APPENDIX C

A Comment from Grush Niles

Comment on "Future of Infrastructure" report

This report makes a key point at the outset: there is too little understanding of the need to build the right infrastructure and the need to build infrastructure right for the long term.

With this in mind, we'd like to focus purely on the issue of road, highway and transit infrastructure. The GTHA's well-documented deficits in transit, road maintenance, bike lanes and tolled highway lanes are not unique. For decades, large cities throughout the world have been up against the wall of urban growth, congestion, rising costs and environmental degradation.

Many thoughtful observers believe the developed world is on the cusp of a tsunami of automotive innovation that could hopefully enable miraculous relief from today's typical circumstances, but could just as likely cause a terrible exacerbation. Furthermore, planning for the next 20 years with an expectation of impending vehicle robotics is wholly unlike any other 20-year planning exercise we might have engaged in over the past decade.

Because the robotization of transportation vehicles is both certain and uncertain, infrastructure planning has been put at a new kind of disadvantage. Specifically, we can be quite certain of someday needing no human operator for nearly all vehicles in almost all circumstances – i.e., pervasive vehicle autonomy. Many of us can guess things about the nature of some of the disruption that will accompany this technology. But for most of the robotic future there is only uncertainty.

Collectively, we read many contradictory predictions about robotics vehicles. These are often biased: a manufacturer's spokesperson wanting to position their firm's products; a professor of transportation engineering simulating or extrapolating hopeful solutions to an enormous set of problems; a safety engineer wanting to advance the life-and-death value of this technology as soon as possible; journalists awed by what they see at a trade show.

Predicting vs. Hoping

All of this taken together leaves those charged with deliberating a path for a regional municipal transportation plan with many difficult questions.

How quickly will the autonomous vehicle arrive? Nobody can ascertain the speed or time of arrival of full autonomy – i.e., full pervasiveness in a region or city. We can easily imagine technical feasibility in most operating circumstances, but we cannot say when sufficient reliability will be exhibited in every circumstance—indeed, some credible analysts express doubts about this. That means we don't know when (or if) any different sorts or scales of infrastructure will be needed, or how long what we contemplate building in the interim will be needed.

Will robotics mean more or fewer vehicle kilometres travelled? Currently, humans are capped out at a worldwide average of about one travel-hour per day. If we can eat, play, sleep, read, work and shop instead of attending to driving, how much further will we choose to sprawl? Recent evidence appears equivocal. Many people who cannot drive now forego trips or have chauffeurs or use transit unwillingly. Will non-drivers with new freedom of mobility add to kilometres travelled? Or increase the number of cars owned?

Will robotics make travel cheaper? Humans now spend an average of 11 per cent of their disposable income on travel. Robotics will lower the cost of the vehicle, its fuel, its insurance and its parking fees. When something is cheaper, more is consumed. Will the travel savings be spent on longer trips? Or on bigger vehicles as is common in North America now? One might think rational travellers would spend the windfall travel budget on something else, but that is true of only some people.

Will new automotive players change the landscape of solutions? Will incumbent automotive manufacturers stage innovations to sell more semi-robotic vehicles and very appealing safety features for more model years, or will new apps-on-wheels players like Google, Apple and Uber steal the puck? Both types of players want to sell more. The new players sell kilometres. The incumbents sell vehicles. And some of those incumbents are already thinking about selling kilometres, too. Either way, there would be more vehicle kilometres travelled.

In what solution order will robotic vehicle technologies be applied? Will we robotize transit or goods logistics first? Expecting both to happen all at once – say over a decade – may be physically, operationally and socially impractical. Or will governments set regulations and let automotive manufacturers sell what they might to household consumers, while letting the insurance companies work out the issues of mixed traffic – driver-in and driver-out – sharing our roads.

Will shared fleets or household vehicles dominate? Critically, the jury is out on the matter of vehicle ownership, even though hope-filled forecasts by some paint a picture of inevitable, widespread vehicle sharing. Will most autonomous vehicles be owned as family vehicles are now? Or will the advantages of shared fleets be available to, evident to, and selected by the great majority of travellers so that household vehicle populations shrink dramatically? Will the car become more of a travel service and less of an accessory – i.e., all about the trip, nothing about status? Many academics are on record as saying "few people will own autonomous vehicles; most will share them," but there are many reasons – rational or otherwise – that most people currently prefer ownership, even while a growing few have found ways to avoid owning a vehicle. The backdrop of culture, habit, status, privacy and convenience of owning can be stacked against the rational economic notions of sharing and be used very effectively by automotive marketers. That has already started. Will irrational consumption or rational conservation win out? It's impossible to know which future will prevail, and we face many debates.

Some simulation-based research has been generated for cities such as Austin, Lisbon, Manhattan, Stockholm and others. Consistently, the researchers find that each simulated autonomous vehicle can replace about 10 current family-owned vehicles. The simulations are realistic in that they have been parameterized using the origin-destination (O-D) data collected in those cities but, in most cases, the researchers imply or reviewers conclude that such figures can be extrapolated to the world vehicle population. In *The End of Doom*, Ronald Bailey writes:

> Researchers at the University of Texas, devising a realistic simulation of vehicle use in [Austin] that took into account issues like congestion and rush-hour usage, found that each shared autonomous vehicle could replace 11 conventional vehicles. Notionally then, it would take only about 800 million vehicles to supply all the transportation services for nine billion people. That figure is 200 million vehicles fewer than the current world fleet of one billion automobiles.

> In the Texas simulations, riders waited an average of 18 seconds for a driverless vehicle to show up, and each vehicle served 31 to 41 travellers per day. Less than half of one per cent of travellers waited more than five minutes for a vehicle. In addition, shared autonomous vehicles would also cut an individual's average cost of travel by as much as 75 per cent in comparison to conventional driver-owned vehicles. This could actually lead to the contraction of the world's vehicle fleet as more people forgo the costs and hassles of ownership.

There are several problems with these simulations and the conclusions drawn from them. Research underway at Grush Niles Associates concludes that these simulations, constrained by the availability of useable O-D data, are unwarranted generalizations that cannot be reasonably extrapolated to suburbs and rural areas or work/service-related vehicles. Extrapolations such as echoed by Bailey must assume an inevitable and general willingness of all or most travellers to use shared vehicles. While there is much good to be said for a sharing economy, there is no evidence that all or most humans will engage this way. In fact, we can show dozens of barriers to such a general outcome. We can also derive ways to overcome these barriers to some degree, as will be described below.

How can we turn such a large ship?

In spite of a plethora of unknowns – or perhaps because of that – Ontario and its municipalities can start now to develop policy direction that is more likely to make a desirable outcome prevail than just hoping.

By waiting, municipalities risk the consequences of being swept up by exponential innovation that government will find hard to track, regulate and manage. If Uber caused regulators headaches in 2015, the disruption wrought by robotics by 2035 will be a thousand times worse. The 20-year future that starts now is harder to predict than any prior 20-year future.

We know we cannot *build* our way out of congestion by simply building larger versions of what we have built until now. And we know what we have now is inadequate to today's task. Without an ability to accurately predict the nature of motorized surface transportation vehicles in 2025, 2035 or 2045, we now cannot even *design* our way out of congestion.

The only way to escape this conundrum is to *innovate and integrate* in order to find a better way through. We need to complement our notion of infrastructure to go far beyond physical facilities to encompass the methods, business models, vehicle access and use models, data and labour models that create transportation value. Road surface, tracks, heavy transit vehicles, schedules and routes no longer explain everything. Current preoccupations obscure our understanding.

The reason that so few people understand prime time or surge pricing from transportation network companies (TNCs), such as Lyft or Uber, is because most people see chauffeurs as employees. But TNC drivers are not employees. They are volunteers. Prime time pricing calls them away from the dinner table or their beds to drive in peak hours or at tavern closing times when rides are needed. The absence of such a mechanism means taxis are unavailable when they are needed and circling pointlessly when they are not. Hence, the Lyft/Uber business model provides better service to its users, is cleaner for the city and encourages some users not to purchase a vehicle. It can also be cheaper than the bus in some ride-sharing circumstances.

Robotic vehicles, as indicated above, have the potential to make big problems worse, especially congestion, sprawl, and a demand for even more traditional infrastructure such as roads and parking facilities. They will almost certainly wipe out any residual value in financially stressed public bus systems. How should municipal and regional governments respond? City governments that fight robotic shared fleets like some fought Uber will lose. The cost per passenger kilometre will be a tiny fraction of the same passenger kilometre on a bus. It would make more sense for municipalities to engage in building massive shared fleets using PPP structures. Municipalities should plan to disrupt transit head on in order to create public robotic fleet services in a way that ensures equitable access for every citizen – a concept still missing from the business model of TNCs. In today's world, at a time when the robotics are not yet ready, cities need to begin to create the pre-conditions for the future they want to become.

The Puzzle of Infrastructure for Robo-Cars

Two critical unknowns among all these uncertainties provide an important key to thinking about the infrastructure issues associated with robotic vehicles:

- Will the majority of autonomous vehicles be owned or shared?
- Will they gradually be mixed in with human-operated vehicles or will they somehow be isolated to carefully constrained applications?

Owned or shared: Private ownership will lead to large extant fleets. Since these vehicles will not require a licensed operator, young, old and disabled passengers can now utilize a dedicated vehicle without a family member acting as chauffer. Hence some families will see owning an additional vehicle as a very rational decision – and the powerful marketing forces of the automotive industry will always prefer the high-volume consumption model stoked by year-over-year feature creep to a shared-vehicle model.

Conversely, a shared-fleet model, if used by a majority of travellers, would mean smaller extant fleets, dramatically reduced parking infrastructure (and space) and less congestion. Ironically, although we might need only half as many vehicles – or fewer – to operate concurrently, there is no assumption of fewer vehicles manufactured since shared use means shorter life cycles – i.e., manufacturers will still make a similar (or greater) number of vehicles. The losers in this scenario are the makers of large shared vehicles (buses). Once freed of the labour costs, a larger fleet of smaller vehicles is far more flexible (and effective) for transit operations.

Freely mixed or constrained and isolated: There are many operational, social and liability complexities involved in freely mixing driver-out and driver-in vehicles on the same roadway. Even as these become solvable, there are other, far tougher acceptability issues. Furthermore, traditional automotive manufacturers will prefer the mixed model, as it justifies many years of feature-creep (safety features, intelligent features) and nurtures an ongoing preference for ownership. They will mine the rich marketing opportunities across the full spectrum of partial-to-complete robotic enablement taking advantage of any cultural predilection toward "my car, my way."

Using increasing automation as a gold mine for adding new and compelling features to each model year is the common commercial practice called "feature-creep." Clearly many automated and safety-related features should not be disparaged as feature-creep, but what is the same is the year-over-year business model of incrementalism to stoke envy and fuel sales. Traditional manufacturers will not abandon this underlying success formula to create new demand or competitive advantage.

New players such as Google/Alphabet, Apple and others promising full robotics sooner than the traditional players see feature-creep as unworkable. Astro Teller of Google X, the business division overseeing the Google automated vehicle, at a keynote given at the South by Southwest Interactive in March 2015, says this best:

> "Even though everyone who signed up for our (self-driving car) test swore up and down that they wouldn't do anything other than pay 100 per cent attention to the road, and knew that they'd be on camera the entire time … people do really stupid things when they're behind the wheel. They already do stupid things like texting when they're supposed to be 100 per cent in control … so imagine what happens when they think 'the car's got it covered.' It isn't pretty. Expecting a person to be a reliable backup for the system was a fallacy. Once people trust the system, they trust it.

Our success was itself a failure. We came quickly to the conclusion that we needed to make it clear to ourselves that the human was not a reliable backup – the car had to always be able to handle the situation. And the best way to make that clear was to design a car with no steering wheel – a car that could drive itself all of the time."

This predicts that feature-creep will fail as vehicles become more automated but well before becoming driver-out, and a jump to full autonomy (Google's position) will be demanded. But we cannot move to pervasive robotics in a day. We still need to creep our way there as well.

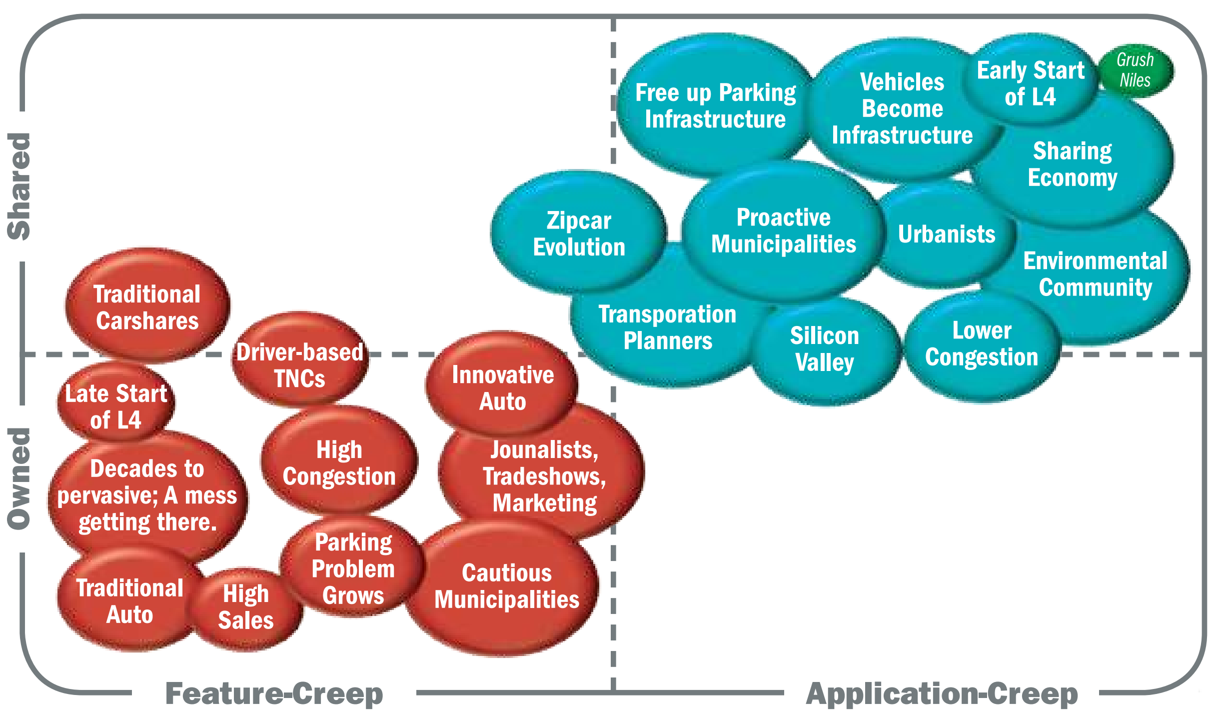
Teller's comment also predicts problems for mixing autonomous and non-autonomous vehicles. Note that all accident involvements for Google's autonomous vehicles to date have all been blamed on drivers of non-autonomous vehicles, which caused rear-end collisions. If mixing is not going to work, it would make much more sense to put robotic vehicles to work in constrained, unmixed applications.

For this, we introduce the concept of "application-creep," meaning we need to find safe, somewhat isolated applications from which we can start small and branch out. The European Union's CityMobil-guided, small-vehicle test project in several different cities is an early example – beginning cautiously, highly constrained, moving slowly and incorporating extreme oversight.

We know about numerous other small-scale applications: parking lot shuttles at airports that could be serviced by six- and eight-passenger vehicles running at modest speeds on clearly marked lanes and tightly constrained to regular service on regular routes. Human attendants would be eased out only gradually, both to provide comfort to early users and to help address labour attrition. Such applications are numerous and can be gradually expanded (the creep part) to longer routes, allowances to handle passenger requests by smartphone (more like a jitney than a shuttle). Following this, retirement communities could use such vehicles for local on demand trips including to local shopping, entertainment and worship.

Cities could begin with smaller urban bus routes at low speeds on constrained lanes at grade and without barriers, set up like bicycle lanes. These city systems would have the experience of the parking shuttles and the retirement communities to rely on. These city routes could expand in number, distance and flexibility until municipal transit is dominated by multi-sized autonomous vehicles. During the latter half of this shift, robotaxi services could begin and would merge so that robotaxi and robo transit are a continuous service spectrum.

Figure 1: Sorting the stakeholders and concepts in modelling the future.



Innovation and Integration

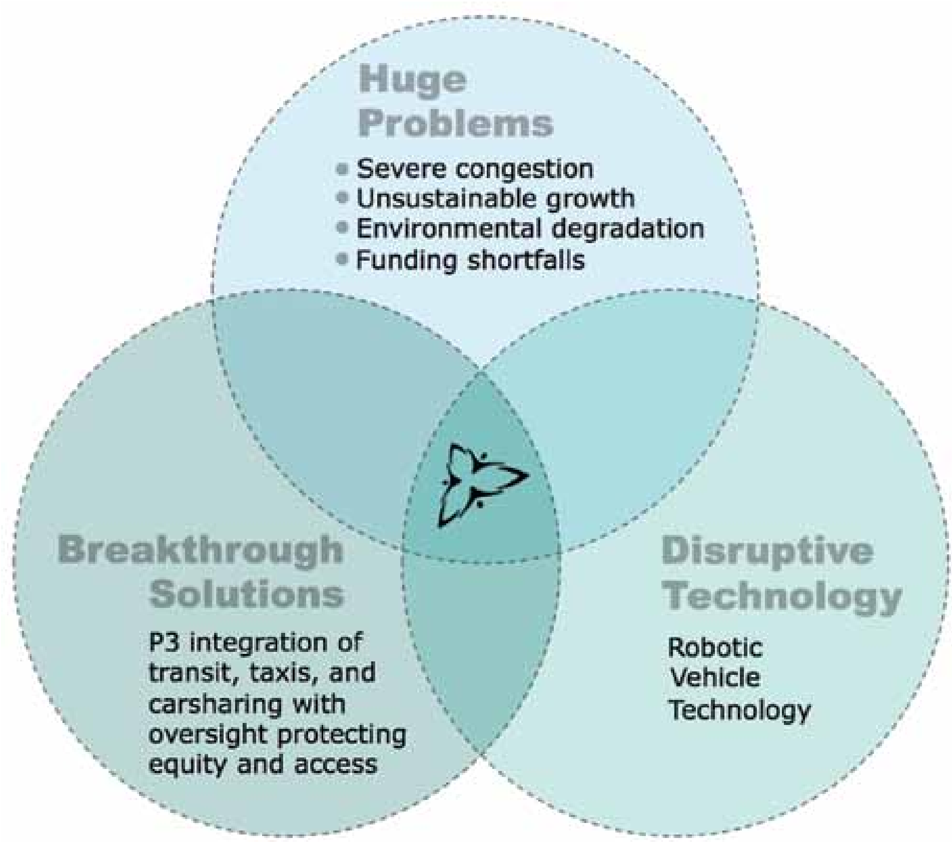
We can now reasonably begin the process of deciding how robotic mobility technology – especially where it involves sharable components – is to be deployed. We want to use this technology to completely transform surface transportation from transit that is cripplingly expensive and used across all trip types for roughly seven per cent of passenger kilometres in Canada. Shared vehicles (taxicabs, transportation network companies and carshare) although growing in number now, still produce statistically invisible passenger kilometres on a North American basis. Private vehicles – idle 95 per cent of the time – handle about 93 per cent of passenger kilometres in Canada, even higher in U.S.

GNA research indicates that setting a long-run target of 80 per cent of all passenger kilometres travelled by shared vehicles – i.e., vehicles that are part of a public, private or co-op fleet – that are busy from 40 to 80 hours instead of only 8.4 hours per week, would motivate an urban region to the point where a community of business and government leaders could begin to innovate just how such a fleet could be financed, maintained, managed and priced. Leaders could begin to figure out how to park this fleet off-peak, how to power it, how to re-purpose the liberated parking areas. Real estate interests in the community could begin a process to decide how to turn parking garages to other uses or re-purpose parking lots as parks. Public works departments and planners might turn street parking to bicycle paths. If community leaders do not set such an assertive target, automotive manufacturers will continue to roll out a high, personal-vehicle consumption model for us with unfortunate results.

Communities should start thinking now who would be best to deploy such fleets. Without going into specifics at this early stage, it's not too early to begin forums to discuss the incentive and regulatory structures that would fit Canadian values. Ideas should be collected regarding ownership models that would make sense. The alternatives of fleets owned and managed by large corporations (such as the Walmart model or franchised to family-run fleet clusters on the McDonald's model) should be put into planning scenarios.

Universities and professional groups should be asked to think about a role in sponsoring affinity fleets run by co-op transportation operators. What kinds of government guides for pricing, service, response times will be needed to maintain equity, or are the forces of the competitive market going to get it right soon enough? All this, and more, is worth discussing now in government-business forums.

Figure 2: Public-Private Partnerships for Innovation could create opportunities for regions to ensure access and equity to all and enormous opportunities for manufacturing and jobs.



The real disruption

It is the difference between the incremental feature-creep model now being pursued by auto manufacturers and the disruptive model of moving directly from driving to not driving pursued by Google, the EU and others that holds a key to the solution we are seeking. There are numerous problems of mixing robotic driven and human driven vehicles at any ratio – whether one per cent, 56 per cent or 99.3 per cent. Following the incremental, gradual mixed-traffic model leads to years of contention regarding traffic rules, overly cautious robotics, insurance liability, new legions of distracted drivers using robotics that operate 90 or 99 per cent of the time but not 100 per cent.

But if Canadian cities emphasized full-solution, application-creep innovation instead of preparing or waiting for household vehicle feature-creep, we could introduce less contentious, incremental improvements in controlled circumstances. If we used innovative business and financing models to replace and grow public (transit) passenger kilometres in increments safe for passengers and in ways that allow for thoughtful mitigation of the forthcoming, inevitable labour disruption, we could reduce the subsidization burden of transit, grow its ridership and attract drivers from household vehicles, in the same way TNCs do now. Rather than resisted, TNCs should be groomed and regulated to be integrated into a new hybrid solution of privately operated fleets governed for access and equity. It is the current case that however much Lyft and Uber may be good for young, carless travellers in our cities, TNC services are not designed to be available to the poorest travellers. Cities have a critical role to ensure access and equity even as current transit is disrupted.

With multiple service levels, related to things such as vehicle age, ride features, number of stops, ride sharing, convenience, comfort and more, a range of prices can be supported to be affordable for all users. There are ways with very little subsidy – very little would be best – to have transportation available to everyone at a level affordable to each. This is a preferred future.

There is also no way to guess all of the effects robotic mobility will have on the future of urban spatial distribution: density and sprawl. The harder truth is that what we believe we are able to predict about this new technology is less important than what we don't know or have not yet imagined. The things we surmise now about safety, productivity and labour disruption or the things we hope about congestion, energy efficiency and parking space recovery are easy enough to imagine. But there are many other things such as how we will locate ourselves in this re-enabled landscape, how transportation business and equity models will change or could be regulated, and how we will think about and finance the infrastructure needed to hold all this together, are much harder to think about.

And these things also need our attention. Starting now.

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