

The two markets for automated vehicles



...and what to do about them

For urban planners, the most important questions about vehicle automation are: When? How many? And, will they be privately owned or in shared use fleets? But even then — so what?

Bern Grush and **John Niles** take up the story

The evident excitement about vehicle automation innovation is exceeded only by its mounting negative hype. Every day there are fresh promises from Silicon Valley and now Detroit that autonomous vehicles will soon arrive. Common, exaggerated hype tells us we can buy one and sleep on the way to work “in only five more years”. A recent autoevolution.com article claimed: “...researchers from Morgan Stanley believe that autonomous vehicles would bring a boost of up to US\$98 billion to the alcohol industry...”¹ In late October of this year, a self-driving beer truck created buzz by making a 200 km delivery.

In the flood of papers and articles about vehicle automation there are an equivalent and growing number of stories about concerns for liability, jobs, safety, congestion, the destruction of the taxi industry — and now transit — by robo-cabs, and whether these robots will choose to sacrifice their passengers or run over pedestrians.

Just as the terms self-driving, semi-automated, driverless, fully-automated, and autonomous are thrown around indis-

criminally, so too is the word “disruption.” Disruption describes what happens to business models, not technology. Technology is merely the enabler. Vehicle automation could disrupt transit if it reduces transit ridership, causing transit agencies to shrink routes, or lay off drivers. Such an effect can be triggered, in a modest way, without automated vehicles as Uber and Lyft have already illustrated using drivers with SAE level 0 and 1 vehicles. They have also illustrated that disruption effects cut both ways, allowing transit route reductions in some cases and increasing ridership in others.

As long as semi-automated vehicles (no matter how capable) require a driver behind the wheel (no matter how infrequently taking control), this technology does not replace drivers. The early threat to transit is not wholesale driver layoff, but the erosion of the business efficacy of bus routes stretching into the suburbs to feed urban and inter-urban rail.

There is indeed potential for disruption of any transit business model that demands a city reach as far into its sprawl as subsidies

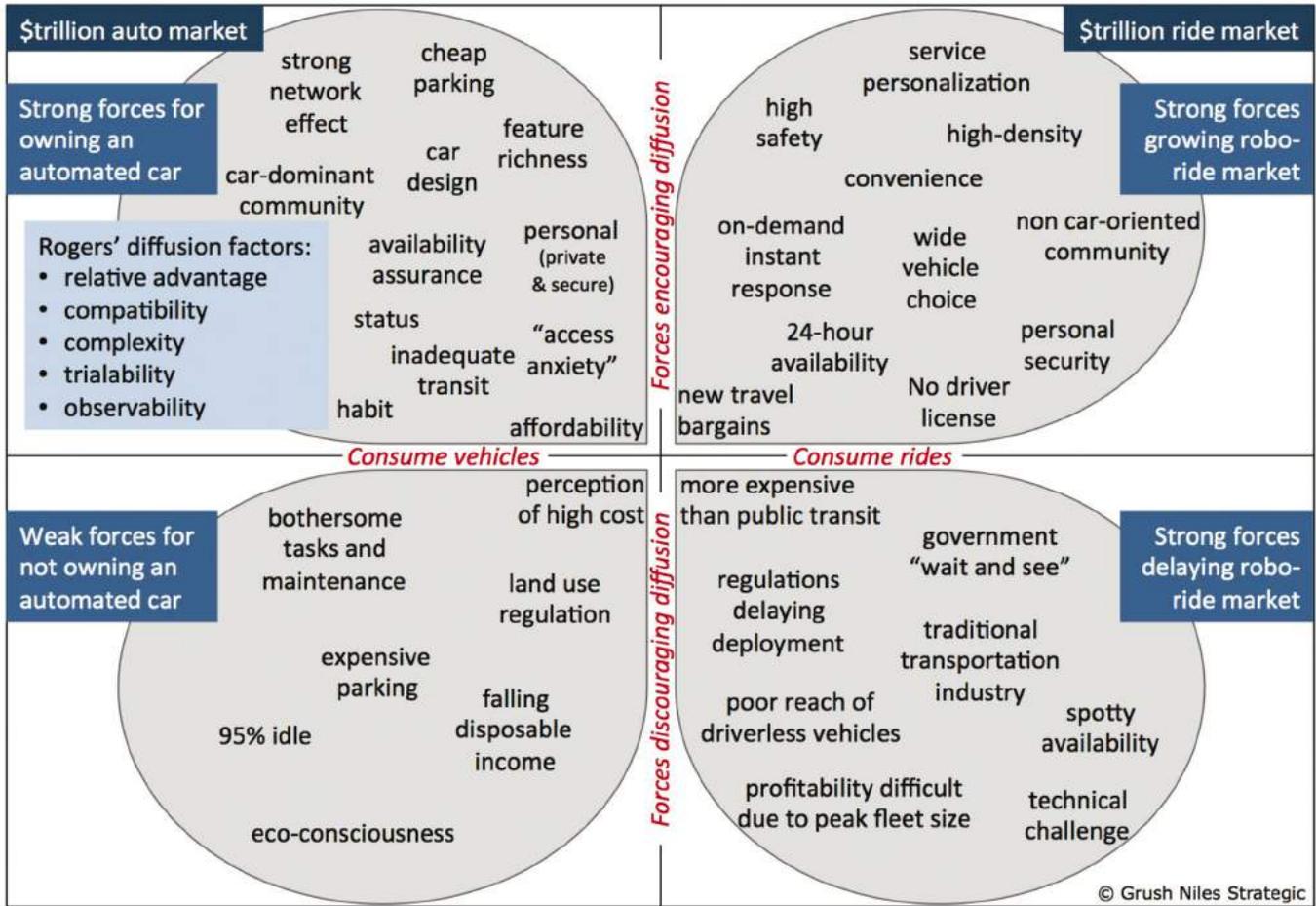
permit in the name of social equity and the aim of reducing the onslaught of single-occupant vehicles into the core.

But there is a municipal activity model under threat as well: municipal transportation management. As mobility digitization grows more competent, innovative and pervasive, demand for infrastructure change will occur — the amount, its configuration, and its oversight. This includes parking, lanes, speeds, congestion, transit (vehicles and routes), and enforcement. Just consider what distracted driving from texting has already done to congestion, enforcement and safety.

It is not useful to consider the market *diffusion* of automated vehicles as a single stream of innovation similar to the way one might study the diffusion of the original automobile, microwave oven, TV, or cell phone. The reason is that while the conceptual automated vehicle springs from a coherent body of AI, sensor, and mapping technology, there are two distinct motivating consumer models — two separate markets — for the actual automated vehicle. And each has its own diffusion path.



▲ Are we embarking on an automated vehicle journey to Heaven or Hell?



TWO CONSUMER MARKETS

Business models are what's *disrupted*, and the automated vehicle is disruptive of two different ones: "household ownership of vehicles" and "publically accessible shared use vehicles" — i.e., the respective businesses of selling cars or selling rides. Both of these business models exist now and already compete for users and infrastructure. Worse, aspects of the automated vehicle technology favor each business model differentially and are sometimes diametrically opposed. In what way will their related markets change due to the diffusion of vehicle automation? It is inconclusive to say "transit will be disrupted by vehicle automation." Which kind of automated vehicles? What sort of disruption?

If we knew which consumption model — cars or rides — will dominate, it would be easy to describe the nature of the coming disruption(s). Robin Chase famously summarized this problem in her 2014 *Heaven-or-Hell*

▲ **Figure 1: Forces of diffusion for automated vehicles. Effects weaken with distance from the centre**

article². But choosing between two extremes — mostly owned or mostly shared — is rhetorical and is a bit like describing the outcome of a single round of Russian Roulette with all chambers full versus all chambers empty.

In order to determine whether we are embarking on an automated vehicle journey to Heaven or Hell, let's look at the forces at play for the diffusion of automated vehicles. After that we can leave the final exercise of choosing the principal direction to industry and government, because — as we know — the average citizen will choose the path of personal least resistance, regardless of whether it leads the commons toward Heaven or Hell.

Industry and its shareholders win regardless of whether we ride our way to Heaven or own our way to Hell, but governments and

cities only win on the trip to Heaven. And the latter benefits accrue to all of us.

In Figure 1, the automated vehicle consumption market is divided into two simple halves: selling vehicles and selling rides (left and right). Of course selling rides means that someone sells vehicles, so that making and selling vehicles does not go away; rather, it grows due to faster relative turnover, and increasing vehicle kilometres travelled (VKT) — which is how the automotive industry gets its win-win hand.

The market diffusionary forces are also divided in a simple binary fashion as they might influence for or against the consumption of cars versus rides (top and bottom). Such a simple dichotomy may miss nuances and some of the markers falling on one side or the other may be equivocal, but the figure acts as a starter map to the landmarks along our way to Chase's driverless Heaven or driverless Hell. If we can construct such a map, we can use it to navi-

gate toward driverless Heaven.

Let's look at Figure 1 clockwise from the upper left.

FORCES EXPANDING DIFFUSION OF VEHICLE OWNERSHIP (UPPER LEFT QUADRANT)

A good starting place when thinking about the diffusion of the automated vehicle is Everett Rogers' list of diffusion factors from his classic *Diffusion of Innovations*. By the early 2020s for most people and most trips in North America, a personally-owned, semi-automated household vehicle would hold a real or perceived *relative advantage* over alternatives — especially over the alternative of not owning a personal vehicle.

Owning a household vehicle is largely *compatible* with current infrastructure, social values, habits and travel preferences. Its use, for those who will afford it, will be on average *less complex* than carsharing or transit as they are currently configured — assuming those options are even sensibly available for persons in our thought experiment. By 2020, the *trialability* of a semi-autonomous (Level 3) vehicle can be expected to be higher than that for riding in a fully autonomous (Level 4) vehicle. This can also be expected to be true for observability.

The last two factors may show a smaller and eventually vanishing differential a few years after 2020, as robo-taxis and robo-shuttles become available for use, but they are selective for ownership at the start and important in terms of pre-2020 user perceptions and fears. This means that asking people their consumption preferences in 2017 may be as useful as asking a horse-and-buggy owner in 1897 about his preference for switching to a Stanley Steamer.

In addition to the current weight of Rogers' core diffusion factors, there are other ownership-favouring forces at play for automated vehicles. Habit, status, privacy, security, and the sense of assurance we get from "my car" all promote the *compatibility* of ownership of a semi-automated vehicle for a majority of current vehicle owners. Unless something causes such people to re-consider their preferences in the light of alternative transportation services that are indeed more personally

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desirable they would, by default, elect to own a semi-automated vehicle rather than consume rides from a robo-vehicle service.

Rogers' insight about status is important as we consider assertions from some experts telling us that many or most people will largely abandon ownership in the face of vehicle automation:

Even though every innovation is judged on economic grounds, at least to some degree ... every innovation also has at least some degree of status conferral. Overadoption is one result of the prestige-conferring aspects of adopting an innovation. Overadoption is the adoption of an innovation by an individual when experts feel that he or she should reject³.

There is also something we call "access anxiety" that will be reason enough for owning a semi-automated vehicle until the reach

of the fully automated vehicle (owned or not) handles the great majority of all trips. Access anxiety will operate for the first decade or two for the fully automated vehicle in the same way range anxiety still operates for the electric vehicle whose sales failed to skyrocket starting back in 2010, as promised.

Other things that act as forces to make owning a vehicle, including a semi-automated vehicle, attractive is the sheer power of automotive design and marketing, its delicious feature creep. My eyes puddle with desire as I sit through the false promises of open-road car ads in front of every movie, my desire undampened by ads for new bus routes or a car-sharing scheme. Consumer desire and concomitant overadoption are bound up in numerous, powerful behavioral-economic forces that are not easily rationalized away. Automotive marketers have mastered this socio-biological space.

Add to this that most of the developed world is fully configured with the necessary network to support vehicle ownership: the installed base of roads, plentiful locations to buy cheap fuel, sales and maintenance depots, dedicated sections of newspapers, endless advertising, and of course cheap or free parking in most circumstances.

For the automated vehicles Silicon Valley and Detroit will offer in the early 2020s, there

▼ **Owning a semi-automated vehicle in the 2020s is compatible in every way to current household vehicle ownership, except that the driver touches the steering wheel less frequently as the decade moves on**





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await daunting forces saying “buy me!” to a majority of people and families in the developed world that are accustomed to owning personal or family vehicles. As automated vehicles become affordable, then-current car-owners will adopt SAE Level 3 vehicles (ADAS, semi-automated, self-driving). A fully automated (SAE level 4) vehicle will not be practical to own due to access anxiety, and a Level 5 vehicle will not be practical to make available at all. Given our current social and conurbation structures, only a small group of then-current owners will choose to adopt non-ownership in the 2020s (upper right quadrant).

The forces in the upper left quadrant are largely outside the reach of policy and planning. They are strong, culturally embedded. People won’t easily be nudged⁴ out of them. They are unlikely to diminish during the 2020s. Only manipulating the factors in the other three quadrants (mostly the two right quadrants) would draw consumers more reliably from the upper left to the upper right. In other words, we will experience little success *pushing* owners away from ownership, but we might have some success *pulling* them

toward non-ownership (Chases’ Heaven), and in helping non-owners remain non-owners even as they begin families (although that will be more difficult). This may sound equivocal, but from a behavioural economics⁵ perspective, it is not.

FORCES EXPANDING DIFFUSION OF VEHICLE RIDERSHIP (UPPER RIGHT QUADRANT)

Some people will find reasons to stop owning a vehicle in the 2020s. These are people moving toward life-styles (retirement, telework, moving close to work or to a non-car community) that increasingly indicate less ownership, especially in conjunction with the sparse, but growing number of alternatives, including newly emerging MaaS services⁶. The growing inconvenience of car ownership, parking and driving will push some to abandon the 20th century freedom of car ownership in favor of the 21st century freedom of non-ownership — should that alternative be reliably available.

Any factor that increases the relative, perceived value of alternatives weakens the

car-consumer’s bond to ownership. These factors might be few and less evident in the 2020s, but as they grow, they threaten the attachment factors in the upper left quadrant. Principle among these would be high transportation service-levels including low price, numerous choices, user convenience, high availability and responsiveness, personal security and privacy, as well as service personalization.

The forces in the upper right quadrant, as they are strengthened, *pull* current owners toward non-ownership. An example might be a car-owning retiree moving into a walkable community that has robo-taxis for local shopping, dining and entertainment and robo-shuttles to transit trunk lines. But a switch to non-ownership would be nixed if their grandchildren live in the suburbs an hour away, and far from satisfactory transit.

It is even more important to consider that transportation preferences become ingrained as we age. The factors in the upper right quadrant would increase the likelihood of a young non-owner to remain a non-owner for life. Creating a sustainable social environment for Chase’s Heaven, is even more critical than rescuing a few boomers from car-slavery in their waning years.

FORCES LIMITING DIFFUSION OF VEHICLE RIDERSHIP (LOWER RIGHT QUADRANT)

In addition to the substantial weight of barely addressable, pro-ownership factors (upper left quadrant), many other addressable factors help prevent the abandonment of vehicle ownership and keep the brakes on the subsequent adoption of ride-consumption.

Reliable ride systems with appropriate prices, reach, and availability need to be in place. Most of this needs government encouragement, planning, and oversight — even as investment is made by industry or public private partnerships.

The changes needed carry risks due to unfamiliarity and complexity, as well as the limited functionality and high expense of early-generation robo-vehicles. These vehicles also generate fear regarding change, jobs, privacy, safety, and personal security. Regardless, industry will be innovating robo-services to compound its ROI from substan-

tial investment in automation. Remember that the automotive industry is a master of marketing to human desires — they will either be a formidable partner or a daunting opponent on the map to Heaven. Notice who won the car versus bus contest for the past 120 years.

History often repeats. Without appropriate preparation — and especially if industry takes over vast tracts of transit — change will not include social equity. By default, corporate intentions tend toward cherry-picking customers that maximize profit.

But the changes needed to ameliorate the negative factors in this quadrant are not difficult to understand. Systems (and the implied policies) have been described to gradually move from limited “last-mile” robo-shuttles to a robust, regional, robo-transit systems over the next few generations of vehicle automation⁷. As a matter of imagination followed by focused civic leadership, public policy can be designed and implemented to retain social equity, transit jobs, urban-planning objectives, and transportation-supplier profits while dramatically increasing robo-transit ridership.

FORCES LIMITING DIFFUSION OF VEHICLE OWNERSHIP (LOWER LEFT QUADRANT)

There are a number of factors that may discourage ownership but have only weak effects to date. Owners that rely on their vehi-



cles for accessing jobs continue to absorb creeping inconvenience and cost. They can keep cars longer, run them in poorer condition, circle for cheaper parking, and buy used vehicles. The fact that household vehicles are “95 per cent idle” influences sharing-economists’ preaching-to-the-choir far more than it influences the market-selection processes of existing car-owners.

Land-use regulation has an unintended effect when families decide to purchase affordable homes that demand increased car use and ownership. It is easy to see that a growth in the adoption of household semi-automated vehicles will encourage more suburban home-buying.

Eco-consciousness while a factor for a few

“Without appropriate preparation, and especially if industry takes over vast tracts of transit, change will not include social equity. By default, corporate intentions tend toward cherry-picking customers that maximize profit”

NOTES

- 1 <http://www.autoevolution.com/news/autonomous-cars-could-bring-100-billion-boost-to-the-alcohol-industry-110025.html>
- 2 <http://www.citylab.com/commute/2014/04/will-world-driverless-cars-be-heaven-or-hell/8784/> 3 Rogers, E., (2003) Diffusion of Innovations, Fifth Edition, p.231
- 4 Thaler, R., Sunstein, C., (2008) Nudge: Improving Decisions About Health, Wealth, and Happiness
- 5 This is discussed in more detail in book, *The End of Driving*, to be published in 2017.
- 6 See URL maas.global for an example.
- 7 Grush, B., Niles, J., Baum, E., (2016) *Ontario Must Prepare for Vehicle Automation: Automated vehicles can influence urban form, congestion and infrastructure delivery.* http://rccao.com/research/files/RCCAO_Vehicle-Automation_OCT2016_WEB.pdf
- 8 Dargay, J., Gately, D., and Sommer, M., (2007) *Vehicle Ownership and Income Growth, Worldwide: 1960-2030*
- 9 Bernhart,W., Winterhoff,M., Hasenberg,J., and Fazel,L. (2016) (R)evolution of the automotive ecosystem. Roland Berger. Munich

◀ Robo-taxis will disrupt taxi, carshare and transit use far sooner and more aggressively than they will disrupt car ownership

is not a game-changer. Our species is socio-biologically wired for individual and small-group success, in that order. Car owners will choose what they perceive as best for themselves and their family. The planet is the last thing on most car-buyers’ minds when visiting the show-room floor.

SOME TIME IN HELL BEFORE HEAVEN

Worldwide organic demand for personal kilometres traveled (PKT) continues to rise with wealth and population growth⁸. This economic force will overwhelm any early shifts in average ownership preferences, even as the absolute use of shared vehicles begins to ramp up in particular locations. On average, in the 2020s, the world population of privately owned vehicles will continue to grow, even as sharing may begin to grow more rapidly. Because sharing systems need much more than just a few people willing to abandon ownership, sharing will initially pool in small geographic pockets and among only some demographics.

At some point (the mid-2030s, according to the robo-taxi evolution forecast of Roland-Berger) we should see a plateauing of ownership, and with rapid growth in the deployment of robo-taxi and shuttle services. When that occurs, there will be finally a decline in absolute registered vehicle count, as vehicles are replaced with high-turnover, public service vehicles, perhaps idle only 30-50 per cent of the time.

City leadership can accelerate the most suitable social steps for what we see as inevitable technical and market revolutions by proactively creating robo-friendly residential and commercial zones and combining them with trial deployments of available robotic vehicles aimed at generating the changes and data that would improve the market embrace of the civic vision.

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