Demystifying the future of connected and autonomous vehicles

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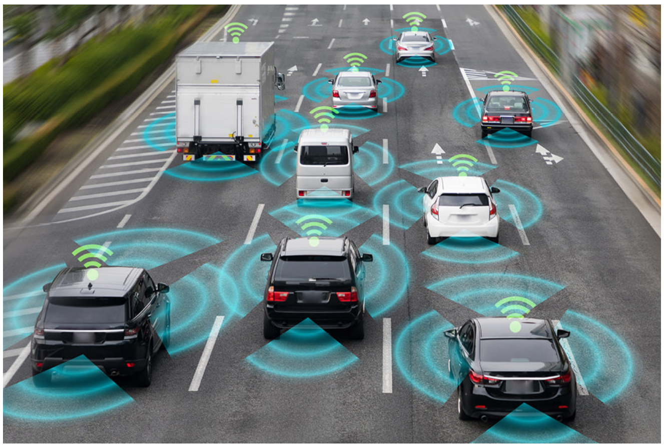

Argonne researchers are modeling and simulating how connected and autonomous vehicles could affect energy and mobility in metropolitan areas. Credit: Shutterstock / metamorworks

No doubt the emergence of connected and autonomous vehicles (CAVs) will have new and exciting effects on patterns and modes of transportation, but when it comes to measuring those effects, the future gets a little hazier.

How might these technologies affect how people travel and how energy will be used? Will they lead people to spend more time on the road or less? How will they alter the way we consume fuel, the time we spend on the road, or the amount of traffic on our roadways?

To answer such questions, and understand future mobility, researchers at the U.S. Department of Energy's (DOE) Argonne National Laboratory are deploying advanced modeling and simulation tools. And in a collaborative three-year project, supported by DOE's SMART (Systems and Modeling for Accelerated Research in Transportation) Mobility Consortium, Argonne researchers are using these tools to predict the impact of CAVs on energy and mobility in metropolitan areas.

"Our goal is to acquire a system-level understanding of how transportation is changing, including how different modes of transportation interact, the decisions made by travelers that underlie those interactions, and how automation affects all of it," said Argonne Computational Transportation Engineer Joshua Auld. "This level of understanding will provide insights to help cities better plan and adapt to future transportation changes."

Argonne's work advances the SMART Consortium's mission to increase our understanding of the impacts that will arise from future mobility systems. Project collaborators include the University of Illinois at Chicago, the University of New South Wales, Texas A&M University, the University of Michigan, Carnegie Mellon University, the University of Washington, George Mason University, as well as multiple cities and planning agencies.

Modeling and simulation

Now two years into their project, Auld and fellow collaborators have developed a model to represent the adoption of partially and fully automated CAVs at varying levels of market penetration, using predictions based on cost and an individual's willingness to pay. Researchers have integrated this model, along with a traffic flow model for CAVs, into the Planning and Operations Language for Agent-based Regional Integrated Simulation (POLARIS) platform, Argonne's transportation system simulator.

POLARIS simulates mobility and traffic flow by predicting the individual behavior of "agents," which can represent people, households and organizations. It analyzes how millions of these agents interact and make decisions on the use of automobiles, bicycles, transit, etc. In turn, these decisions affect the transportation system as a whole. Researchers used POLARIS to simulate mobility and travel flow impacts of these different scenarios.

To complement their POLARIS analyses and measure energy effects, researchers used Argonne's Autonomie tool. Autonomie is the industry-leading tool for predicting fuel consumption from current and future vehicles. For their analysis, researchers relied on Autonomie to measure the impact of CAVs on energy use.

Quantifying energy and mobility impacts

To quantify the mobility and energy impacts of CAV adoption, researchers took into account a number of interrelated metrics. Among them are changes in vehicle miles traveled (VMT), value of travel time (VOTT), amount of congestion and energy consumption.

Value of travel time measures the perceived burden of time spent on travel, the assumption being that, the lower the burden of travel time, the more an individual is willing to travel on the road.

"We looked at VOTT as a critical factor affecting both mobility and energy because, no longer having to deal with the burden of driving, CAV drivers may choose to spend more time on the road, knowing they can use their travel time to do other, productive activities," said Argonne Vehicle and Mobility Simulation Manager Aymeric Rousseau. "We focused on understanding the impact of VOTT on mobility and energy for different vehicle technologies and consumer behaviors."

"Overall, our research found that people with access to partially automated CAVs do tend to take longer trips, as the value of travel time decreased, and the driver was alleviated from the focus on driving. We also saw congestion increase in certain scenarios," Auld said. "We also found changes in fuel usage, including an increase in fuel use as CAV market penetration went up, with the increase in VMT."

Future steps

To improve their ability to represent and analyze the complex interactions affecting transportation and mobility, researchers are working to enhance POLARIS and Autonomie to better account for CAV technology choices (like varying levels of automation) and their impacts on traffic flow. They're also looking at new mobility technologies, such as transportation network companies and car sharing services.

"Our modeling and simulation approaches are vital to anticipating the transportation and energy needs of our nation. By continuing to enhance these tools and techniques, we'll be better equipped to deliver tools and solutions that address future needs," Rousseau said.

This work is being sponsored by the DOE Vehicle Technologies Office (VTO) under the Systems and Modeling for Accelerated Research in Transportation (SMART) Mobility Laboratory Consortium, an initiative of the Energy Efficient Mobility Systems (EEMS) Program. David Anderson, a DOE Office of Energy Efficiency and Renewable Energy (EERE) program manager, played important roles in establishing the project concept, advancing implementation and providing ongoing guidance.

Provided by Argonne National Laboratory