MPC-542
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Project Title:
Exploratory Modeling and Analysis for Automated Vehicles in Utah

University:
University of Utah

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Research Needs:
Technological advances are impacting transportation across many dimensions. Private industry is driving one of the major advances, automated vehicles (AVs), with a number of companies ranging from Google to Audi testing cars with full automation (SAE Level 5). The organizations tasked with planning for transportation facilities – DOTs and MPOs – are in a reactive mode in figuring out how best to respond.

AV will impact mobility, congestion, and safety, and their introduction into the vehicle fleet clearly brings a great deal of uncertainty with respect to forecasting travel demand and vehicle operations. AVs will deliver mobility to historically low mobility demographics such as the elderly, disabled, and children. AVs will also reduce the burden of long travel times by enabling passengers to focus on tasks other than driving. Both of these effects suggest that AVs will amplify growth in Vehicle Mile Traveled (VMT) that is already projected to increase due to population growth in Utah. Utah is currently the fastest growing state in the U.S., and this growth will most certainly translate into higher levels of VMT in the future. AVs are likely to reinforce the traditional source of VMT growth from population and economic growth. The timing and magnitude of this VMT-augmentation are not well understood, however.

Research Objectives:
1. To estimate the effects of varying levels of AV market penetration in the Wasatch Front region on VMT.
2. To estimate the effects of reduced travel time burden (referred to a Value of Travel Time, VOTT) on VMT.
3. To estimate the effects of increased capacity from AV technology such as platooning.
4. Informed by addressing Objectives 1 - 3, above, to develop future (2040) VMT estimates.
5. To provide a knowledge foundation from which the issue of "zero-occupant vehicles" can be systematically investigated.

This research focuses on studying the impacts of AV penetration into the Utah vehicle fleet. Specifically, three aspects of such effects will be examined:

1. Its impact on travel demand from currently mobility-challenged markets – youth and the elderly;
2. Its impact on travel demand due to the reduced disutility of travel time;
3. The potential impact on capacity from AV technologies enabling vehicle platooning.

Research Methods:
The research approach is designed to result in a clearer estimate of future travel demand related to varying levels of AV penetration into the Utah vehicle fleet, and the net impact on network capacity. In this study, an Exploratory Modeling and Analysis (EMA) framework is proposed for investing the macro- and micro-level demand impacts of AVs. Specifically:

1. EMA specifies a range of input assumptions to vary; and
2. EMA uses an experimental design to define a set of model runs to test the effects of varying assumptions.

Travel models such as the Wasatch Front model are useful for evaluating a subset of the questions relating to AVs that impact travel demand. Microsimulation models, such as an I-15 corridor VISSIM model, are appropriate tools for evaluating operational impacts such as vehicle headways and AV-only lane designations.

At the macro level, travel demand models can be used to investigate the following types of questions:

1. AV Market Penetration: What percent of households own will own autonomous vehicles, and which households will those be? Predicting AV market penetration will vary according to income level, age of head of household, presence of children and/or retirees, number of workers, and home-to-work commute distance. Three proposed levels are:
    a. Low – 10% of region HH's own AV's
    b. Medium – 50% of region HH's own AV's
    c. High – 90% of region HH's own AV's
2. Use of Paid Ridesharing as a Substitute for Private Vehicle Ownership/Use: Another key question on the demand side is what mode share will be achieved by paid ride-share services such as Uber and Lyft in the future, assuming that those will be the first to offer the use of autonomous vehicle, and to what extent that will substitute for private vehicle ownership and use. The propensity of use of these services varies for different age groups and travel purposes. The price per mile, wait time, and mode constant can be adjusted to reflect future scenarios where these services are more ubiquitous. Three proposed levels are:
    a. Low – 3% of trips by paid rideshare mode. No corresponding effect on auto ownership.
    b. Medium – 30% of trips by paid rideshare mode. 15% reduction in auto ownership.
    c. High – 60% of trips by pair rideshare mode. 30% reduction in auto ownership
3. Reduction of the Burden of In-Vehicle Travel Time: In travel modeling parlance, this refers to the "disutility of in-vehicle travel time"; in other words, as AVs assume the driving function, the cost, or "disutility", of being in a vehicle is reduced, as that time can

be used for other productive purposes such as reading or communicating. Three levels of disutility can be modeled:

   a. Low – The auto in-vehicle time is reduced by 10% in AVs.
   b. Medium – The auto in-vehicle time is reduced by 40% in AVs.
   c. High – The auto in-vehicle time is reduced by 70% in AVs.

At the micro level, traffic microsimulation models can be used to investigate the following types of questions:

1. Reduced vehicle headway characteristics for AVs: Microsimulation models use input assumptions regarding safe speeds and safe following distances as a function of speeds. Potential levels to test are described below:
   a. Low – Slightly different parameters for AVs compared to conventional vehicles
   b. Medium – Moderately different parameters for AVs compared to conventional vehicles
   c. High – Substantially different parameters for AVs compared to conventional vehicles
2. Provision of AV-only lanes: Because AVs will be able to operate most efficiently and safely when they only interact with other AVs, the percent of infrastructure that is restricted to AVs only could have a substantial effect on network outcomes. Proposed levels for testing are:
   a. Low – No AV-only lanes
   b. Medium – Roughly 25% of freeway lanes are AV-only, with selected designated on-ramp lanes
   c. High – 100% of freeway lanes and 100% of ramp facilities including dedicated AV-only lanes
3. Provision of “smart intersection controls” (connected vehicles and infrastructure): The parameters on intersection delays and timing will be adjusted in a microsimulation to reflect more efficient and dynamic traffic controls. Exact methods and levels are TBD, but proposed are:
   a. Low – No dynamic optimization of signal controls.
   b. Medium – Some dynamic improvement of throughput.
   c. High – Dynamic optimization to significantly improve throughput

Expected Outcomes:
At the end of the research, the transportation planning community will have greater confidence in VMT forecasts incorporating specific assumptions about AV market penetration and use, which assumptions are based in the most recent research on the topic. Further, this research can provide a foundation from which additional AV questions can be investigated. For example, there is great uncertainty relating to additional VMT from zero-occupant vehicles. To begin to address the question of zero-occupant vehicles, a foundation of understanding related to AV market penetration needs to be established, which is the key objective of this research.

The expected outcomes of this research are summarized as follows:

1. VMT estimates (to 2040) under varying assumptions regarding AV usage for key Utah demographics (within Wasatch region)

2. Guidance for UDOT, WFRC, and MAG long-range transportation plans on the impacts of AVs on future VMT, and how to account for AVs in future planning.
3. Discussion of how/whether “zero-occupant” vehicles may present planning challenges with increased VMT and possible land use impacts.

Relevance to Strategic Goals:

- Economic Competitiveness
- Livable Communities

A high quality and fully functioning transportation system is vital to the economy development and livability of citizens, it is also the prerequisite for future growth. this project establishes a simulation-based data-driven framework to address disruptive technologies in the planning process. As we move towards this type of planning, the need to precisely forecast the future becomes less important. The ability to understand the cause and effect relationship between technology, transportation investment, land use policies, and travel behavior becomes more important. The planning and forecasting of AV’s impact will naturally shift towards creating systems which puts us in the best position to meet our stated goals, and which are capable of adapting to a variety of external influences.

Educational Benefits:
One graduate student will be heavily involved in this research. He/she will lead the preparation of journal publications resulting from the work, and in most cases, deliver conference presentations. The project will serve as a basis for his/her dissertation work. The PI is currently offering a graduate level course “Transportation Network Modeling” every Fall semester. The EMA framework developed in this research will lead to new material included in the course to teach the students practical skills on simulation and analytic techniques for modeling AV’s impact on transportation network.

Tech Transfer:
The research will inform the Long Range Transportation plans of UDOT, WFRC, and MAG. It is clear that AVs will integrate into the vehicle fleet over the time frame of the analysis, to 2040. Not accounting for AVs will certainly underestimate future VMT. This research will result in greater certainty surrounding the impacts of AVs on VMT, and may be used to understand future capacity needs, as well as point to operational needs during the transition period when AVs begin getting absorbed into the overall vehicle fleet, but represent small fractions thereof.

The potential audiences for this research are individuals involved in the traffic operations and transportation asset management, including traffic engineers, planners, and senior leaders at FHWA, state DOTs, and MPOs. The following agencies, offices, and committees are those most likely to take a leadership role in implementing the research results:

- Utah Department of Transportation
- FHWA Office of Planning
- TRB Highway Capacity and Quality of Service Committee
- TRB Managed Lanes Committee

The proposed principal investigator routinely interacts with UDOT, WFRC, UTA, FHWA, SHRP 2 Reliability Program, and the listed TRB Committees. The 2018 Midyear Meetings of TRB Highway Capacity and Quality of Service Committee and TRB Managed Lane Committee will be an opportunity to share early results and future directions of the research project. The proposed principal investigator will work with the committee chairs to possibly get a presentation on the project added to the agenda. The proposed principal investigator and her graduate students routinely attend TRB's annual meeting as well. At least one TRB paper on this work will be submitted for presentation and publication.

Work Plan:

1. Research Scan
2. Stakeholder Outreach
3. Scenario Development
4. Scenario Testing
5. Final Report

Task 1 – Research scan (2 months)
Determine the most probably ranges of AV penetration in new vehicle sales, and the reactions of specific demographic populations to the adoption of AV technology.

Task 2 – Stakeholder meetings (1 month)
Assemble a group of stakeholders from UDOT, WFRC, MAG, and other transportation planning organizations to advise the research. A total of three meetings is envisioned: 1) kick off and introduce the project; 2) present AV penetration scenarios; and, 3) present findings from the Exploratory Analysis.

Task 3 – Scenario development (4 months)
Following the research scan, the research team will develop three scenarios for AV market penetration based on the mobility benefits for specific demographics – elderly, disabled, young. The analysis will identify candidate households from projected demographic data, and specify three AV penetration levels for candidate households (e.g. Low 10%; Medium 50%; High 90%)

A similar set of 3 scenarios will involve estimating the reduction in travel time burden related to AVs. In travel modeling parlance, this refers to reducing the "disutility of in-vehicle travel time"; in other words, as AVs assume the driving function, the cost, or "disutility", of being in a vehicle is reduced, as that time can be used for other productive purposes such as reading or communicating. As with the demographically-driven AV penetration scenarios, three levels of disutility can be modeled (e.g. Low 10% reduction; Medium 40% reduction; High 70% reduction).

Before proceeding to Task 4, Scenario Testing, the research team will meet with the AV Stakeholder group (meeting #2) to proposed a 3X3 experimental design, with 3 AV penetration scenarios and 3 Travel Time burden reduction scenarios. The proposed scenarios will be based on the most recent research from the Task 1 scan. We will also propose a set of performance measures to compare model runs such as Total VMT, VHT, and operating speeds on selected highway segments.

Task 4 – Scenario testing (6 months)
After establishing agreement on the experimental design with the Stakeholder group, we will modify and parameterize the Wasatch Front regional travel demand model to conduct a total of 9 model runs (3 AV penetration scenarios X 3 travel time burden reduction scenarios).

Task 5 – Final report (1 month)

Project Cost:

Total Project Costs:	$100,000
MPC Funds Requested:	$50,000
Matching Funds:	$50,000
Source of Matching Funds:	Utah Department of Transportation