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Fall September 1, 2018

Sense of Self

William W Riggs
Ronald R Milam, *Fehr & Peers*

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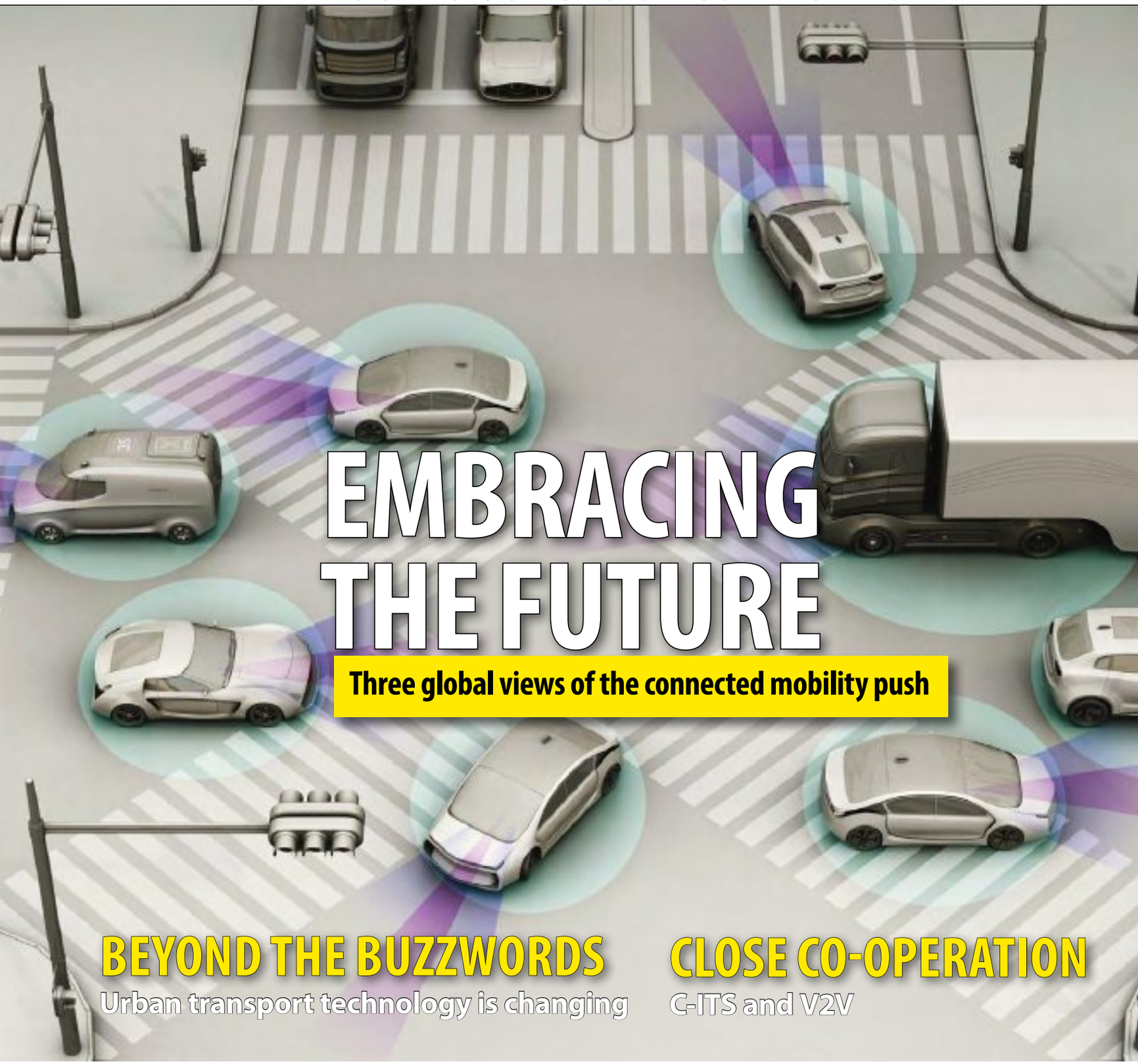

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Kevin Borras

Convergers Assemble!

This may be an odd way to start a foreword, even for me, but I'm going to talk about *Thinking Highways*' sister title, *Thinking Cities*. We launched the latter magazine in 2012, six years after the former and we did so because contributors were writing really interesting and thought-provoking content for *Thinking Highways* that I was struggling to use. A lot of the articles I was receiving just didn't fit the realms of an ITS and advanced traffic management title, especially not a printed one.

Our erstwhile colleague Gary Bridgeman suggested that we do one of two things and we did neither. His first suggestion was to run a branded smart cities section in *Thinking Highways*, in which we would devote eight pages of every issue to this burgeoning sector. His second suggestion was that we ran a yearly supplement to our flagship title, call it *Thinking Cities* and bind it into the centre of the issue or as an insert into the plastic bag that our magazines used to arrive claustrophobically trapped in.

Gary was always full of ideas (he more than likely still is) and it wasn't that his ideas were not good but they made us think "without the parameters of the conventional parallelogram." We liked the name *Thinking Cities* but wasn't it about time that the subject of smart city mobility, told from the point of view of the cities themselves, deserved its own publication? A small section was probably not going to be enough and a supplement might be seen as something of an afterthought or the publishing industry's equivalent of the aftermarket add-on.

As you are no doubt aware, we decided to create a brand new magazine that, after a very brief meeting, we joined forces with Polis to bring to life. Even as recently as 2012 the two sectors, ITS and smart cities, were separate and disparate enough to entirely warrant their own dedicated publications and to a certain extent but less degree they still do.

But now, if you forgive my inevitable regression back to my favourite type of diagram, the Venn, the intersection of the two sectors is vastly superior in size to the combined surface area of the remainder. If you only exist in the ITS sector or only exist in the smart city sector then there isn't just a fear of missing out (FOMO), there's the reality of missing out (should be ROMO but I've never seen it written anywhere else). The bit in the middle, the intersection, is where the concept of Connected Mobility lives.

In my August 2016 foreword I proffered forth the concept of Connected Mobility as, I suggested, the term ITS was no longer entirely fit for purpose. Two years later and I will now suggest that the term smart cities is also no longer entirely fit for purpose and that Connected Mobility is what it's all about now. It's what you're doing. It's what we're covering. It's why you are reading this and, if you're reading the ITS World Congress edition, it's the main reason for you travelling to Copenhagen, even if you aren't convinced of it yourself.

Connected Mobility is the theme for our tri-partisan cover feature(s) and it's also the theme of our new website, **h3bconnected.com**, that brings together the best writing and thinking in the sector under one "roof". The individual websites are still there and you can enter them separately but this new intersection, if you like, heralds the start of a new era for us.

And by us I mean H3B Media…and you.

> "I will now suggest that the term smart cities is also no longer entirely fit for purpose and that Connected Mobility is what it's all about. It's what you're doing. It's what we're covering..."

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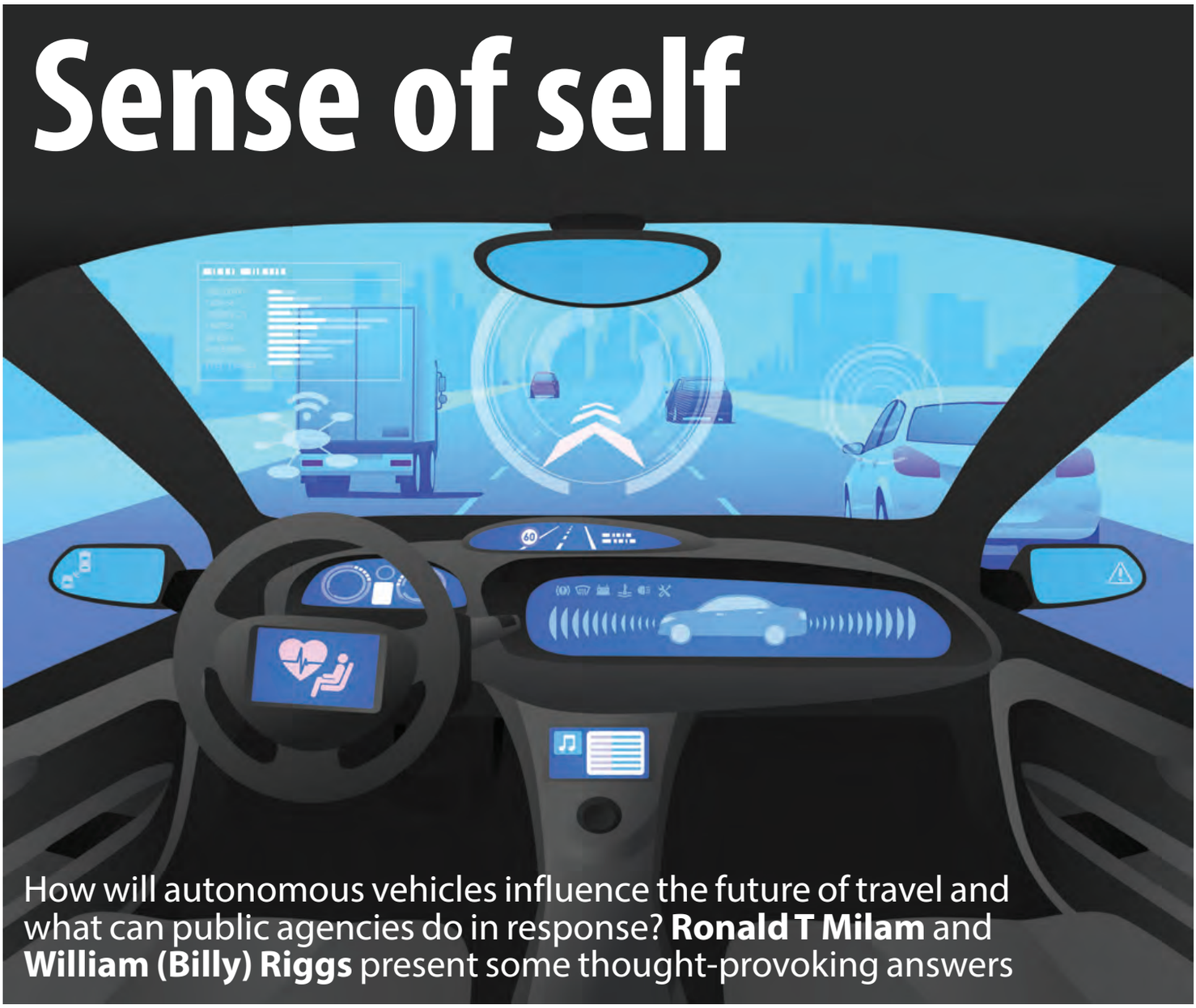


How will autonomous vehicles influence the future of travel and what can public agencies do in response? **Ronald T Milam** and **William (Billy) Riggs** present some thought-provoking answers

What if public agencies do not change transportation policies or regulations as autonomous vehicles (AVs) enter the market and expand their presence on American roadways? This is one of many questions we investigate in this article, assessing the potential risks that AVs present to the desired future outcomes that cities, regions and states have established through their land use and transportation plans. We use the term 'risks' purposefully. This is because our research and modeling reveal the potential for substantial increases in vehicle travel and decreases in transit ridership if AVs operate under current policy and regulatory frameworks.

So, what can policy makers and local agencies do? We will get to that but, first it is important to understand how private sector market forces are changing travel decisions and behavior. This article will conclude with a look at what communities can do now to influence these trends.

CHANGES IN BEHAVIOR

In an era of disruptive trends and new mobility, travel behavior is changing in ways that directly influence how we model traffic implications. Specifically, these include:

- **Reduced the cost of vehicle travel (in both money and time).** The concept of mobility or transportation as a service (MaaS or TaaS) relies on only paying for the cost of travel when a trip is made. Sharing trips can further reduce individual traveler costs and is made convenient by app-based technology through smart phones.
- **Eliminated burden of driving.** Autonomous vehicles (AVs) complement the MAAS model by removing the driver from transportation network company (TNC) services or by allowing private vehicle owners to avoid the driving task. For TNCs, eliminating the driver lowers the cost of service. For private individuals, time otherwise spent driving is now available for other

▲ **UBER vehicle choice and service offerings in a suburban market** Source: Uber app, accessed April 2018 in Roseville, CA

purposes.

- **Reduced potential for collisions.** AV technology offers the potential of computer and sensor-aided travel that is designed to avoid collisions. If connected vehicle (CV) technology is also included, vehicle travel can occur with even greater awareness of environmental conditions to minimize the risk of collisions.
- **Vehicle travel made more convenient.** TNCs today provide door-to-door service, eliminate the chore of parking, and offer a variety of vehicle choices and services including wheelchair assistance and Spanish-speaking drivers (see image below). However, TNC trips are expensive enough that few people that rely on vehicle travel are willing to forgo owning their own vehicles. The transition to AVs will change the cost equation and vehicle design flexibility may result in even greater vehicle and service choices in addition to providing more travel options for the young, elderly, and those with a range of disabilities.

These changes create strong possibilities for increased traffic generation, loss of transit ridership, reduced parking needs but increased curb space demands, raising important decision-points for public agencies. To date, public agency action has been limited. Although some municipalities like London have restricted new mobility services, public agencies in the US have largely accommodated disruptive transport. Evidence includes things like 1) the explosive growth of TNCs and 2) the openness to AV testing on public streets. This is happening around the world, in states such as California (where recent laws are focused on reducing vehicle travel and encouraging more active transportation), but also in multimodal havens such as the Netherlands.

In light of this, a key policy question is, "What motivates this accommodation?" This is a central question because, without government action, the private sector business model for TNCs and MAAS generates revenue based on miles of travel, minutes of travel, demand levels, and choice of vehicle/service. Hence, the private sector is currently incentivized to increase the use of vehicles while the public sector in many cities and states like California has spent the past couple of decades focused on reducing vehicle miles of travel (VMT) to improve sustainability.

To grapple with this dichotomy, between what the market wants and the sustainable and equitable vision that most cities are trying to achieve, we used regional travel forecasting models to test potential future outcomes with and without the influence of new government policies and regulations.

MODELING DISRUPTIVE TRENDS

Disruptive trends extend beyond just the technology changes in transportation. While not a complete list, we identified 16 factors related to trends including, but not limited to, job market health, fuel prices, social networking, vehicle ownership, AVs, and internet shopping. The potential outcome for the future travel associated with these factors is difficult to predict because of the unknown reactions below.

- Government regulation of AVs, TNCs, and new modes.
- Public transit agency responses to TNCs and AVs.
- Public acceptance and use of AVs and sharing them for regular travel.
- Public acceptance and use of new modes such as e-bike and e-scooters.

Despite the unknowns, we tested the potential AV effects using traditional regional travel forecasting models. In our case, we tested scenarios using models from seven regions across the US combined with similar test results from two additional regions. All model runs include full market penetration of AVs in the horizon year of the models, which was 2035 or later, and AV-related changes to the following travel forecasting model variables related to travel behavior.

- **Terminal Time –** Travel models define the time needed to park your car and walk to a destination as "terminal

time." The higher a terminal time, the less likely a person will choose an auto for a particular trip. AVs are likely to reduce terminal times by eliminating the need to park and providing on-demand door-to-door service.

- **Parking Cost –** Most models include a variable for parking cost in areas where costs are imposed. AVs have the potential to lower or even eliminate these traditional parking costs.
- **Value of Time –** Travel models also incorporate the value of time, but in different ways. Travelers using AVs will have lower values of time because the opportunity cost of driving will be reduced.
- **Auto Availability –** Models generally have variables tied to trip rates and auto availability. AVs may increase trip rates due to their greater convenience and ready availability. Greater convenience could lead to more discretionary vehicle trips for shopping, social, leisure or recreational purposes. Additionally, people not licensed to drive will be able to make vehicle trips.
- **Roadway Capacity –** As vehicles become more automated and connected, they offer greater potential to increase roadway capacity especially on freeways. The increase in capacity will come from shorter headways, less weaving, and more stable traffic flows. Roadway capacity will increase first on freeways and expressways, then on major arterials.
- **Auto Operating Costs –** Vehicle travel has costs associated with purchasing or leasing, operating, and maintaining the vehicle. Travel decisions tend to focus on the operating costs such as fueling the vehicle and can be expressed in a model as a per mile cost to capture higher costs for longer distance trips. For AVs, operating costs are expected to be lower due to electrification of vehicles and potential for vehicle sharing.
- **Auto Occupancy –** Auto occupancy is the number of persons per vehicle and it has a substantial effect on the number of vehicle trips and related effects on how the roadway network operates. We test traditional levels of auto occupancy and a scenario with higher levels of shared trips (i.e., carpooling).

The general expectation from testing AV effects was that vehicle travel would likely to increase and transit ridership would decrease for the main reasons cited at the beginning of this article.

- AVs will reduce the cost of vehicle travel (in both money and time).
- AVs eliminate the task of driving.
- AVs will reduce the potential for collisions.
- AVs will make vehicle travel more convenient.

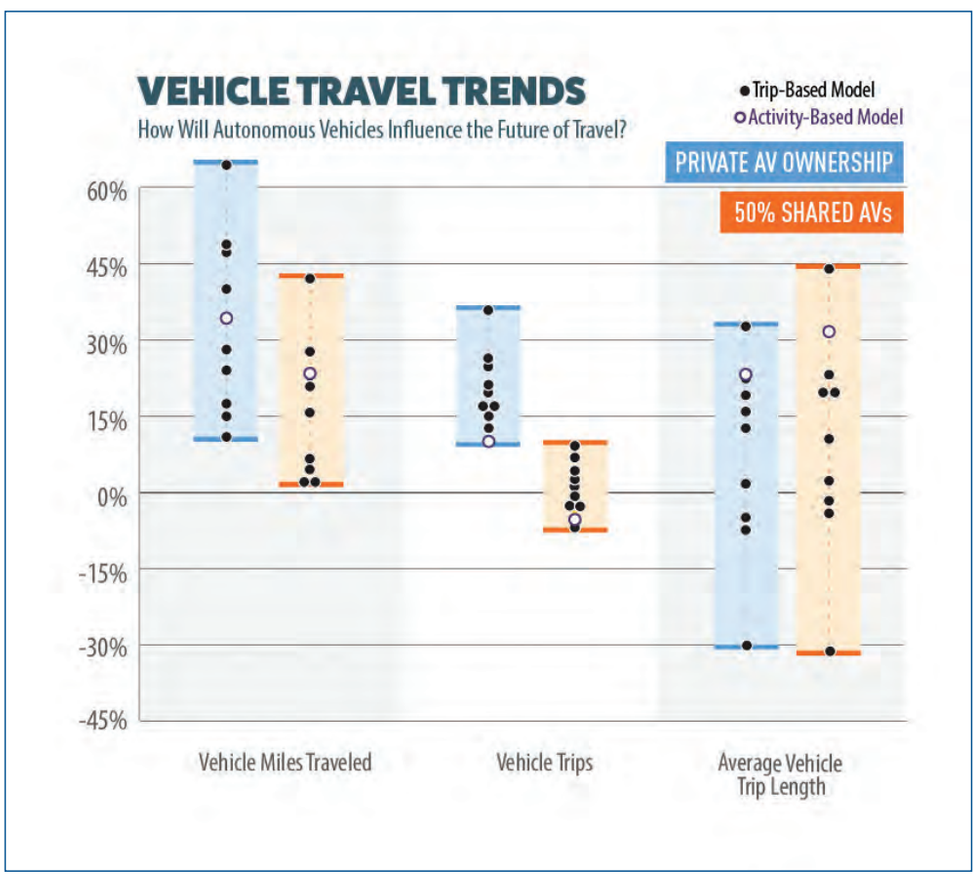
RESULTS: THE FUTURE OF TRANSPORTATION DISRUPTION

Our modeling results confirmed the expectations noted above, but the magnitude of the effects may be surprising. Figures 1 and 2 show the range of effects captured by the models for vehicle travel and transit use. Each dot in the chart represents the results from an individual model and the tests included both private ownership of AVs similar to automobile ownership today plus a scenario where 50 percent of drive-alone (i.e., single-occupant) trips were shifted to shared vehicles (i.e., carpools).

This 'shared' scenario is intended to capture the potential influence of government policies or regulations to encourage much higher levels of ride sharing than have traditionally occurred with privately owned vehicles. The models were not capable (without substantial modification) of capturing the zero-occupant vehicle trips that would occur as AVs travel between different passengers or to final parking locations when not in use. Also, long-term land use changes were not accounted for in these model applications. So, higher levels of VMT are possible.

While the results are best viewed for the potential range of effect. The averages are also provided below.

▼ **Figure 1. AV Effects on Vehicle Travel**
http://www.fehrandpeers.com/autonomous-vehicle-research/
Source: Fehr & Peers, 2018

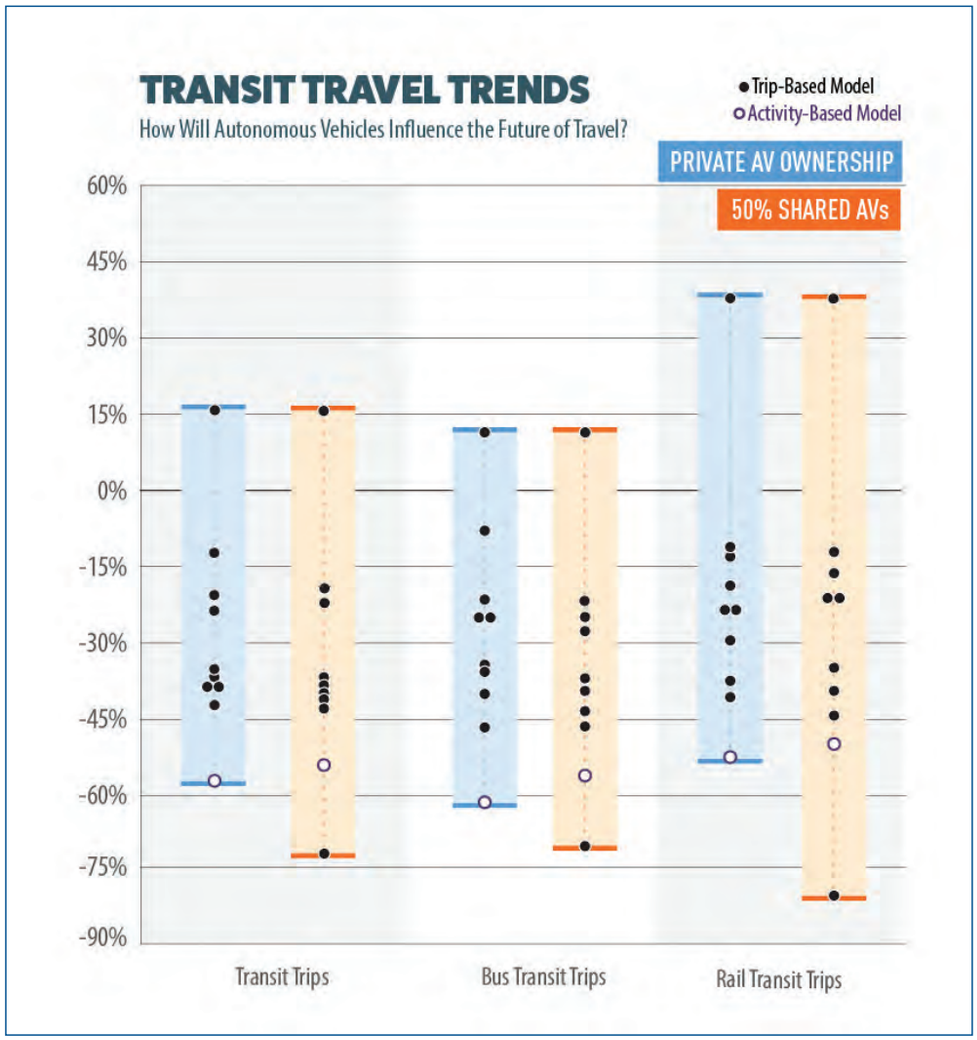


- Vehicle trips increase by an average of 20 percent without any shared-use regulation. That increase is virtually eliminated (on average) with 50 percent of the AVs required to be shared rides.
- VMT increases by an average of 31 percent without any shared-use regulation. That increase is halved (on average) with 50 percent of the AVs required to be shared rides.
- Transit trips decline by an average of 29 percent without any shared-use regulation, which grows to 35 percent with 50 percent of the AVs required to be shared rides.
- On average, bus and transit trips less than 5 miles decrease more than rail and transit trips greater than 5 miles.

In comparison to other research we see that these results may be highly relevant. For example, a unique experiment involving the provision of 60 hours of free chauffer service for one week (2) and showed a VMT increase of 83 percent for those participating. While, this experiment was conducted using a small sample of 13 test subjects from the San Francisco Bay Area it underscores the significance and importance of our modeling.

While the results may be due to different model strengths and weaknesses rather than real-world variations in effects. They did not capture all induced growth and induced vehicle travel effects. The model tests themselves were designed as 'stress tests' to better understand potential effects and level of sensitivity to help inform future research and analysis.

▼ **Figure 2. AV Effects on Transit Ridership**
http://www.fehrandpeers.com/autonomous-vehicle-research/
Source: Fehr & Peers, 2018



WHAT CAN POLICY MAKERS DO GIVEN THESE FUTURE OUTCOMES?

These modeling results are important at framing future behavior and transportation trends, but they also underscore the policy context. The actions of government can have a dramatic effect on these outcomes. Policy or regulatory responses can change costs of a ride or the number of people in a vehicle. Governments can use policy and regulation to balance the desires private companies with the public good.

With that context in mind, we provide a brief list of potential policy and regulatory responses designed to offset the effects revealed by the modeling tests. In general, the responses include: increasing public transit competitiveness; increasing the occupancy of new mobility vehicles, decreasing their size, and increasing the cost of zero-or-low-occupancy vehicle travel; and using land use policy.

Transit Competitiveness

Part of the explanation for the decrease in transit ridership is that transit travel times are much slower than automobile travel especially if delivered in a TNC or MAAS platform door-to-door. Today, TNC passengers have very short wait times, often less than 5 minutes, and in-vehicle travel times that are similar to using a private auto. AVs could improve upon the wait time and possibly the in-vehicle travel time due to capacity increases. AVs will also reduce the cost of vehicle travel. In response, transit travel experiences and travel times need to improve to remain competitive as outlined below.

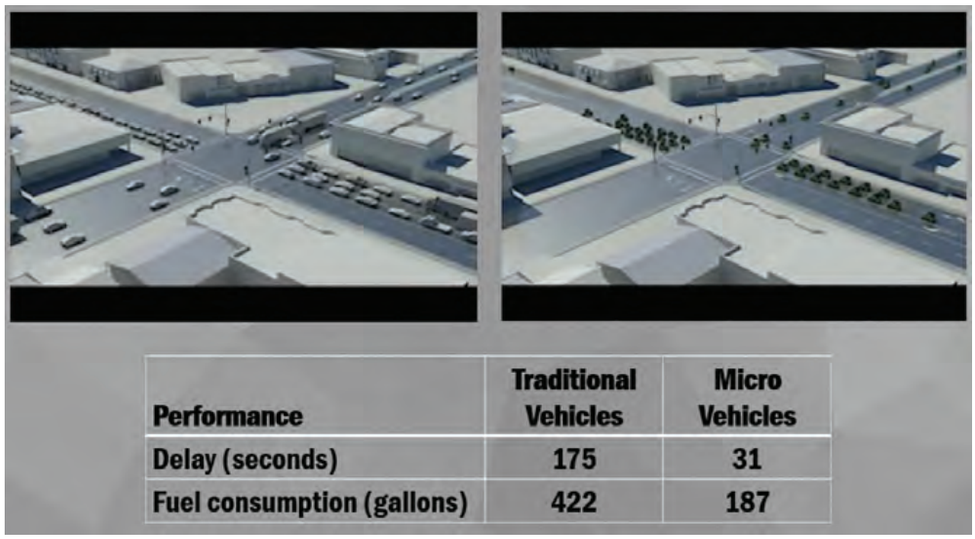
- **Increasing frequency of service –** Frequency directly influence wait times and provides flexibility to system users to come and go from destinations without having to worry about schedules.
- **Providing transit-only lanes –** Similar to operational hours, in-vehicle travel time on buses needs to be faster to compete with vehicle travel. Transit-only lanes (during peak periods) improve roadway space efficiency and utilization and would lower current in-vehicle travel times.
- **Automating transit service –** Buses on fixed routes are one of the first

opportunities for autonomous vehicle use. Fixed routes are easier to navigate than an open network and the switch to autonomous operations reduces labor costs. Savings could be redirected to expanding core services especially rail service, which would minimize the impact of driver reductions by increasing other operational and maintenance jobs. Savings could also be translated into reduced fares, with the possibility of offering free transit service that could stimulate a virtuous cycle of attracting more ridership and reducing cost per rider such that service could be expanded to attract even more riders. If automated operation is combined with technology for matching riders and vehicles, then autonomous rapid transit (ART) service could be offered. This type of service would operate in transit only lanes but have the benefit of matching riders with common destinations together in transit vehicles. This type of matching would allow ART vehicles to skip some stations once the vehicle is full thus improving in-vehicle travel times compared to conventional transit.

- **Better match or 'right size' transit demand to type of service –** TNCs, MaaS and AVs offer expanded options for demand-responsive and crowd-sourced transit in low- to medium-density areas whether service is provided by the public or private sector. Private sector TNC platforms benefit from costs only being incurred when a trip is made. Public agencies could benefit if allowed to operate this type of on-demand door-to-door service using a similar platform or by contracting for this type of cost-effective service when traditional fixed-route bus productivity would otherwise be low (ie, less than 10 riders per hour). Being more cost-effective could also allow for extended operating hours that are necessary for transit to provide reliable all-day travel.

Increasing Occupancy or Decreasing Size

In terms of AVs, absent government regulations, initial implementation will likely occur through TNC or MAAS platforms (although companies like Tesla may offer AV technology through a traditional private ownership model). While AVs offer potential benefits such as reducing collisions they also make vehicle travel more attractive. Increases in vehicle use could exacerbate current problems associated with congestion and emissions especially if vehicle sizes remain large and occupancy levels remain low. The following actions are intended to minimize adverse effects of greater vehicle use.



Performance	Traditional Vehicles	Micro Vehicles
Delay (seconds)	175	31
Fuel consumption (gallons)	422	187

▲ **Vehicle Size Effects on Traffic Delay and Fuel Consumption** Source: Fehr & Peers, 2018

- **Require AVs to be electric –** Using electric power generation would minimize the emissions associated with AV travel.
- **Support small or micro-sized AVs for personal use –** The image above shows how vehicle size influences intersection delay and fuel consumption. Today's large vehicle sizes (combined with low occupancies) consume substantial physical space, capacity, and green time at signalized intersections. Reducing vehicle sizes improves network performance.
- **Manage or price AV travel to encourage high occupancy levels –** Various studies of AV effects emphasize that the only way to prevent substantial increases in vehicle use (i.e., VMT) is require AVs to operate as taxis carrying multiple passengers. Building pricing into AV use early can help shift ground transportation towards more efficient travel outcomes and to partially offset transportation revenue losses from parking and citations. Instead of peak period travel demand routinely overwhelming available roadway supply, demand-responsive pricing of AVs especially in TNC or MaaS platforms could help manage fleet sizes and roadway space utilization. This policy response is not simple though and would require addressing numerous issues typically raised for any US road pricing proposal. Notably, equity of any change given current system is publicly owned and perceived as 'free' by users, absence of an existing market (creating prices does not necessarily create a market), use of revenues to ensure efficient outcomes, limited ability to transfer payments from those willing to pay for travel to those willing to forgo travel, and whether revenue transfers must account for who paid the taxes to build the current network.

Land Use

As explained above, new mobility and autonomous vehicles have the potential to contribute to more dispersed land use patterns. Greater land use controls such as those listed below may be necessary to offset undesirable expansion of land use development.

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- **Urban growth boundaries –** AVs and new mobility may extend the distance people are willing to travel between their home and major destinations such as employment and education centers. Urban growth boundaries are one mechanism for directing growth to help minimize undesired expansions of urban area footprints.
- **Zoning changes –** AVs and new mobility may increase development pressure on land areas and parcels that previously were not envisioned for residential development. Some cities and counties allow residential development under a wide variety of zoning classifications. With housing supply constraints in many major U.S. cities, AVs may extend travel distances as notewd above, which could increase demand to build residential homes on parcels originally intended for other uses.

In sum, disruptive trends and new mobility have the potential to increase the use of vehicles and extend regional accessibility by lowering the costs (money and time) of vehicle travel. Offsetting potential undesirable effects requires government actions. It requires difficult policy decisions that conflict with the current norm. As we alluded at the start, and is reinforced throughout this article, the objectives of the private market to incentivize vehicle use may generate outcomes that are mis-aligned with important government objectives.

The private market will be incentivized to generate revenue from new mobility services based on miles of travel, minutes of travel, and choice of vehicle/service. This structure does not guarantee that these vehicles will be shared. Conversely it will likely increase trips, creating competition between service providers to reduce costs, increase choices and attract more riders. More miles and minutes mean higher revenue, and in this light, policy is needed to balance these private market interests with public policy goals. We provide some policy and regulatory responses for the public sector, but it is up to planners, engineers, citizens, and elected officials to take action.

And that action should happen now. Onward.

Further information

Read more in the forthcoming book *Disruptive Transport: Driverless Cars, Transport Innovation and the Sustainable City of Tomorrow*, edited by William Riggs and published by Routledge.

This article was originally published in two parts by Meeting of the Minds, August/September 2018, ahead of the forthcoming Meeting of the Minds Annual Summit in Sacramento, California, 27-28 November: https://meetingoftheminds.org/events/motm2018

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