New **E**ngland **U**niversity **T**ransportation **C**enter

NE University Transportation Center
77 Massachusetts Avenue, E40-279
Cambridge, MA 02139
Phone: 617-253-0753
Fax: 617-258-7570
web.mit.edu/utc

Principal Investigator:	Lisa Aultman-Hall	**Co-Principal Investigator:**	Clara Fang
Title:	Professor	**Title:**	Associate Professor
University:	University of Vermont	**University:**	University of Hartford
Email:	laultman@uvm.edu	**Email:**	Clara Fang <fang@hartford.edu>
Phone:	802 656 1312	**Phone:**	860.768.4845

Final Report

Project Title:

Characterize Older Driver Behavior for Traffic Simulation and Vehicle Emission Model

Project Number:	**Project End Date:**	**Submission Date:**
UVMR20-12	8/31/11	5/25/12

Project Objectives[1]:

The use of traffic simulation models is becoming more widespread as a means of assessing traffic, safety and environmental impacts as a result of infrastructure, control and operational changes at disaggregate levels. It is imperative that these simulation models are well calibrated so that they accurately reflect real world conditions and scenarios, produce meaningful results, and take full advantage of the capabilities of these advanced modeling approaches. Especially for vehicle tailpipe emissions modeling, it is becoming increasingly evident that individual driving style and second-by-second vehicle operations (i.e. velocity, speed and engine load) are determinants of the level and composition of tailpipe emissions – yet, data collection has been limited.

This project was focused on the lead-vehicle behavior of older drivers relative to younger drivers on clear roads in daylight conditions. A forward facing video camera was used to isolate the instances where the driver was not constrained by other vehicles or traffic control devices. The study included 10 sections of a 7.2 mile route in Shelburne, Vermont that was driven by each of the 35 volunteers three times and includes both horizontal curves, vertical curves and a mix of traffic control types. The primary objective was to assess whether there is a difference in second-by-second driving style of older versus younger drivers through examination of operating speed and acceleration noise. Moreover, these data were analyzed to determine under which conditions these differences are statistically significant – likely to be indicators of variation in driving style. The segments were chosen to reflect areas where the drivers were most likely to be unconstrained.

A baseline simulation experiment was also developed using a microscopic traffic simulation modeling program, namely AIMSUN. Based on the field data collection above, various scenarios were designed to study how lead vehicle speed varies including along basic uniform roadway segments and with grade in the microscopic traffic operations. The development of API was a key step in this project. The API was developed and applied in this project to study lead vehicle behavior. Its main functions include during every simulation step (0.5 second) to detect a lead vehicle based on user-defined criteria, trace it, capture its attributes, force the change of vehicle behavior (such as speed reduction, etc.) and finally output necessary performance measures, i.e., speed and acceleration/deceleration and position.

Findings – Field Experiment:

The results on basic segments suggest that older drivers drive 6.2% slower in 35mph zones and 10.7% slower in 25mph zones than do younger drivers. Curvature affects younger drivers 64.5% more than older drivers in 35mph zones, but no statistically significant differences were observed for 25mph zones. Older driver speeds were slowed by grade 87% more than younger drivers in 25mph zones, with no statistically significant difference observed in 35mph zones. For accelerations on basic segments, grade affected younger drivers more than twice as much as older drivers. Also, speed limit affected older drivers 2.5% more than younger drivers in 25mph zones but affected younger drivers 17.3% more than older drivers in 35mph zones.

During departure-from-stop, the speed of younger drivers increased with the log of distance-from-departure 18.4% more than the speed of older drivers. Similarly, the accelerations of younger drivers were 13.3% greater than the accelerations of older drivers. However, the low

[1] PIs Aultman-Hall and Fang acknowledge the contributions of Dr. Xue Fei of the University of Hartford and Nathan Belz of the University of Vermont.

adjusted R-squared values for the acceleration models imply that there is a lot of variation in the acceleration data that cannot be explained by the measured variables.

Vehicle specific power (VSP) is a surrogate variable reported in kilowatts per metric ton (kWt) that can be calculated to describe vehicle operations from instantaneous velocity, acceleration and grade. VSP has been found to be highly correlated to increased concentrations of gas phase vehicle emissions. Older and younger drivers had an average VSP of 4.767 kWt (±0.174) and 5.249 kWt (±0.196) for the basic segments, respectively ($t = 3.605$, $p < 0.001$). During departure-from-stop average VSP was 8.806 kWt (±0.354) for older drivers and 10.702 kWt (±0.384) for younger drivers ($t = 7.116$, $p < 0.001$). While statistically significant, the more meaningful differences in terms of tailpipe emissions may be that younger drivers spent 13.9% of their departure-from-stop in the highest emitting EPA VSP categories ($VSP \geq 19$), while older drivers spent only 6.8% of their time.

Findings – Simulation Experiments:

The simulation results show lead vehicle speed stays constant in all circumstances whether with slope or with grade on all selected road types. The results generated by the traffic microscopic simulation model do not match the field observations. The simulation results were not able to reflect real lead vehicle dynamics in the real environment. The reasons why simulation results are considered to be inaccurate are two-fold.

First, in Aimsun, when a car travelling on a horizontal surface, its speed will affected by three factors , maximum desired speed of the vehicle, speed acceptance of the vehicle and speed limit of the section or turning. The maximum desired speed is a maximum value between a speed generated by its driver characteristics and a speed imposed by the presence of its front vehicle, both of which have no consideration for road geometric information. Speed acceptance of the vehicle is a part of the driver attributes that still do not include effects of the geometry of the section. The only geometric information used is the speed of the section that is unfortunately a fixed value, so it becomes very easy to understand why the vehicle speed will not be affected by any horizontal curvature of the section.

Second, in Aimsun, when a vehicle is travelling on a section, the slope percentage will only impact the vehicle’s maximum acceleration. The vehicle velocity remains the same as the calculation when the vehicle is on the horizontal surface. Therefore, the slope percentages will not change the vehicle speed. In a word, Aimsun like other models applies many mathematical “rules” but cannot replicate all details of actual driving style.

Conclusions:

This project has demonstrated the need for more field data collection and simulation logic development to create traffic simulation models that are more in line with emissions modeling approaches.

Publications from the Project:

Belz, Nathan and Lisa Aultman-Hall (forthcoming). Analyzing the Effect of Driver Age on Operating Speed and Acceleration Noise Using On-board Second-by-Second Driving Data. Transportation Research Record

Fang, F. C., "Simulation Study of Lead Vehicle Behaviors", American Society of Civil Engineers (ASCE) Proceedings of the 10th International Conference of Chinese Transportation Professional (ICCTP 2012): Integrated Transportation Systems: Green, Intelligent, Reliable, Beijing, China, August 4~8, 2010.