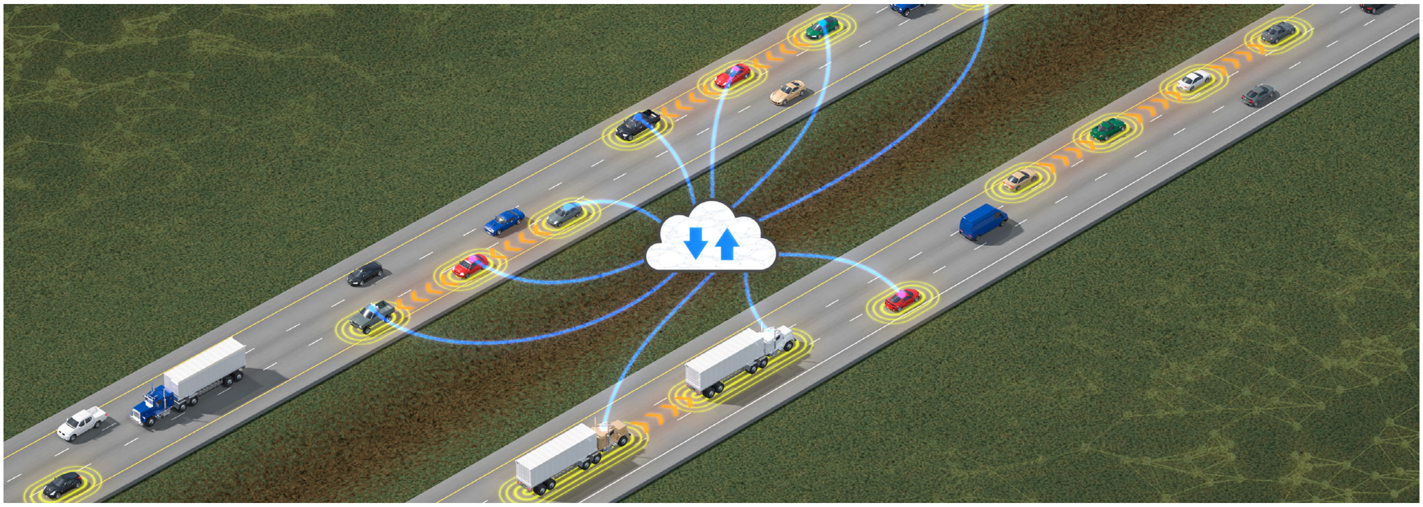

EXPERTS TALK

Experts Talk: Connected and Automated Vehicle Microsimulation with Mike Forsberg

Modeling Traffic of the Future Through CAV Microsimulation

Many transportation agencies have begun to investigate the impact that connected and automated vehicles may have on their infrastructure, including some in place for decades, and others that are being planned over the next 20-plus years. Knowing what to expect in the future and what will be needed are key. When combined with sophisticated new applications that integrate CAVs into the modeling process, traffic microsimulation software holds almost limitless potential to help agency leaders make better-informed decisions.

Mike Forsberg, P.E., PTOE, serves as a senior traffic engineer at HDR, focusing on transportation planning and traffic operations, including new technological applications surrounding CAVs. In this interview, Mike draws on his work with the Iowa Department of Transportation, including the I-80 Automated Corridor Study, and the Colorado Department of Transportation, where he helped develop a framework for incorporating CAVs into simulation models, to forecast the possible impacts of this technology on traffic flow. Contact **Mike Forsberg** for more information on connected and automated vehicle microsimulation.

Q. What are the key benefits of using traffic microsimulation modeling tools in traffic analysis?

A. Let me start by saying that traffic microsimulation software can model pretty much any transportation condition. Its potential is practically limitless. Its use depends on what questions we want answered and how much time and effort we are willing to invest in getting the answers. The key is to optimize this effort to get meaningful answers. Microsimulation's biggest benefits are being able to assess specific sites involving complex traffic conditions not easily evaluated with more simplified tools. Imagine a congested freeway with bottlenecks that create long, freeway-to-freeway interchanges, ramp meters, queues from signals at the end of ramps extending to the freeway, toll lanes, etc. Traffic analysis tools less sophisticated than microsimulation can only approximate some of these conditions. Microsimulation can model the cumulative effects of all the influencing factors.

Microsimulation software also can report detailed operating conditions, such as speed by lane at specified intervals, travel time between any two points, and specific operations by vehicle mode (vehicle, transit, bike, pedestrian, etc.) or class (passenger car, single-unit truck, semi-truck, etc.). While microsimulation is commonly used to model heavy traffic volumes in major metropolitan areas, it may also be useful for modeling an atypical intersection layout on the fringe of a small town with moderate traffic volumes — where an innovative layout could provide the best operations at the lowest cost.

Another benefit to using microsimulation is that we can provide a visual of traffic conditions. While traditionally, we created many tables and fancy figures to report traffic analysis results, now we can create a series of images or videos from a simulation that can really tell the story. Simulation videos have become instrumental in helping agencies, stakeholders and the public understand how a geometric solution would address a problem and that helps in gaining acceptance of the proposed solution. Even something fairly common like a roundabout can benefit from a visual representation when displaying the solution to those who may be skeptical of roundabouts.

Now, with so much focus on advanced technology solutions (CAVs in particular) as a way to improve traffic safety and operations, the benefits of microsimulation are more evident. We can use microsimulation to model the complex interaction of CAVs with each other and with non-CAVs; and we can visually show how CAVs and non-CAVs can coexist to improve transportation systems.

Q. How is microsimulation traffic analysis helping transportation agencies plan for CAV user adoption?

A. Most agency budgets continue to fall short of what is needed to maintain and improve their roadway systems. As agencies plan for future improvements and investment strategies, they want to know if they should continue their traditional approach of planning for roadway improvements — or if CAV adoption will provide additional safety and operational benefits that will require an innovative approach to improving the transportations systems.

Microsimulation provides the sophistication needed to model CAVs. Microsimulation software developers have started to add out-of-the-box features in their products to model CAVs. These features include car-following modifications to CAVs that allow for reduced headway between CAVs and reduced or eliminated stochastic car following (the dynamic headway for a trailing vehicle due to human imperfection). Microsimulation software can also interface with external computer scripts that provide special instruction to guide a simulation. Scripts can be used for more advanced CAV modeling such as how CAVs form platoons, interact across lanes in freeway merge areas and exchange information with signal controllers to optimize signal timings.

With new software features and supporting scripts, microsimulation can help determine how CAV adoption will improve roadway operations. Since there are fewer conflicts on freeways, most of the completed CAV evaluations to date involve freeway applications. This nicely supports agency priorities as they are looking first at freeways for broad-based CAV infrastructure. On these freeways, microsimulation is used to determine increases to roadway capacity at various CAV adoption rates, and the impact of providing dedicated CAV facilities (similar to carpool lanes).

Q. What do the results of microsimulation modeling tell us about the impact CAVs will have on our transportation system?

A. The results are providing some exciting insights into what future highways will look like. As we learn more about the algorithms that help us show how CAVs will operate, we'll continue to improve our ability to simulate CAV impacts to traditional traffic operations. Since most of the microsimulation analysis with CAVs have been completed for freeway facilities, I will share some of those results.

For low- to mid-level CAV adoption (25-50% of all vehicles as CAVs), we see a range from no change to roughly a 20% increase in roadway capacity. For CAV adoption at or above 75%, we see the possibility of a 25-50% increase in roadway capacity. We also find that higher travel speeds can be maintained with higher traffic volumes as CAV adoption increases.

For the low-to-mid adoption rate, the limited improvement to operations seems fair considering the high percentage of non-CAVs and the unpredictability of human driven vehicles limits the platooning ability of CAVs. At higher adoption rates, there are more opportunities to platoon CAVs, which can take advantage of knowing detailed information about more of the surrounding vehicles. For roadways at capacity, the reduced headways and lost startup time of CAVs can maximize system performance.

Q. Since the most touted benefit of CAVs is improved safety, can microsimulation be used to substantiate and report on those benefits?

A. Yes and no. It is challenging to simulate the random events that cause a crash; however, microsimulation can evaluate the effects of a crash on the system. We can start by estimating the probability for reduction of specific types of crashes using industry estimates for different types of autonomous vehicle features. Then, we can use microsimulation to evaluate how the system's reliability improves with fewer crashes. We also can use microsimulation to show improvements that CAVs provide in terms of fewer blocked lanes and faster system recovery times after a crash has occurred.

Q. How can we use and adapt microsimulation to inform future transportation functionality as shared and electric vehicles become more prevalent and transportation technology continues to advance?

A. The functionality of microsimulation tools will continue to improve as CAVs and supporting technology evolve. Software developers are getting more heavily involved in major research projects to understand and test advanced technology solutions. This involvement is allowing them to adapt their tools to more accurately simulate real-life conditions. Developers are also leaning on the users of their products to share solutions that can be included in future software versions.

We can increase our ability to successfully simulate traffic impacts by creating solutions that are easily adapted as the technology evolves. This allows us to more easily modify the work that has been previously completed. An example of this is to create scripts that allow for user-defined performance of CAVs. This permits testing of different CAV performance in current models with the potential to refine performance values down the road as we learn more. Testing CAV performance also gives insight into what the technology must do to achieve system benefits.

Microsimulation also can evaluate the impacts of new and future trends in transportation. This allows us to model the increased use of Uber and Lyft, mobility-as-a-service, and changes to vehicle emissions as a result of electric vehicle adoption. Microsimulation route selection for shared mobility continues to evolve as well. Also, microsimulation scripts have been developed to identify the appropriate sharing of a trip based on origins, destinations, out-of-distance travel, user delay tolerance and a number of other input variables. These scripts are set up to be adaptable as more defined algorithms for ride-sharing become available.

With these new tools and the advancements we're seeing every day, we're better positioned to understand the benefits CAVs provide and their positive impact on the transportation system in the future.

Inspiration & Advice

Q. What inspired you to focus your career on traffic engineering?

A. I became fascinated with creative transportation solutions while I was in college. At the time, I was actually tailoring my coursework toward structural engineering when I saw a presentation on a local transportation project by someone at HDR. The presenter was Dave Meier, who's still at HDR as senior transportation project manager. He was presenting on the West Dodge Expressway in Omaha. This project included elevated expressway bridges over an at-grade section and filled a gap in the freeway system in west Omaha. After that, I started looking into a number of other innovative solutions and became intrigued with even the most basic traffic engineering principles. Structural engineering always felt a little foreign to me no matter how much I wanted to study it, and I finally felt that I found my calling when traffic engineering came into focus. I'm actually not sure I've ever told Dave that he inspired my career decision. Hopefully, he will read this and have a sense of accomplishment from his presentation 17 years ago.

Q. What advice would you offer to new professionals in the transportation industry who will work with future microsimulation tools?

A. My first piece of advice is perhaps a cliché, but if you want to get into microsimulation modeling, get involved in as many microsimulation projects as you can and learn from the experts. There are so many ways to use microsimulation software, but it takes a lot of experience before you develop a good handle on how to accurately model and take full advantage of the software. Every model you create, even the most basic ones, will give you a better grasp of the software's capabilities and fundamental driving behavior.

Secondly, push the boundaries of what microsimulation software can do, so we can keep expanding its potential. Seek out creative solutions that incorporate advanced technology, and find ways to use microsimulation to show how effective the solutions are. This will be critical as we adapt to the future of transportation and seek ways to advance technological solutions through microsimulation modeling.