

Frequent assertions that car owners will easily abandon ownership and become robo-vehicle ride-buyers are largely wishful and without sufficient evidence, according to **Bern Grush** and **Blair Schlecter**. How much travelers tend toward increased (or sustained) vehicle ownership, and how much toward car- and ride-sharing depends as least as much on human behavioural preferences and habit as on pure economic considerations



Ownership matters



“Car ownership will survive. Car purchase and usage decisions are separate, and there are many reasons not to give up our cars. We forecast global car sales holding firm and rising slightly to 100 million in 2030 vs. 87 million today, helped by rapid turnover of ride-share cars, in spite of declining car penetration” [Burgstaller]

Two great myths surround vehicle automation. The first is that this technology will drive traffic congestion out of our road transportation system. This cannot happen *soon* for four reasons: (1) human populations are still increasing, (2) more people continue to migrate to cities and do not always abandon vehicle ownership and use, (3) infrastructure is generally very much less than what is needed to always have free flow given our current land use patterns, trip habits and travel decisions, and (4) we face two to four decades of mixed traffic — non-automated and automated — which will delay wide-spread deployment of platooning, lane narrowing, intersection optimization, and dramatic downsizing of street parking that are among the promised advantages of driverless vehicles.

And the cessation of congestion cannot happen *easily* for two more reasons: (5) every easing of congestion generally induces more traffic and (6) congestion is often a measure of success or desire: we crowd near things we want and on roads that take us to preferred places. No matter how cleverly cars are sized and connected, or how brilliantly they coordinate and swarm, surface vehicles occupy road space and competition for that space will not cease. Congestion is its own feedback loop — it tends to fill up space made available and becomes gradually self-limiting as that space fills up, although it is certainly less effective at self-limitation than it is at filling up.

Whenever goods or services become more efficient or less costly humans tend to consume more. Given a self-driving

vehicle, some people will prefer to live further from the city core, especially if central housing prices remain increasingly out of reach for so many (the drive toward higher density is also a somewhat self-limiting system). Everywhere that mobility becomes easier or more efficient on a personal basis, more vehicles will show up. The success of on-line shopping has put more goods vehicles on the road, which some claim moots the net effect of online commerce in reducing road traffic. [Zaleski] However, other evidence says this may not be the case, [Schmitt] serving to mock the certainty with which popular media portrays current traffic circumstances, much less future scenarios.

As well, we could never afford to build and maintain enough capacity to be forever congestion free. Only a significant decline in vehicle kilometers traveled (VKT) accompanied by a sufficient improvement in technology will end congestion, and a long-term, permanent decline in VKT is not predicted as long as road pricing with high peak and lower off-peak prices is considered anathema by the general population. Freedom from congestion is not in our immediate future, and it will certainly not “just happen” because cars become driverless.

THE OWNERSHIP QUESTION IS MORE IMPORTANT THAN AUTOMATION

The second great driverless-vehicle myth is that “no one will own a car.” It may be reasonable to expect a *relative* decline in per capita ownership, but to date there continues to be an *absolute* increase in total ownership.¹ Since urban space is con-

strained, an absolute increase — which many mobility optimists ignore — tends to overwhelm any relative decline that may occur. That private ownership will cease or become rare is wishful thinking — at least for the next half-century and for any country whose government will not ban ownership.

The effort required to convert the majority of vehicle owners into ride-buyers will be far greater than the effort to turn the current population of drivers into users of automated vehicles. The best we can hope for is to gradually reduce vehicle ownership thereby reducing absolute vehicle numbers, not just per capita numbers. But significant reduction in private ownership will not happen until robo-ride services are clearly better than current ride services including being an improvement over the perceived serviceability of private ownership. Humans change behaviour when forced or when the replacement behaviour yields a better personal outcome by a significant amount. According to behavioral economists “the pain of losing is psychologically about twice as powerful as the pleasure of gaining.” [Samson, p.111] If giving up personal car ownership is psychologically framed as a loss, then *loss aversion* would effectively prevent vehicle owners from abandoning vehicle ownership until it is reliably and overwhelming clear that robo-ride services are better in the domain(s) for which each such owner sees ownership as valuable.

Having a cheap robo-taxi able to take you to *some* destinations — the initial service expectation for select locations in the 2020s — is insufficient to have most car owners abandon ownership. Having a wide-variety of vehicles take you literally anywhere after only short wait times and with clearly lower costs and in a vehicle the trip-taker judges as comfortable might convert many more vehicle owners into users of shared vehicles. But how long will

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¹ According to Desrosiers’ May 2017 Automotive report [Desrosiers] the annual YOY rate of new car sales increased in Canada for each of the seven years starting in 2010 has averaged 4.0 per cent, and ranged between 2.1 per cent and 8.2 per cent with 2016 showing the second strongest growth for the period. The same reports show a YOY projected slowing in growth for 2017. Regardless of YOY variability in sales, the total number of cars on Canada’s roads is still growing. A decline in absolute ownership is not evident; to date, any relative slowing in ownership is masked by population growth.



“If we have learned anything since the rising popular awareness of global warming, it is that most humans consume what they desire first then maybe think, often in minor, ineffective ways, about the environment second”

it take for this service level to be achieved?

It is commonly claimed that robo-taxis will be cheap and will arrive within a couple of minutes of being summoned. It is easy to imagine that they will be cheap — less than today’s taxis or even ride-hail vehicles, and even less than owning your own vehicle — but will they really scale below the cost of taking the bus?

This is notably questioned by Burgstaller et al:

Although the driver accounts for close to half of per-mile ride-hailing costs, we do not think that the arrival of autonomous cars will bring correspondingly cheaper ride hailing. Asset-light ride hailers have little interest in entering the asset-heavy fleet business, a situation that could open up the biggest revenue pool in new mobility: autonomous fleets. The autonomous fleet business is potentially transformative for OEMs. [Burgstaller]

Furthermore, to have autonomous shared vehicles always arrive within a couple of minutes will require a large, carefully sized and orchestrated fleet and will — in the early decades of automated vehicles — not

be practical everywhere as user densities vary over urban geographies. Both “cheap” and “immediate” are bold claims that are easily (and often) simulated in the lab, but harder to substantiate. Until they are reliably proven, it is hard to see a majority of vehicle owners abandoning ownership.

ENVIRONMENTAL VS. PERSONAL CHOICE

But, are affordability and instant arrival even the prime determinants? According to a 2017 survey of 2,320 holders of driver licenses from 15 countries, “the majority of those who drive ... choose their car because it’s the most comfortable option.” In the same survey, the importance of speed was clear: “70 per cent ... say they’d be more likely to use public transport if they had a faster journey time.” [Averkamp]

The ideal fleet according to the environmental and livability perspective comprises vehicles that are automated, connected, electric, and shared — ACES. The ideal fleet from the common traveler’s perspective would have vehicles that are comfortable, affordable, fast and instantly available — CAFI. Sharing of cars or rides would only be acceptable to CAFI thinking — if ever — when it makes access to rides more affordable, reduces parking hassles and does not slow down ride commencement with long wait times. The ACES-CAFI difference is the divide between what planners wish and consumers want. This gap is now very wide. It has to be closed in order to achieve the holy grail of having most people use “mobility as a service” (MaaS) rather than owning their own vehicle.

Shared CAFI robo-taxis sound more desirable than ACES taxis as an enticement to abandon ownership. Alas, automated CAFI is much farther off than ACES. Even



▲ Is the robo-taxi the shape of things to come?

if CAFI vehicles were to become pervasive, an agreed definition of “comfortable,” “affordable” and “instant” would be elusive. Surely, any city will have travelers willing to use robo-ride services, and it would be reasonable to expect a slowly-growing segment of the population to not own vehicles, but projections of 25 per cent of PKT by 2030 or 80 per cent by 2040 in on-demand robo-taxis are wishful thinking unless we can create a dramatic social, regulatory, urban, and technological shift. Vehicle automation by itself will not be enough. Rather, as discussed below, we need to think about autonomous taxi or shuttle systems that will appeal to passengers with a wide variety of needs and preferences.

ACES and CAFI are not necessarily contradictory, but they are independent of each other. If we focus on deploying ACES fleets while ignoring CAFI, we will have an ideal environmental solution with modest user acceptance. If we focus on CAFI at the expense of ACES we will have higher user acceptance of a less than ideal — and possibly harmful — solution. If, however, we design and manage CAFI fleets that are constrained by ACES technology, we can address both environmental goals and traveler satisfaction. There is hope, but the demand and deployment challenge is higher.

If we have learned anything since the rising popular awareness of global warming, it is that most humans consume what they desire first then maybe think, often in minor, ineffective ways, about the environment second. We can deploy whatever robo-taxi fleets we want, but only CAFI fleets will succeed to the extent needed to become pervasive and to be able to draw a majority of users away from personal vehicle ownership.

THE CHALLENGE OF TRAVELERS WITH NON-ROUTINE NEEDS

Even when and where robo-rides become CAFI, it is important to consider why some individuals and households might still elect to retain a personal vehicle and how these choices might be addressed to increase the portion of shared-use autonomous vehicles.

If comfortable is a critical decision criteria, then we need to consider what “comfortable” actually means to each traveler. Trip takers have a wide range of ride preferences and tolerances from exclusive access to a personal luxury vehicle, through cycling and to the backseat of a poorly maintained taxi or standing room only on a city bus. All of us know people who are comfortable taking whatever means are cheap and available and others who refuse to use bike or public transport. Some people are uncomfortable using a taxi or bus late at night. Others are more comfortable using Lyft than the hotel shuttle.

Comfort not only means many things to many people, there are certain issues of comfort — which may include perceptions of safety and reliability — that will ensure that some people will continue to own their own vehicle, even if they sometimes use on-demand robo-services. Here are a few:

Travelers with children



Young children need to be restrained in car seats that are customized for their age and weight. In most provinces and states, children under a certain age must be secured in a car seat or booster seat in the back seat of the vehicle. [CHP] Canada has strict laws that vary by province. [BCAA] Similarly, child safety laws across the United States vary but in general require car seats for children until they are least 5 years old (or a certain weight) and in many cases older than that. [BCAA] In the United Kingdom, children are required to use a child car seat until they are 12 years old or 135 centimeters (about 4.5 feet) tall, whichever comes first. [UK] It is also well known that

many parents continue to deploy car seats beyond the required age or weight while car safety laws continue to get stricter. In short, a substantial portion of vehicle passengers need to be in appropriately-sized car seats.

Such safety regulations, coupled with parental concerns for “instant” availability of an on-demand vehicle with suitable seats that are correctly configured and sufficiently sanitary for their child would have most travelers with small children prefer ownership of a personal or family vehicle.

One can imagine new safety innovations, such as more easily installable and highly portable child seats or new sorts of child restraints standard in all vehicles, but until such innovations are pervasive in robo-vehicles, travelers with children will be a major logistical and operational challenge for robo-taxis. If shared automated vehicles are to be used by this group, a certain percentage of these vehicles will need to have customized car seat configurations to handle young children. For example, for a family with two children aged one and three, the vehicle would need to be equipped with two child seats each of a different size and design. For a family of five with three young children, a different configuration will be needed in a larger vehicle — and so on.

Yet other issues would make travel with children less amenable to robo-taxi use. Child-related commuting often involves multiple intermediate stops (school-after school program-groceries-home). Unless a parent or caregiver is accustomed to handling this trip on city transit, these stops make it inconvenient and expensive to use robo-taxis. These issues can be addressed, but until such trips are more convenient and cheap they pose barriers to shared use. This is perhaps reflected in the fact that current ride hailing services generally do not focus on servicing families with young children.

Travelers who are disabled or elderly

Disabled travellers represent a significant and often underserved segment of the population from a transportation stand-



▲ The mobility needs of disabled travellers are often overlooked

point. This is also true of the elderly who may have some difficulties getting around, even if they are not disabled, per se. Some disabled individuals are still able to travel independently. Others utilize shared vanpools, private assistance, or public transit for trips.

The United States Census reports that nearly 20 per cent of Americans (now over

55 million people) have some form of disability. [USCB] According to earlier data from the United States Department of Transportation, about 23 per cent of individuals with disabilities need some sort of specialized assistance or equipment to travel outside the home. [USDOT] And 65 per cent of individuals with disabilities drive a car or other motor vehicle. [USDOT]

It is reasonable to assume a similar portion of Canadian travelers are disabled or elderly. Indeed, it is known that this portion is increasing in Canada. [Hodge]

Since many disabled or elderly individuals are less mobile than non-disabled individuals, projections have been made that automated vehicles would provide new opportunities to the disabled and elderly, permitting those who are aged, blind, or with other disabilities to travel more easily and more frequently.

Hence, the percent of VKT by those with disabilities is likely to grow in an automated vehicle world, making the disabled an expanding segment of the trip-taking population. This would be compounded as baby boomers age out of their licensed driving years, while some remain frequent and independent travelers.

To provide mobility to some disabled travelers using on-demand robo-fleets would still require, as now, special fittings, sizes, egress, loading areas, and occasionally human assistants (stewards). So while automation could provide greater access to mobility for the disabled and elderly, it is difficult to see how a large portion of this segment would necessarily utilize on-demand fleets, preferring to own a private vehicle provided they can get into and out of the vehicle unaided.

Of course, disabled individuals who are not able to help themselves into and out of a vehicle — no matter how equipped — will require customized services and vehicles, adding a logistics challenge reminiscent of today's highly subsidized demand-response services for accessibility. The costs savings achieved by automation would therefore be mooted by the requirement for a human assistant.

Baby boomer travelers

Baby boomers pose a related issue. They will be a large, if not the largest, cohort in many jurisdictions in North America during the first decade or two of the adoption of highly automated personal vehicles and fully automated robo-taxis. The baby boomer's affinity toward owning vehicles will affect their consumption preferences. Their waning driving capabilities and inter-

action times may challenge user-interface engineering for highly-automated vehicles and their declining physical capabilities will put more pressure on existing programs for labour intensive and inefficient on-demand transportation models for the disabled. This means a large segment of the current driving population may completely skip the purely driverless robo-taxi as they move from private, highly-automated vehicles directly into robo-shuttle fleets with human attendants.

There may be opportunities created by integrating mobility devices and the design of autonomous vehicle and services that would promote aging-in-place strategies, with the accompanying reductions in healthcare cost projections. Savings in health costs and improved health outcomes may fully offset public and personal investments in transportation service technologies. If such a direction is adopted within a shared-service fleet setting, care must be taken to segregate higher service expenses from majority users to avoid nudging them toward personal ownership.

Travelers with animals

Many individuals travel in their cars with pets, particularly dogs. They travel to the park, veterinarian, work, school, and on vacations. They sit in the back seat, if not on the driver's lap. Because these pets tend to leave odours or hair, some robo-fleet operators may decline to permit pets in their

vehicles, narrowing the range of vehicles available for persons with pets and encouraging pet owners to own a private vehicle.

Consider a blind person with a helper dog. A robo-taxi would be perfect, especially since such a person might not have owned a vehicle before and might not wish to start owning one. Will there need to be a special sub-fleet for such users? Or will long waits be acceptable, if such specialized vehicles would be few and far between? In a Toronto condominium building, someone recently left a note on the door addressed to the city's disabled transit Wheel-Trans service: "I waited for two hours, I had to call my sister to get me. Sorry I was not here."

Travelers who smoke

Similar to the issue of pet owners, some travelers prefer to smoke while traveling in an automobile. It is likely that some fleet operators will decline smoking customers or at least segregate smoking and non-smoking vehicles, as hotel operators do with their rooms today. Even if a smoker does not smoke during a journey, there will be complaints about odours from the next customer or – worse – from a ride-sharer. Smoking will tend to make some smokers prefer to own their own vehicle. In the mirror-reverse, those travelers who

are strongly put off by the smell of stale tobacco smoke or other smells may also prefer to own their own vehicle in order to avoid this exposure.



This argument extends to drinking, drugs, and other human behaviours that leave smells and sights that others may wish to avoid. A couple of instances of a ride buyer on the way to a business or romantic meeting sitting in an odour-filled vehicle will have such a user consider returning to vehicle-ownership. While these behaviours will not always discourage travelers from using on demand robo-taxis, they will be a deterrent to some. And this "some" may be significant enough to disrupt the economies of scale that would otherwise come from widespread adoption of shared use vehicles.

Travelers concerned about communicable disease

Some travelers are especially concerned with the risk of contracting an illness. Toronto, Canada had a pointed experience of this in 2003 during the outbreak of SARS, which saw many people avoiding public transit. In some Asian cities, many public places were closed temporarily. We can expect the frail, elderly and the health-obsessed to be leery of some forms of mass transit vehicles, including taxis and shuttles. Many such travelers who are able to do so would prefer personal ownership.

Travelers requiring carrying and storage capacity

Some individuals require a considerable amount of mobile storage space throughout the day. Gardeners, plumbers, electricians, construction workers and dozens of other service providers carry tools. Sales representatives often carry samples, equipment and signage from site to site. Such tools and equipment are usually too inconvenient to carry on public transit or in shared cars.

Anyone running multiple errands, such as picking up groceries and dry cleaning,

▼ Would robo-fleets permit users to bring their pets on board?



“Many people use a vehicle to carry things in the ordinary course of family life, even if only once a week. That means robo-taxis will need to accommodate these trips and capacity needs such as carrying a bookcase home from IKEA”



has come across the same issue. They often store goods from the first stop in their vehicle before continuing on to the next stop. Because of their need to make multiple stops per day and carry large, heavy or multiple items, or picking up kids from school, such individuals will typically prefer to own a personal vehicle with storage capacity in the form of a trunk, back seat, or truck bed.

There are many people who use a vehicle to carry things in the ordinary course of family life — even if only once a week. That means that robo-taxis will need to accommodate these trips and capacity needs — from stopping and waiting several times during a multi-stop shopping trip or be able to carry a bookcase home from IKEA. If they do not, some car owners will remain car owners.

The cumulative impact of travelers with non-routine needs

This list of exceptions to the default, simple,

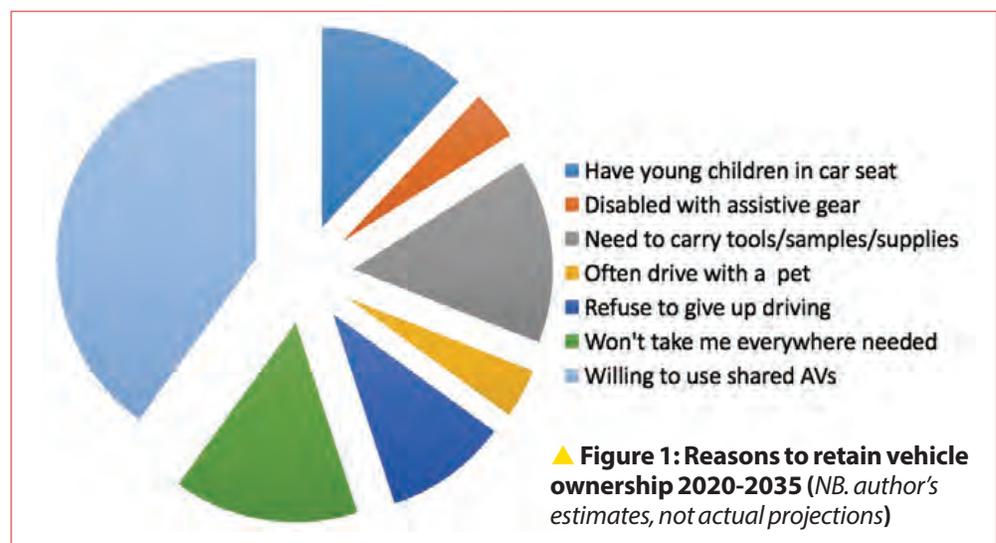
able-bodied commuter with an umbrella and a brief case might have many think: “sure, some people will continue to own a personal or business vehicle, but not most people.” This is wishful thinking. The cumulative number of individuals with non-routine needs is high and can be expected to have a significant impact on the adoption

of shared use autonomous vehicles.

Not only do all of us sometimes have non-routine travel needs— even if only occasionally — a majority of us in the developed world have become accustomed to have access to a family vehicle and most of the rest of us can find a friend’s vehicle to resolve occasional outsized needs.

Early robo-taxis will be an excellent service upgrade for those who use transit and taxis now, saving them time and money while adding convenience. Robo-taxis are expected to be in common use by 2030 and this may help some families get rid of a second car. But it will take much longer for robo-taxis to dislodge a family’s only private vehicle. It is not at all clear that vehicle automation will have the desired effect on congestion, parking, sprawl, and urban livability, until shared use vehicles and our urban environment are designed to accommodate those with non-routine needs. Automation alone will not be enough to move the sharing needle more than a few percentage points.

Figure 1 (below) illustrates these observations with estimates constructed by Grush Niles Strategic. They are not formal projections, but have been tempered by a number of recent surveys. [Averkamp; Merat; Zmud] We suspect that it will be easy to move toward 25 per cent of regional PKT served by automated, on-demand fleets in the 2030s, but we assert it will be more difficult to get to 50 per cent in the 2040s and very difficult to get to 75 per cent before mid-century, if ever. Considering that PKT



“Current thinking orbits around the fact that urban millennials are less likely to be focussed on car-ownership than are other demographic cohorts, hence the default caricature of a robo-taxi user is the younger, urban, employed, middle-class, able-bodied, Uber user of today”

demand historically doubles every 25 years, and that then-existing taxi and transit users will dominate the first wave of robo-ride users, it is hard to argue that automation will relieve our urban traffic woes in the first two decades after introduction.

These exceptions to common optimism for driverless-taxi adoption are neither comprehensive nor are their relative proportions well understood. They are presented to illustrate a sample of non-routine traveler needs and the potential heft and variety of the barriers to giving up personal vehicles. The critical issue is that there are many personal vehicle users whose definition of comfort is difficult to satisfy with a narrow range of robo-taxi service vehicles designed as simple people movers always available within a couple of minutes of a smartphone request.

CONCLUSION

Much discussion around the impact of shared autonomous vehicles is based around users getting to and from work carrying only a briefcase or bag or getting home from a bar after too many drinks. This thinking often orbits around the fact that urban millennials are less likely to be focussed on car-owner-

ship than are other demographic cohorts, hence the default caricature of a robo-taxi user is the younger, urban, employed, middle-class, able-bodied, Uber user of today. Much less thinking revolves around trip-planning for Saturday shopping, taking the dog to the veterinarian, the baby to day-care, or the family to grandparents for dinner 60 minutes out of town. Yet such trips are in the future of millennials as well. The more a robo-fleet is configured and managed to address all these users, the harder the logistics become, the longer the average wait, and the more costly the average PKT for the imagined perfect fleet.

Currently, the idealized vehicle fleet would satisfy only a fraction of user trips. For every pet taken in a pet-free vehicle or smoker using a smoke-free car, a robo-ride user might be disappointed and encouraged to buy a car or join an exclusive car-club, diminishing the pool of riders for massive robo-fleets and the efficiency of massive, relatively uniform, coordinated fleets.

Making the utopian robo-fleet system as flexible and serviceable as the private vehicle is now might make robo-taxi PKT as expensive as current private vehicle PKT. It is worth considering why [Burgstaller] wrote: “we do

not think the arrival of autonomous cars will bring correspondingly cheaper ride hailing.”

To have on-demand robo-vehicles persuade car owners to switch overwhelmingly to ride buying, we need to do more than make them cheaper. We need to start thinking about how to design on-demand transportation services — including their constituent vehicles — to make them more convenient, comfortable and accommodate as many non-routine needs as possible. We may also need to consider other changes in the built environment, such as public storage lockers or new forms of wearable or portable accessories to make it possible for a large variety of individual needs to be addressed by shared vehicles. We will then be in a better position to shape a shared use autonomous vehicle future.

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SOMETHING TO CALL MY OWN

Bern Grush and Blair Schlecter discuss the
challenges of ride-sharing in an autonomous future



TALE OF THE TAPE

David E Pickeral on the
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INCLUSIVE MOBILITY

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