Getting past the hype: revisited

Bern Grush and **John Niles** from Toronto-based Grush Niles Strategic offered a cautionary analysis for *Thinking Highways North America's* January 2016 issue, describing why the market perception of the fully autonomous vehicle would be guaranteed to falter for the next five or 10 years – and falter badly. Given the majority positive press, daily announcements and apparent progress being made for semi-autonomous technology they return with more analysis for *Connected Canada*, supporting their observation that negative hype has taken root and is growing in intensity. We are reprinting their original article, including its proposed transit-oriented solution complete with a preface and seven new, compelling sidebars.

A couple of years ago, we started writing about getting ready for autonomous vehicles. We called our collected work *The End Of Driving* in recognition of our certainty that robotics will displace the driver just as the motorcar had replaced the horse. We were as excited then, as would be anyone contemplating all the utopian mobility on offer.

We're still certain of a driverless future, but by now we hold a much more sobering view of the path to get from no AVs to all AVs. We are reminded of the 40 years spent getting from only horses to no horses, and the unfortunate turn city planners took almost universally as they reacted to an exciting, empowering technology and began creating automobile-centric urbanscapes, carved up by eight-lane highways embedded in a matrix of parking lots.

We now contemplate the very real danger of planners taking the same turn and building AV-centric cities biased for household owners of robotic vehicles. What would stop planners and city leaders from repeating the past if they see the AV as addressing all the ills of the motorcar car and its fallible, human consumer? The motorcar was such an improvement over the horse that embedding the automobile into civic design was certainly logical 100 years ago. Today, there are legions of consultants, journalists and entrepreneurs painting a future of all the upsides of the new robotic car that would eradicate all the downsides of the old human-driven, fossil-fuel car, while maintaining the personal mobility model that emerged in the last century.

We remain convinced that no one can yet forecast how this will unfold in any useful detail or at least useful enough to write infrastructure plans or social policy. We continue to describe the next quarter century as the most difficult transportation planning horizon ever faced by urban planners.

Over the past couple of years, prognostication has ranged from "no more personal automobile ownership," to "no more public transit," to "instant-and-just-right robo-cab within 2 minutes of a request," to "a clean and perfect car for every garage." It still does. And this frames green utopias of no accidents, no parking, no congestion, and info-cocooning on the way to work. Or perhaps dystopias of sprawl, transportation inequity, increased congestion, and robots chauffeuring parent-free five-year-olds to ballet.

In the 7 March issue of *Time* magazine, this year, Xerox Executive David Cummins, thinking about all the immediate, incremental changes, comes off as indifferent. "Cars parallel park themselves now. Cars speed up and slow down on their own already. Cars have all kinds of accident-avoidance technology. And you are going to have more and more and more of that introduced over the next three to five years. By the time that first car rolls off the factory line without a steering wheel, it's not going to be that much of a shock. The collective response may be more of a shrug. As in, 'It's about time.'"

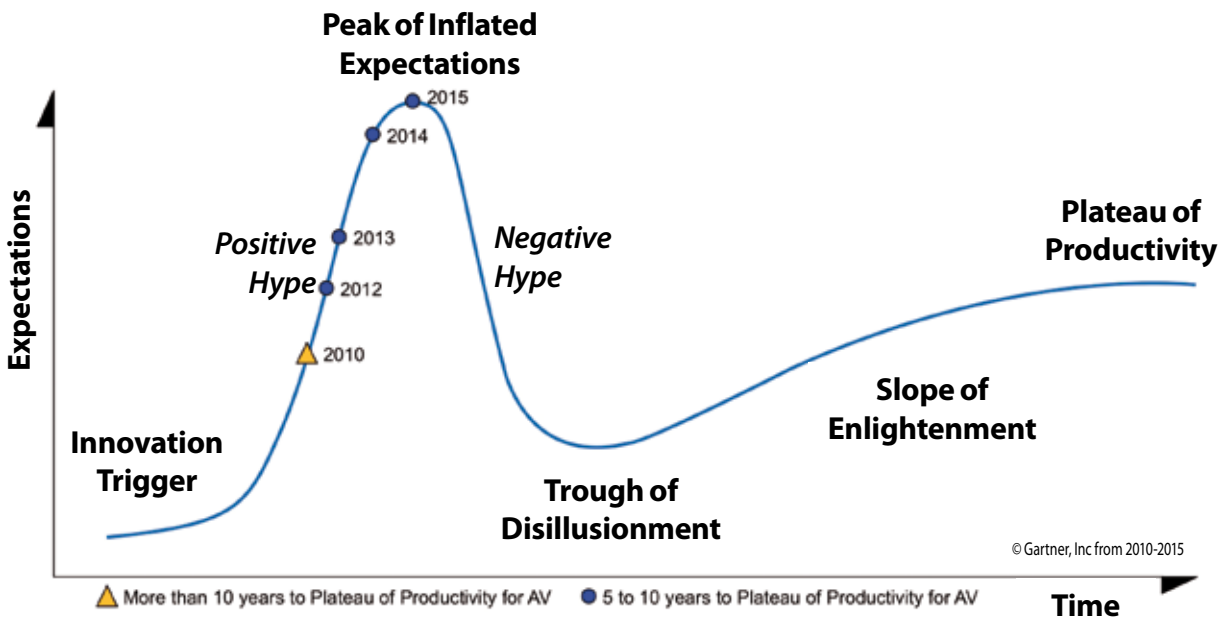
"In 2010 self-driving hype was about Sebastian Thrun winning the DARPA challenge, retellings of the General Motors exhibit at the 1939 World's Fair, and how many thousands of lives robotic vehicles could save since most accidents are caused by human error"

This illustrates a critical issue. Generally, the autonomous vehicle has been described as enveloping us in a gradual accretion of better and better features and capabilities until soon (2020 is often mentioned) the user can get in, provide a destination and the car will handle the rest. Most often this is framed as just a series of problems to solve, improvements to add, and prices to fall. Then urban utopia can begin.

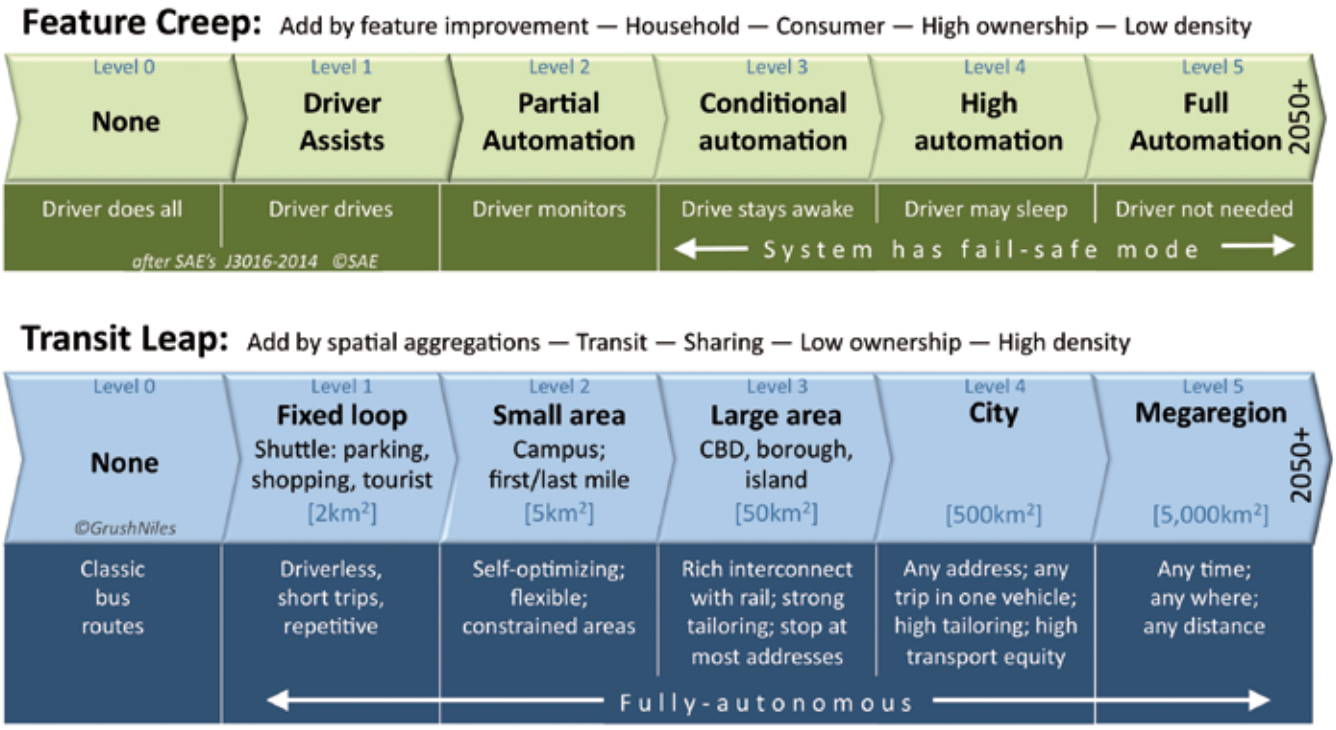
There are only two routes to having a meaningful number of household owners or a robocab fleet operators purchase SAE Level 5 autonomous vehicles. The first is that these vehicles have to be capable almost everywhere, almost always, and in almost all conditions – and they are programmed to safely avoid places and circumstances that cannot safely operate in. The latter condition can probably be met soon, but a prospective buyer might pause to wonder if the vehicle can take them, or their customers, wherever and whenever they need to go. This would give rise to a new kind of buyer disorder we call access anxiety, akin to the market-limiting range anxiety that beset the electric car until now.

The second route is to deploy Level 5 vehicles in constrained environments making them suitable in transit applications and domain-constrained taxi applications, until the technology gets so good that access anxiety disappears. We describe this as Transit Leap in the article that follows.

Considering how long household and fleet buyers have continued to avoid mass adoption of electric vehicles, it would seem that mass adoption of SAE Level 5 vehicles is still fairly far off. It is this sort of reasoning that has Jurgen Nieuwenhuijsen[1] reason that the market will linger for decades over Level 2 and



▲ **Figure 1: Gartner's Emerging Technology Hype Cycles from 2012-2015 indicate the rising hype for the Autonomous Vehicle peaking in 2015. Gartner Hype Cycle model and the positioning of the AV in its context from Gartner, Inc. 2010-2015**



▲ **Figure 2: [top] Feature Creep as expressed in the five-level autonomous vehicle standard, J3016 from the Society of Automotive Engineers. Only the Level 5 vehicle in fully autonomous (no driver controls needed); [bottom] five levels of Transit Leap spreading autonomy by spatial transit extensions rather than by household consumer purchase. All vehicles in Transit Leap Levels 1 through 5 can be fully autonomous SAE Level 5 vehicles**

Level 3 before finally adopting Level 5. Essentially, until Level 5 can go anywhere, a good Level 3 is all one needs. What we seldom consider, and David Cummins doesn't mention, is that the practical barrier to full autonomy is far more than just a few final improvements to a long string of robotic innovations. We will not feature-creep our way to a driverless world, which is why Google wants to take out human steering and acceleration controls (see sidebar (R)evolutionary Hype).

In the middle of last year, we wrote about the impeding downslide in market excitement surrounding fully autonomous vehicles. A downslide that, according to Gartner, Inc., would counter the rising hype for AVs experienced from 2010 to 2015. Our observations match remarkably Gartner's Hype Cycle assertion that 2016 would begin five to ten years of sobering reassessment. Our original article, below, underscores a few reasons for disillusionment, but there are many more. This new edition addresses that shortcoming by adding several sidebars that illustrate more negative hype. We end with an excellent summary by Robert Poole of Reason Foundation (with permission).

AROUND THE CORNER LIES THE FUTURE

Much is written about the expectations for autonomous vehicle technology. The attention is deserved. Surely the switch from driver to driverless is as remarkable as was the switch from horse to horseless 120 years ago? A science fiction fantasy at the 1939 World's Fair is finally showing up in bits and pieces as automated driver assistance systems in many automotive brands. Robotic vehicle features like lane keeping and automatic braking are on their way to becoming the norm. AVs are just around the corner. Or are they?

Every year Gartner Inc., an information technology advisory, publishes its Emerging Technology Hype Cycle (Figure 1). This model based on observations of hundreds of trajectories of successful technologies, arranges emerging technologies on a time spectrum of five phases from "*Innovation Trigger*" to the "*Plateau of Productivity*". All technologies go through these developmental stages: they get over hyped, disappointment sets in, and after some time the technology is viewed more realistically and settles into a role where it is most useful. With this model, which CeBIT describes as "astonishingly accurate",[2] Gartner is a telling seer for the progress of robotic vehicle technology.

The Autonomous Vehicle first appeared on Gartner's 2010 Emerging Technologies Hype Cycle[3] about a third of the way up the *Positive Hype* slope toward the *Peak of Inflated Expectations*. In 2010 self-driving hype was about Sebastian Thrun winning the DARPA challenge, retellings of the General Motors exhibit at the 1939 World's Fair, and how many thousands of lives robotic vehicles could save since most accidents are caused by human error.

From 2012 to 2014 Gartner gradually promoted the Autonomous Vehicle from halfway up the *Positive Hype* slope to the *Peak of Expectations*, which it reached in July 2015[4] (Fig 1). In 2010, Gartner positioned the Autonomous Vehicle as "more than 10

years from mainstream adoption". By 2012, Gartner upgraded this prediction to "the Plateau of Productivity will be reached in five to 10 years", a five-year advance in 24 months. That projection has remained unchanged since then.

THE TROUGH OF DISILLUSIONMENT

A lot of excitement (and hype) has indeed built since 2010. But as with all technologies studied by Gartner, the full, Level 5 autonomous vehicle is now inescapably poised to fall into the *Trough of Disillusionment* and recover on the *Slope of Enlightenment* before it reaches the *Plateau of Productivity* within Gartner's estimated 2020 to 2025.

The impending slide through Negative Hype and into the Trough of Disillusionment has started, manifesting as barriers to the gradual, market-envisioned feature creep through advanced driver assistance systems. This household ownership model would spawn 20 or 30 lucrative years for consumer vehicles and technology companies, as they would eventually reach pervasive uptake of SAE's Level 5 autonomy (Fig 2, top).

One of the barriers is that humans generally come to rely on assistive technologies quickly and incautiously. The reliability with which drivers will remain attentive while using intermediate levels of semi-autonomous features, or be able to rapidly re-refocus their attention in the event the vehicle requests oversight, is very challenging.[5,6] Driving becomes the distraction.

Another barrier is the organization of public infrastructure. Near term use of fully autonomous, Level 5, vehicles implies either mixing them with semi-autonomous ones on the same roadway, setting up separate lanes and safe-havens at great expense, or as Google (and now reportedly, Ford[7]) has elected, jumping immediately to Level 5 AVs skipping the intermediate semi-robotic levels altogether. Of course Level 5 AVs would suffer severe access limitations in their first decade or so. The owner of a Level 5 AV would be able to use it only on fully qualified lanes and areas. These would not likely appear quickly given the social, political and funding hurdles that slow any major change to our public spaces. Access-anxiety for early adopters of Level 5 AVs would be worse than the range-anxiety afflicting early EV adoption.

A further barrier to consumer ownership of fully robotic vehicles will be financial. Because the technology for robotic mobility will evolve so rapidly, household vehicle lifespans will plummet and their ability to retain resale value after purchase will be abysmal. These vehicles will not have 12-15 year life spans as now. Three years would become a more typical expectation for even meagre value retention. If you are on your second or third smartphone, you will understand.

"Strategic expansion of the geographic reach of autonomous Transit Leap vehicles will increasingly erode the need for vehicle ownership. Peak car ownership becomes declining car ownership"

For consumers who can't use them or can't finance them, how much more disillusionment is needed?

THE SLOPE OF ENLIGHTENMENT

Happily, there is a solution to this impending slump in enthusiasm for the fully self-driving car. Just as the barriers to the household market for Level 5 autonomous vehicles are becom-

SIDEBAR 1: ARRIVAL HYPE

It is important for governments to be prepared for vehicles that drive themselves, whether moving people or goods. Since there are scores of considerations, this anticipation is critical. The untold number of effects, interactions and unintended consequences, means the task of mapping out this future is daunting. Technological change has a habit of taking far longer than promised to arrive. When is does arrive, it sweeps in dramatic and sudden change on its famous S-curve. That will happen with Level 5 AVs. They will take far longer to begin penetration than automotive marketers and consultants suggest (remember the lesson learned as range anxiety halted the meaningful uptake of electric vehicles). Once accepted, Level 5 vehicles will likely become pervasive in a tsunami. When the upswing on the S-curve begins, the ensuing scramble would result in disruption of almost everything. That's the fear that consultants thrive on, but the number of reliable, nuanced projections is near zero. We know robotic vehicles are coming, but little else.

There are many contradictory promises regarding when Level 5 technology will become pervasive. Some of the contradiction is because the expression "self-driving" correctly describes both a fully robotic machine (no driver role) as well as the features of Level 2 or Level 3 vehicles when they are switched to automatic mode – a temporary state set by the driver that still requires driver presence and attention to varying degrees. The marketing of increasingly capable semi-autonomous features provides a degree of market confusion that benefits manufacturing and consulting brands. This promotes the expectation that showrooms will soon have fully autonomous vehicles requiring no driver at all, and turning municipal planners into deer in headlights.

Experts that understand the deeper complexities of AI, of preparing the road and infrastructure environments, of fleet turnover, of retooling plants and regulations, predict Level 5 arrival and acceptance in meaningful numbers sometime between 2040 and 2070. The high-end Level 3 semi-autonomous vehicles that automotive marketers promote as "self-driving" still need drivers and parking spots. Level 3 vehicles may be a tremendous improvement over Level 1 or Level 2 vehicles – they would likely deliver a safer, cleaner ride for their owners, and for the pedestrians, cyclists and other vehicles they share the road with – but they don't wipe out driving jobs or return vast tracks of parking real-estate for redevelopment.

It is true that there are many things to prepare for the arrival of Level 5 vehicles. It is prudent to start thinking and planning now. The likely span of two or three decades of Level 2 and 3 dominance means a significant period of more congestion, more parking, more distracted driving, more sprawl and reduced transit ridership. Such an interim outcome threatens cities 2020-2040+ and leaves urban environments that much more difficult to heal when the Level 5 vehicle does arrive.

SIDEBAR 2: CONGESTION HYPE

There are always several inputs to traffic congestion. Its nuance fills textbooks.

Several expected attributes of Level 5 vehicles are touted to reduce congestion. They will travel in tighter formation and in narrower lanes. Moving at uniform speeds, traffic waves would no longer slow highways packed with commuters. Far fewer crashes will mean avoidance of many other jams. Optimal navigation systems take over connected control to balance loads removing any residual congestion.

Before these vehicles can occupy narrower lanes, move with shorter headways and end traffic waves, there needs to be minimum portion of the fleet converted to Level 5 vehicles. These effects are mostly unmodeled and the minimum conversion required is unclear. The cost and timing of reconfiguring lanes is unknown. Adjusting some lanes would shift problems somewhere else in the system.

In the interim, vehicle use will continue to grow. In Level 3 or 4 vehicles, near-flawless robotics would relieve drivers' attention while on highways reducing the perceived pain of congestion and offering productivity gains during a trip. This is expected to create more sprawl and add VKT to our highways. This would demand more capacity at choke points such as entrance and exit ramps to cities and more parking in our cities as car travel becomes yet more convenient compared to transit. Being able to work, nap or conduct business while traveling solo in a car would tend to lower occupancy and counter the effects of ridesharing efforts.

More critically, worldwide demand for motorized PKT doubles every 20 years. Whether reflected in vehicle ownership or trip count, PKT translates to VKT unless vehicle occupancy can increase at a matching rate. While vehicle occupancy may improve will it be enough to offset the increase in PKT demand?

Growth in demand is not uniform. Some jurisdictions, especially in wealthier countries, are seeing a slow down in demand growth. Depending on demographics and policy, some populations will be more willing to ride-share than others. Not every jurisdiction will see the same congestion effects.

But to assume that congestion will naturally reverse or evaporate due to the deployment of vehicle robotics is naïve, at best.

SIDEBAR 3: SOLUTION HYPE

Because automotive robotics hold so much promise, it is easy to compile a lengthy list of benefits: greater safety, less congestion, more access, more productivity, more sharing, and many more. In contrast to such a list are counterbalancing advantages: more access means more congestion; more productivity means greater sprawl; greater sprawl affects land prices, more sharing affects transit ridership, less parking means less municipal revenue and jobs, redeveloping parking spaces as residential condos changes the tax base, and so on. System interactions are always more numerous and harder to divine that simple effects. It is always the interactions – the second and higher-order effects – that trip us up.

The more interactions, the harder is it to model. The harder to model, the more confusing it is to regulate. Clearly vehicle robotics imply both a virtuous cycle and a vicious cycle. Some manufacturers and consultants espouse the virtuous. Other consultants and pundits magnify the vicious. Because of the number of variables and interactions, confident projections are impossible. This is why we say that the decades in front of us comprise the most difficult transportation-planning horizon ever faced by urban planners.

SIDEBAR 4: (R)EVOLUTION HYPE

Will the arrival of the autonomous vehicle be revolutionary or evolutionary? Will we jump suddenly to robotaxis as Google is proposing? Will we evolve our way to Level 5 autonomy as many manufacturers appear to be hoping? Or will Apple announce something one year later that changes everything, anyway?

In March 2015, in its newsletter, Clearthought, Clearwater International, a corporate finance house with an automotive practice, wrote: "…a consensus is emerging that the journey to autonomy will be a progressive one in which small steps are made along the way and new features are added to vehicles every six to nine months or so."

That same month, executive Astro Teller of Alphabet's business division overseeing the Google automated vehicle, said at the South by Southwest Interactive in Austin, Texas: "We came quickly to the conclusion that … the human was not a reliable backup – the car had to always be able to handle the situation. And the best way … was to design a car with no steering wheel – a car that could drive itself all of the time."

Seeming contradictions, both the Google and Clearwater views carry credibility – and both will happen. There are two ways to reason through this. The first is that highly automated vehicles typified by the early Level 3 releases such as Tesla's Autopilot and Volvo's IntelliSafe Auto Pilot going into 200+ vehicles in Sweden and China from 2017, comprise many hundreds of hardware and software elements each of which has an innovation trajectory and are implicated in enormous numbers of system interactions. These Advanced Driver Assistance Systems (ADAS) are technological evolution, pure and simple. In fact, whether one or more of the several companies engaged in this innovation develops better technology than the others is part of that evolutionary process. To the extent that Clearwater's progressive, feature-creep vision operates, this form of technology trajectory is incremental. Things gradually improve, the driver stays in the vehicle, parking demand grows gradually, sprawl increases a bit more. Big Auto consolidates and gets bigger.

The second way to think about this is that if at some point the driver is to leave the driver's seat something more fundamental has to have taken place – enough incremental changes, enough social readiness, enough infrastructure preparation – so that a whole new species of motor travel becomes available. The car itself will be unsurprising, as David Cummins predicted (see Preface). Levels 2 through 4 are evolutionary. Level 5 is revolutionary. Connected, robotic, driverless, revolutionary Level 5 vehicles follow from the evolutionary development of earlier levels.

But there is a break between Level 5 and the earlier levels, and Transit Leap is the missing link.

ing apparent,[8]the application of robotic vehicles to public transit is gaining advocates. We see successful instances of the use of robotics for transit applications on constrained routes and limited networks[9] via government-franchised, private investment as well as public investment. Already, on the public side, there are semi-robotic vehicles providing very high frequency transit in closed environments such as airports (driverless circulators among terminals) and elevated rail systems (Vancouver, BC's SkyTrain system). Meanwhile, the private sector is quickly developing its own transit routes, still driven by human drivers, such as Chariot and UberHOP. One can easily imagine these routes persisting – and growing – as operating costs drop during the transition to robotics. These public or commercial TaaS applications would address most or all of the barriers faced by early, access-limited, self-driving vehicles in the driveways of household consumers. As this happens, the autonomous vehicle could find an important niche in disrupting transit – and with more, not fewer, transit jobs, as described below.

By design, public transit vehicles are limited in their routes and spatial ranges. Targeted, spatially constrained, affordable, roadway preparation would be associated naturally as autonomous transit applications and routes are mapped and prepared one-by-one. There would be no opportunity for access anxiety among users of such services.

Add robotic, on-demand taxis and shuttles (limited networks at first, extended over time) in seamless multimodal integration with each other, along with rail and autonomous transit vehicles. With focused effort and public-private cooperation, significant transportation-as-a-service (TaaS) systems can be realized in the early 2020s.

Driverless vehicles in public service would be designed with life cycles appropriate to rapidly evolving technology and high vehicle-turnover due to 10 to 16 hour daily use cycles. With lower per-mile user costs, user-fees can be set for cost recovery. With growing ridership, user-fees could support public-private partnerships (P3s) as investors and fleet managers.

INTRODUCING TRANSIT LEAP

Transit Leap means public-use, robotic, shared-mobility applications that start small, expand by demand, grow, merge, and spread (Fig 2, bottom). The core motivation for focusing on *Transit Leap* is to accelerate the arrival of Gartner's *Plateau of Productivity* and all the promised social value of robotic mobility.

Transit Leap encourages the incursion of robotic mobility into the urban landscape incrementally, application-by-application and area-by-area rather than car-by-car and owner-by-owner, as has already started with *Feature Creep* technology releases such as Tesla's ADAS and Volvo's planned Level 3 autonomy pilot for Gothenburg in 2017.

The spatially constrained nature of early transit and robo-shuttle

SIDEBAR 5: SHARING HYPE

Clearly it makes rational, economic sense not to own a car if you can reliably call up the exact vehicle you need with a click on your smartphone and have it arrive in a promised two or three minutes. And there seem to be many forecasts for an ability to fulfill such promises in huge numbers years in advance of a practical capability to deliver them!

However, once someone begins to deliver on this promise, Robin Chase may be sensible to say: "If you're financially smart and living in the city and you don't need a car to get to work, you're insane to own one." And for people who do not yet own a vehicle or have one they hardly use, she would also be clearly correct. Unfortunately, there are many reasons people own a vehicle and dialing up an instant robocab addresses only some of them.

Most people who current own a vehicle would need to have several concerns addressed. This is more about behavioral economics than the rational economics that Chase is describing.

To have a majority of drivers abandon ownership for the various forms of sharing expected to become dominant, many concerns in addition to job access must be addressed. These include convenience, time saving, anytime-anywhere access, social status, personal objects in the car, transporting loads and small children as well as personal privacy, hygiene, and safety. It is the perceived value of all these benefits weighed against the financial savings that will be telling.

SIDEBAR 6: CITYMOBIL2 EXPERT POLL

We cannot use empirical studies to determine the future. That means in the run up to robotic vehicles, we cannot determine the future volume of car sharing or the decline in vehicle population or growth in VKT or changes in transit demand. Some transportation academics have run simulations that use current origin-destination data to ask what would happen if everyone used only robotaxis. Based on very optimistic, often fanciful assumptions, most such simulations show we'd only need one car in ten – something Zipcar first claimed about their service about a decade ago. Unfortunately, they assume everyone would be willing to share vehicles and rides, they do not include all the new users that might be served, they ignore the fact the current world motorized VKT demand doubling time is about 20 years, and they generalize the results based on data from more populated central urban areas. These simulations of city vehicle populations tell us the maximum potential efficiency for vehicle sharing (we clearly have an embarrassment of excess capacity), but sadly, they are not a reliable gauge of future, revealed demand.

While many journalists and sharing-economists have succumbed to the illusion "everyone will share", there is yet another way we try to guess the truth about the future: ask a lot of experts, then pool their opinions. In March 2015, experts from Europe, the US, Japan and Singapore met in La Rochelle in the context of the European project CityMobil2. After discussing socio-economic impacts, these experts were polled about the expected long-term impacts of road vehicle automation for four different urban environments – suburban, urban, rural and small compact city – and for two different scenarios: dominant self-driving household cars and dominant self-driving robocabs. The direction of the responses point to more VKT, lower vehicle occupancy and lower ownership. When considering this, remember that demand for VKT will continue to rise independently in most countries during the switch over from driver to robotics. Hence, according to this group of experts vehicle robotics would likely make the growing problem of congestion a bit worse still.

SIDEBAR 7: THE EMERGING CONSENSUS ON AUTOMATED VEHICLES AND VMT

by Robert W. Poole, Jr, Reason Foundation, Surface Transportation Innovations, April 2016

In the initial rush of enthusiasm for the potential benefits from a transition to mostly autonomous vehicles, reduced congestion and vehicle miles of travel (VMT) came in as a close second to reduced deaths and injuries from traffic accidents. But a growing array of studies suggests that a majority of researchers now think VMT will increase in an AV world, possibly by a great deal.

In the January issue of the Surface Transportation Innovations newsletter, I noted a report from KPMG (The Clockspeed Dilemma: What Does It Mean for Automotive Innovation) that used extensive focus group data to project large increases in VMT primarily due to increased personal vehicle travel by those unable or unwilling to drive today: teenagers and children, elderly people, and disabled people. But that's just the tip of the iceberg.

A paper published in February in Transportation Research Part A, by Zia Wadud and several academic colleagues, analyzed potential US car and truck energy demand by 2050, assuming significant AV market penetration. They estimated percentage ranges for a variety of energy-saving factors (including platooning) and reduced congestion, but did likewise for an array of possible energy-increasing impacts. These included people shifting from rail and airlines to AV travel, people living farther from work since they can be productive while commuting in an AV, and net new car travel by the kinds of people noted by the KPMG study (though their estimates on this were far lower than KPMG's).

Overall, they concluded that the net impact of these factors could be increased or decreased energy use (and correspondingly increased or decreased VMT). A major factor in the outcome will be the extent to which people do or don't shift from vehicle ownership to vehicle sharing.

A 2015 OECD International Transport Forum project simulated a possible AV fleet serving Lisbon, Portugal. It found that if shared-use AVs reached 50% of total vehicles, with the rest being human driven, total VMT would increase between 30 and 90 per cent. A panel discussion at an Eno Center for Transportation conference last month again identified the ride-sharing question as the largest factor in the extent of VMT change. *Eno Transportation Weekly* summarized the discussion on the question this way:

"With regard to the VMT question, the underlying assumptions about ridesharing versus single-use vehicles make an enormous difference in the outcome. . . . [A]utonomous vehicles could eventually result in a lot of people owning and operating cars that would be unable or unwilling to operate a conventional auto. Alternatively, the assumptions about AVs leading to lower overall VMT involve a mass migration from personal car ownership to shared-ownership or for-hire fleets."

A new overview report, Driving Towards Driverless: A Guide for Government Agencies, by WSP Parsons Brinckerhoff, concludes that, "No matter the scenario, there are a few impacts that are likely in a future driverless vehicle society, including increased safety, increased VMT, and reduced GHG emissions… VMT will likely increase as the cost of travel decreases and more people choose to drive."

Researchers with a planners' mentality are unhappy with that likely outcome. The author of the WSP Parsons Brinckerhoff report presents it as the "Driverless Nightmare" scenario, in which the demand for highways increases and the dreaded "urban sprawl" gets even sprawlier. She contrasts this with a "Driverless Utopia" scenario in which shared use of non-individually owned AVs plus expanded mass transit lead to more-compact, "smart growth" metro areas. In the Policy Activities section, the author writes, "This guide assumes that local, regional, and state governments will want to take actions that encourage moving toward the 'driverless utopia' scenario," via such policies as disincentives for driving, enforcement of urban growth boundaries, increasing taxes on personally owned vehicles, and enacting legal limits on parking capacity.

The Transportation Research Part A authors agree, saying that it may be necessary to financially intervene in [people's] transport decisions.

Don't say you weren't warned.

applications means that progressive, urbanized regions can jump directly to fully autonomous vehicles, with rapid, tangible applications of SAE Level 5. Courteous, deliberate, cautious, and slow at first, these vehicles address user anxiety and safety while avoiding the distracted-driver issue plaguing semi-autonomous, pre-Level 5 vehicles.

Local, constrained, first-last mile applications expanding gradually into larger areas such as downtown cores, is an immediately available first step. While the first Transit Leap project for each transit agency is the most difficult, as experience builds these applications merge and grow into urban-wide, then region-wide systems, through a connected series of increasingly flexible and capable extensions.

The nature of public service employment will change resulting in job growth in transportation services. Consider a country that currently records 90 to 95 per cent of its passenger miles traveled (PMT) in privately owned vehicles and the remainder in shared vehicles (taxi, bus, car-share, shuttle, TNC). Assuming that on average one shared vehicle were to provide four times the PMT of a personal household vehicle and that it wished to halve its total fleet population, such a country would have to triple or quadruple its shared-vehicle portion to support its total (national) PMT. The labour contingent required to manage a tailored and responsive fleet that provides this increased level of TaaS services would, at a minimum, double its current public transit workforce, even as jobs, job training and job expertise changes.

Strategic expansion of the geographic reach of autonomous Transit Leap vehicles will increasingly erode the need for vehicle ownership. Peak car ownership becomes declining car ownership. Stagnant transit ridership and the threat of transit job-loss become growing ridership and job growth.

ROBOTIC TRANSPORTATION CAN'T BE STOPPED

The AV is bound to disrupt both public transit and the use of public-access shared vehicles. The Transit Leap opportunity lies in leveraging this disruption to increase transit ridership (robo buses, robo shuttles), and TNC ridership (robo-taxis).

Under a Feature Creep paradigm of consumer ownership of AVs, transit will be disrupted, as well – but negatively. The effect of a strong robotic offering by TNCs competing with a laggard offering from municipal transit will mean a decline in transit ridership and transportation equity. Uber's CEO, Travis Kalanick is on record saying he will provide better transit. The choice facing municipalities is whether to abdicate or grow transit.

Let's face it, there is a massive, 120-year-old automotive industry that is premised on making and selling a physical consumer product. Those commercial enterprises will remain and they will continue to build vehicles better and cheaper – and in greater numbers. The ethos of the status machine, the personal machine, the private machine, the convenience machine, the fast machine, and the sleek-and-sexy machine will remain as will consumer predilections for owning one. This currently saturates at around 0.8 vehicles per capita as national GDP rises,[10] but it will not evaporate.

Left to its own, automotive *Feature Creep* will erode the comparable, already-disadvantaged appeal of transit. Our current world aspires to a "car-in-every-garage", but TaaS is a "ride-for-every-need" world. If we want TaaS we need to change something fundamentally social about transit. Removing the driver from the private car is only an enabler for TaaS and may even be a step backward if municipalities "wait and see".

WHY TRANSIT LEAP?

Gartner's Hype Cycle is descriptive rather than prescriptive. It tells us the SAE Level 5 AV will slump in mass media and consumer perceptions, but not why this will happen. For that we need to watch 2016 and 2017.

The Hype Cycle also predicts that there will be a reputation recovery for the technology sometime after that – perhaps as early as 2020. But it is harder to fathom how this will unfold. Since we are certain that robotic vehicle technology is unstoppable and that the nearest mobility market begging for disruption is transit, we define *Transit Leap* as the mechanism to ascend Gartner's *Slope of Enlightenment* and reach their *Plateau of Productivity*.

The path to the frequently predicted, smart urban future of any-time, on-call, mobility-on-demand will be easier to traverse if the Transit Leap paradigm is deployed. Urban transportation leaders need to not dither in the face of AV technology hype, hope, and fear. City builders need to step up to implementing what is feasible right now. This is how Gartner's Plateau of Productivity for autonomous vehicles could indeed be reached within the five to 10 years predicted. ●

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