a treadmill, while a trained driv follows a fixed drive cycle. By design, the current standardized fuel economy testi system neglects differences in how individuals drive their vehicles on the road. autonomous vehicle (AV) technology is introduced, more aspects of driving are shifted in functions of decisions made by the vehicle, rather than the human driver. Yet the curre fuel economy testing procedure does not have a mechanism to evaluate the impacts of A technology on fuel economy ratings, and subsequent regulations such as Corpora Average Fuel Economy targets. This paper develops a method to incorporate the impac of AV technology within the bounds of current fuel economy test, and simulates a ran of automated following drive cycles to estimate changes in fuel economy. The results show that AV following algorithms designed without considering efficiency can degrade fuel economy by up to 3%, 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.

THE FUSE | Igniting conversations and commentary about energy

< BACK TO AUTONOMOUS VEHICLES

CMU: Testing Of Autonomous Vehicles Needed To Drive Fuel Economy Gains

by Leslie Hayward | March 31, 2016

SHARE

Green Car Congress

Energy, technologies, issues and policies for sustainable mobility

23 May 2016 Home Topics Archives About Contact RSS twitter Headlines Search GCC

« Aemetis acquires license from LanzaTech with California exclusive rights for advanced ethanol from biomass including forest and ag wastes | Main | ABI Research: 6 transformative paradigms driving toward smart, sustainable automotive transportation »

Print this post

CMU study shows autonomous vehicle algorithms can have considerable effect on fuel economy; need for new approaches in testing

24 March 2016

Autonomous vehicle driving behavior can have a considerable effect on fuel economy. Researchers in the College of Engineering at Carnegie Mellon University have determined that fuel efficiency for self-driving cars—within the bounds of current fuel economy testing—could improve by up to 10% under efficiency-focused control strategies when following another vehicle.

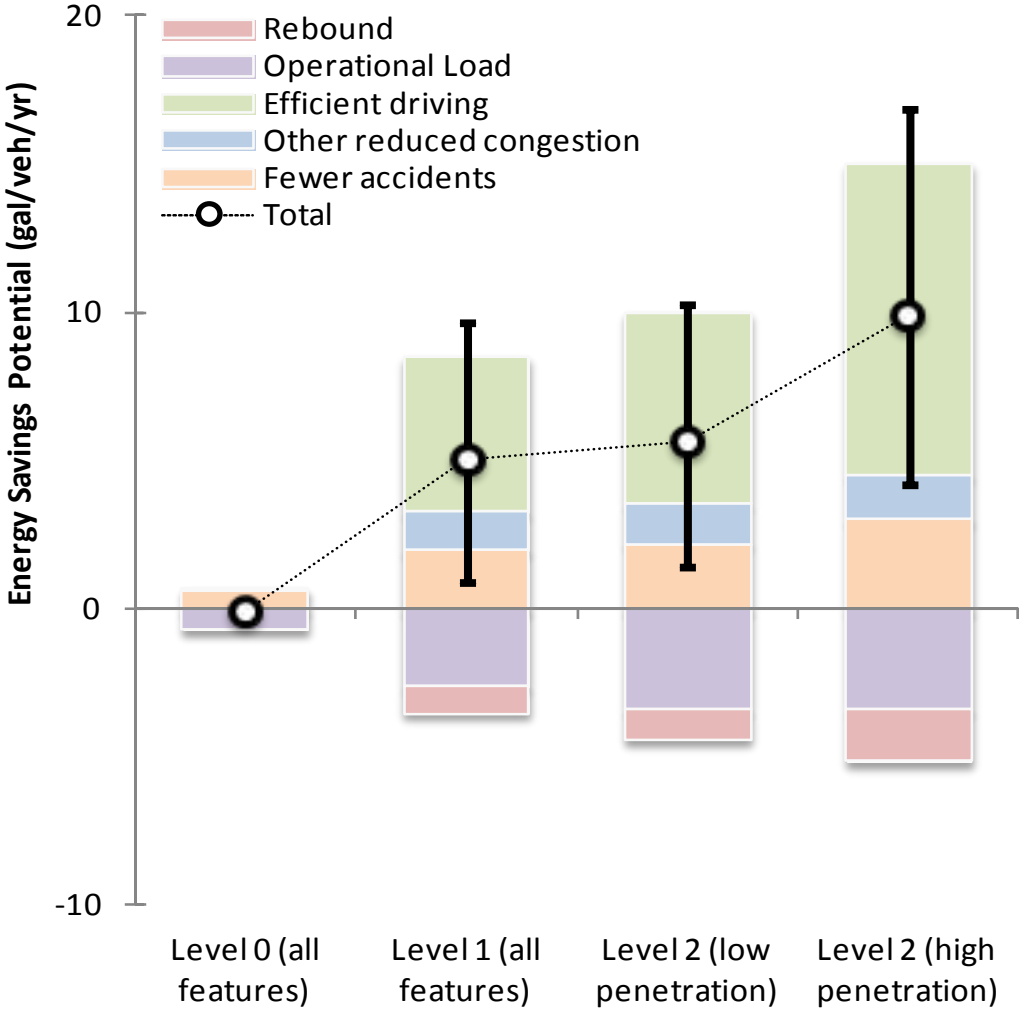
However, the study also showed that autonomous vehicle (AV) technology following algorithms designed without considering efficiency can degrade fuel economy by up to 3%. In a paper published in the journal *Transportation Research Part C: Emerging Technologies*, Assistant Professor of Civil & Environmental Engineering Constantine Samaras and Ph.D. student Avi Chaim Mersky suggest the need for a new near-term approach in fuel economy testing to account for connected and autonomous vehicles.

Source: Mersky and Samaras, 2016

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?



Source: Mashayekh, Michalek, Hendrickson, Samaras, 2014. Under Review. Preliminary Results.

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**

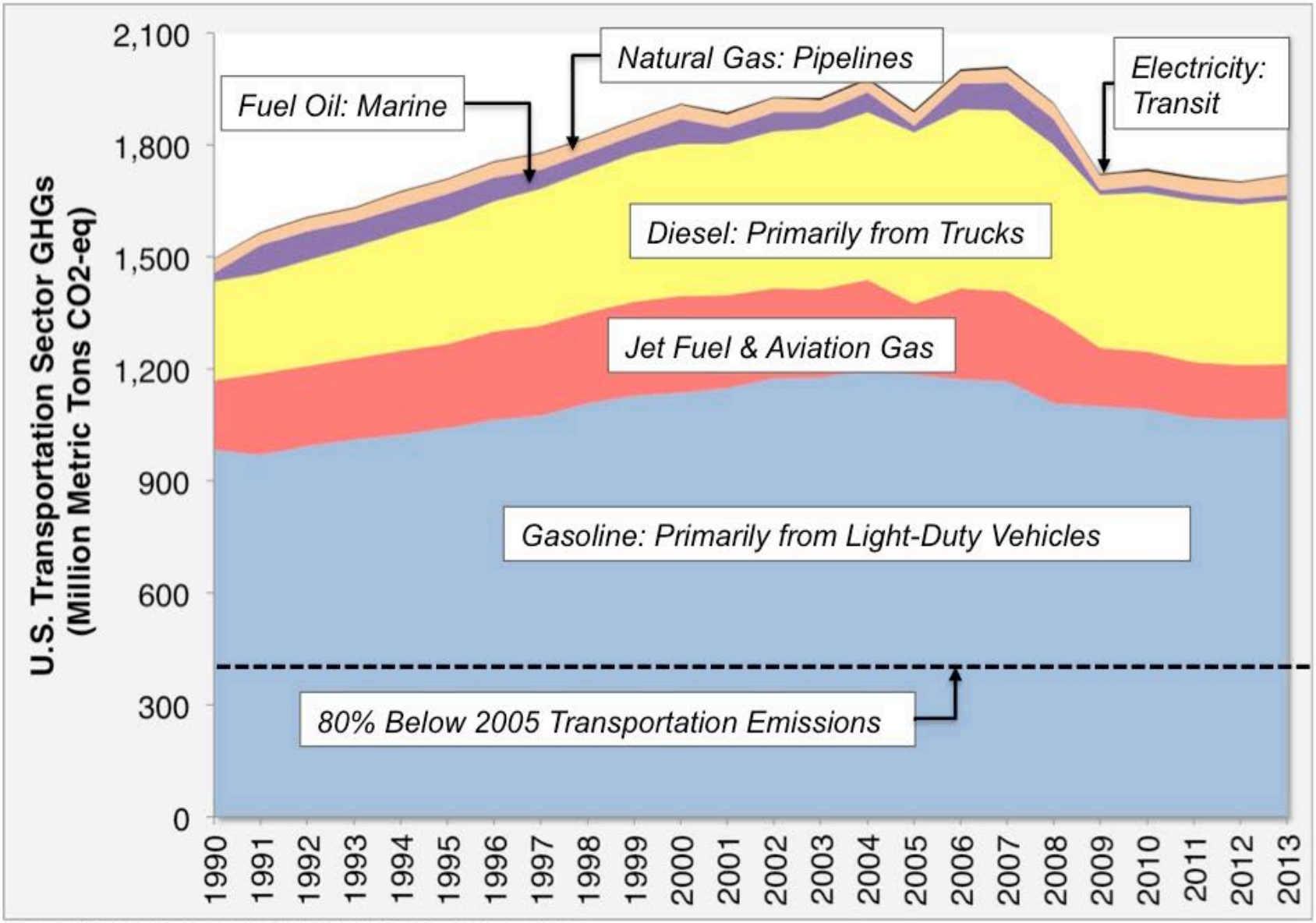
Questions?

Thank you!

csamaras@cmu.edu

@CostaSamaras

Reducing Electricity Emissions Looks Easy Compared to Transportation



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

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

Source: Harper, Mangones, Samaras, Hendrickson, 2014. Under Review

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